The Value of Technics: An Ontogenetic Approach to Money, Markets, and Networks

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The Value of Technics: An Ontogenetic Approach to Money, Markets, and Networks

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This thesis investigates the impact of the digitalization of monetary and financial flows on the political-economic sphere in order to provide a novel perspective on the relations between economic and technological forces at the present global juncture. In the aftermath of the Global Financial Crisis and with the rise of the cryptoeconomy, an increasing number of scholars have highlighted the immanence of market logic to cultural and social life. At the same time, speculative practices have emerged that attempt to challenge the political economy through financial experiments. This dissertation complements these approaches by stressing the need to pair the critical study of finance with scholarship in the philosophy of technology that emphasizes the value immanent to technics and technology – i.e. the normative and genetic role of ubiquitous algorithmic networks in the organization of markets and socius. In order to explore these events, I propose an interdisciplinary theoretical framework informed largely by Gilbert Simondon’s philosophy of individuation and technics and the contemporary literature on the ontology of computation, supported by insights drawn from the history of finance and economic theory. This novel framework will provide the means to investigate the ontogenetic processes at work in the techno-cultural ecosystem following the digitalization of monetary and financial flows. Through an exploration of the fleeting materiality and multifaceted character of digital fiat money, the social power of algorithmic financial logic, and the new possibilities offered by the invention of the Bitcoin protocol, this research aims to challenge some of the bedrocks of the economic orthodoxy – economic and monetary value, liquidity, market rationality – in order to move beyond the overarching narrative of capitalism as a monolithic system. The thesis instead foregrounds the techno-historical contingencies that have led to the contemporary power formation. Furthermore, it argues that the ontogenetic character of algorithmic technology ushers in novel possibilities for the speculative engineering of alternative networks of value creation and distribution that have the potential to reverse the current balance of power.

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0. Introduction: A Technogenetic Approach to Economy and Power

Physicists and electrical engineers had little to do with the invention of the digital computer ... the real inventor was the economist Adam Smith –
Herbert Simon and Allen Newell[1]

0.1 Economic Calculation, Algorithmic Computation, and the Social

In recent years, money, finance, and the economic profession have been subjected to an unprecedented critical scrutiny. Since the Global Financial Crisis (GFC), popular and scholarly attention has increasingly focused on these topics, partly to explain the collapse that hit markets, but also to gain an understanding of the profound decline of the social and political spheres. The US subprime mortgage crisis in 2007-08, and the collapse of financial powerhouses such as Lehman Brothers and Bear Stearns in September 2008, are paradigmatic events that uncovered systemic problems in the financial ecosystem, such as the over-reliance on computational modeling for risk management by investment giants. Furthermore, they highlighted the ubiquitous role that money and economics play in daily life. Similarly, the threat of 'Grexit' – the possibility of Greece's withdrawal from the Eurozone monetary union in 2015 due to the enormous amount of public debt it accrued against other European Countries – foregrounded the nature of the European Union as a large scale financial operation. This suggested that, on the one hand, a monetary union does not necessarily lead to a political-economic union, and on the other hand that "the person who controls money, monetary policy, and interest rates, controls the politics of the social economy."[2] In addition to this, the extension and intensification of economic considerations and activity has profoundly affected planet Earth. For instance, NASA reported that July 2016 was the hottest month ever recorded, crowning a trend of consecutive monthly temperature records that started in October 2015.[3] While scientific authorities have

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[1] Herbert A. Simon and Allen Newell, "Heuristic Problem Solving: The Next Advance in Operations Research," *Operations Research* 6, no. 1 (February 1, 1958): 2.

[2] Yanis Varoufakis, "State of Power 2016: Democracy, Sovereignty and Resistance," in *Democracy, Power, and Sovereignty in Today's Europe*, ed. Nick Buxton and Deborah Eade (Amsterdam: Transnational Institute, 2016), 24, https://www.tni.org/files/publication-downloads/state-of-power-2016.pdf.

[3] Goddard Institute for Space Studies, "GLOBAL Station Temperature Index in 0.01 Degrees Celsius," *National Aeronautics and Space Administration - Goddard Institute for Space Studies*, July 2016, http://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts.txt; Michael Slezak, "July 2016 Was World's

demonstrated that one of the major contributing factors is the emission of greenhouse gasses by human activity, climate science denialism persists, allegedly funded by those industries that benefit from the status quo (for instance, fossil fuel and tobacco lobby groups).[4] Albeit rather different from each other, all these examples testify to the centrality of economic calculation, traditionally carried out through the medium of money, to daily life. From interpersonal relations, to education, to political activism, money is what enables (or, more often, hinders) our capacity to act within a market economy. Even the cultural sector has been increasingly subsumed into market dynamics – a theme I will further explore in the thesis. Indeed, it seems that today every micro-political decision is underlain by a micro-economic consideration.

In the *Postscript on the Societies of Control*, Gilles Deleuze observes that the passage from the Foucauldian disciplinary societies to the societies of control is perhaps best expressed by money. In disciplinary societies, money is anchored to gold as numerical standard (that is, money is literally disciplined by gold), while in control societies flows of self-referential fiat currencies are modulated according to the movements of the market: "The old monetary mole is the animal of the spaces of enclosure, but the serpent is that of the societies of control."[5] According to Deleuze, the shift to the societies of control and the corresponding "mutation of capitalism"[6] are to be connected to the technological changes that started in the second postwar period – in particular, with the advent of the computer. As a matter of fact, a series of events and technological innovations in the early 1970s marked a shift in the ways in which financial transactions are effectuated, profoundly impacting geo- and socio-political configurations.

Electronic trading began with the opening of the National Association of Securities Dealers Automated Quotations (NASDAQ) in 1972, which effectively marked the beginning of global modern finance. The NASDAQ – today the second-largest stock

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Hottest Month since Records Began, Says Nasa," *The Guardian*, August 16, 2016, https://www.theguardian.com/environment/2016/aug/16/july-2016-was-worlds-hottest-month-since-records-began-says-nasa.

[4] Graham Readfearn, "Doubt over Climate Science Is a Product with an Industry behind It," *The Guardian*, March 5, 2015, https://www.theguardian.com/environment/planet-oz/2015/mar/05/doubt-over-climate-science-is-a-product-with-an-industry-behind-it; Douglas Fischer, "'Dark Money' Funds Climate Change Denial Effort," *Scientific American*, December 23, 2013, http://www.scientificamerican.com/article/dark-money-funds-climate-change-denial-effort/.

[5] Gilles Deleuze, "Postscript on the Societies of Control," *October* 59 (1992): 5.

[6] Ibid., 6.

exchange in the world – was the first purely electronic stock market, in that it didn't have a physical location (although at the beginning it only offered automated quotes). Yet the invention of the NASDAQ by itself would not have revolutionized stock trading were it not for a series of events, occurring in the same time period, that contributed largely to the conditions for the emergence of global markets. Specifically, I am referring to: the end of the Bretton Woods system in 1971 that introduced contemporary fiat money (although, as I will clarify in chapter two, the origins of fiat money are to be found in the invention of paper money in UK in the seventeenth century); Milton Friedman's proposal for a futures market in foreign currencies in Chicago in 1971, which became operative in 1972 and allowed for the hedging of risk by betting on the exchange rates of the now 'liberated' national currencies; and the publication of the infamous Black-Scholes equation in 1973. It is also important to mention the opening of the Chicago Board Options Exchange (CBOE) in the same year, the first modern market entirely dedicated to the trading of derivatives. As I will argue in this thesis, these events were crucial for the extension of financial logic to aspects of culture previously exempt from it, in concomitance with the development of planetary computation, also impacting the ways in which power operates. Below, I present these events in more detail, before turning to an exposition of the present techno-economic situation.

The end of the Bretton Woods system on August 15, 1971, put an end not only to the convertibility of the US dollar into gold but, more strikingly, ended 2,500 years of history by introducing the contemporary and fuller form of fiat money – "money created from nothing, by the sheer force of a demiurgic word."[7] Fiat money is a kind of money that is inconvertible, supposedly valueless and neutral, and which acquires its value from government regulations. More importantly, this money is not backed by anything; at most, it is backed by the groundless ground of an actually irredeemable global debt – which it is the job of the State, as lender of last resort, to manage (for instance, with quantitative easing, by buying junk bonds, etc.).[8] The end of Bretton Woods enabled the

[7] Massimo Amato and Luca Fantacci, *The End of Finance* (Cambridge: Polity, 2011), 88. As we shall see in chapter two, however, the origins of fiat money are inextricable from the introduction of paper money in the seventeenth century and the institution of the function of store of value in the monetary architecture. Furthermore, as Amato and Fantacci clarify, "every currency owes its existence to a '*fiat*' … The only way for a currency to come into circulation legitimately is through the sanction of an authority." The real novelty of Nixon's declaration, as the authors explain, was to eliminate gold's "major prerogative of money, which is to pay debts." Ibid. (emphasis in original).
[8] See: ibid., 89–99.

creation of new markets for the trading of futures contracts in foreign currencies,[9] following the proposal by Milton Friedman in 1971 at the Chicago Mercantile Exchange.[10] This inaugurated international currency trading and allowed money to float freely according to market dynamics. The rationale for this proposal was that finally, with the end of the convertibility of the US dollar with gold, speculations on stocks could be hedged through speculations on foreign currency:

> The larger the volume of speculative activity, the better the market and the easier it will be for persons involved in foreign trade and investment to hedge at low costs and at market prices that move only gradually and are not significantly affected by even a large commercial transactions [*sic*].[11]

Further, 1973 saw the publication of the infamous Black-Scholes formula for the pricing of options, which provided a general model for option trading based on stochastic calculus aimed at the normalization of risk.[12] The opening of the CBOE – the first modern market entirely dedicated to the trading of derivatives – followed right after the publication of Fischer Black and Myron Scholes' paper. Since then, the rise of computational technologies that perform increasingly complex calculations about 'value' through time has allowed for an acceleration and expansion of global financial trading to the point that, as Donald MacKenzie puts it, what was initially proposed as a model for the pricing of options – the Black-Scholes formula – has become the *de facto* engine for financial trading, testifying to the performative nature of mathematical modeling.[13] Since then, money and the economy have been progressively digitalized and automated, to the point that, as Alexander Galloway observes, "the economy today is not only driven by software (symbolic machines); in many cases the economy is

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[9] Futures contracts are derivatives products according to which two parties agree to exchange an underlying asset at a price stipulated in the present, but with payment and delivery occurring at a time in the future (so-called 'delivery date'). In the specific case of currency futures, the price of the underlying asset (i.e. foreign currencies) corresponds to the exchange rate between two currencies.

[10] See: Joseph Vogl, "Taming Time: Media of Financialization," trans. Christopher Reid, *Grey Room* (January 1, 2012): 72–83.

[11] Milton Friedman, "The Need for Futures Markets in Currencies," *CATO Journal* 31, no. 3 (Fall 2011): 638.

[12] Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," *The Journal of Political Economy* 81, no. 3 (1973): 637–54. I will discuss the Black-Scholes formula in more detail in chapter four.

[13] Donald MacKenzie, *An Engine, Not a Camera: How Financial Models Shape Markets* (Cambridge: The MIT Press, 2008).

software, in that it consists of the extraction of value based on the encoding and processing of mathematical information."[14]

As a matter of fact, with the advent of computational modes of evaluation, management, and planning, the axiom of economic calculation has been profoundly challenged. Customarily, economic calculation asserts that anything that pertains to the realm of monetary exchange – and that therefore can be valued in money – becomes an object of study for economics. Yet today it has become increasingly difficult to separate what belongs to the realm of economic calculation and what doesn't. Arguably, with the digitalization of money, the architecture of planetary computation has increasingly come to mirror the "axiomatic of abstract quantities in the form of money" that constitutes capitalism, as Deleuze and Guattari put it in the Anti-Oedipus.[15] For Deleuze and Guattari, this axiomatic of abstract quantities indicates the concrete abstraction of value from the material relations of production calculated differentially. This new conjunction "defines the immanent social field particular to capitalism, and confers on the abstraction as such its effectively concrete value, its tendency to concretization."[16] From this perspective, one could see how the tendency toward the concretization of value has progressed with the development of the digital, which already incorporates these differential relations in terms of electric impulses.

Today the digitalization of monetary flows raises a series of important questions on the intersection between economic calculation, algorithmic computation, and social exchange. As Celia Lury, Luciana Parisi and Tiziana Terranova argue, ubiquitous digital computation has turned culture into a series of surfaces that behave topologically. According to the authors:

> This 'becoming topological' [of culture] can be identified in the significance of a new order of spatio-temporal continuity for forms of

[14] Alexander R. Galloway, "The Poverty of Philosophy: Realism and Post-Fordism," *Critical Inquiry* 39, no. 2 (January 1, 2013): 358.
[15] Gilles Deleuze and Félix Guattari, *Anti-Oedipus* (Minneapolis: University of Minnesota Press, 1983), 139.
[16] Ibid., 227. Concretization is a term borrowed by Gilbert Simondon to indicate the process by which technical objects develop analogically to living beings by becoming specialized (that is, individualized) and acquiring an internal resonance according to its own finality. I will discuss Simondon's philosophy in more depth in the following chapter. Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 20–24.

> economic, political and cultural life today. … In this multiplication of relations, topological change is established as being constant, normal and immanent, rather than being an exceptional form, which is externally produced; that is, forms of economic, political and cultural life are identified and made legible in terms of their capacities for continuous change.[17]

This process further impacts how control operates, precisely through the programming of "the becoming of continuity itself,"[18] which Parisi calls postcybernetic control. From this standpoint, contemporary money becomes an interface of topological mediation that cuts across the economic, social, and political sphere – always in flux – and which introduces new continuities among these realms. In this optic, the subsumption of the social under the universal *numéraire* of digital computation seems inevitable. This is because both financial transactions and social relations are expressed in data and algorithms that capitalize on every bit of information available, thereby seemingly leaving no room for resistance or political counteraction. Indeed, "the coils of a serpent are even more complex than the burrows of a molehill."[19]

For financial institutions 'digital money' is a pressing concern. For instance, for the past three years, financial corporation Citi Group has held a Digital Money Symposium aimed to "deliver on the promise of digital money" and "open the digital frontier to commerce." In its 2015 report, Citi Group speculates that the process of digitalization of the flows of transactions will "eventually [lead] to a more integrated and personalized experience, where digital money is seamlessly integrated into our lives — what we call the Experience Economy."[20] This is evident in contemporary payment systems. Revisiting Félix Guattari's example of a bankcard payment, Gary Genosko notes that the "part [sometimes particle]-signs"[21] of a credit card's magstripe are "perfectly

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[17] Celia Lury, Luciana Parisi, and Tiziana Terranova, "Introduction: The Becoming Topological of Culture," *Theory, Culture & Society* 29, no. 4/5 (2012): 3.
[18] Luciana Parisi, *Contagious Architecture: Computation, Aesthetics, and Space* (Cambridge: The MIT Press, 2013), 79.
[19] Deleuze, "Postscript on the Societies of Control," 7.
[20] Sandeep Davé, Ashwin Shirvaikar, and Greg Baxter, "Digital Money: A Pathway to an Experience Economy" (London: Citi, January 2015), 3, http://www.citibank.com/icg/sa/digital_symposium/digital_money_index/pdf/Digital%20money%20A%20pathway%20to%20an%20Experience%20Economy.pdf.
[21] Gary Genosko, "A-Signifying Semiotics," *The Public Journal of Semiotics* II, no. 1 (January 2008): 15.

adapted to the quasi-automated networks of contemporary infocapitalism."[22] This is because the "diagrammatic modulations"[23] of these part-signs operationalize power through the automation of the flows of data and other signals required for card payments. This has also profoundly impacted processes of collective individuation and subjectivation, turning subjects into "dividuals."[24] Since Genosko's example, means of automated payments have become increasingly personal, attached to the body, and immediate. Not only can one pay through her phone or smart watch without the need to produce a card, today the process of personalization and interiorization of payment systems is epitomized by the possibility of having a radio-frequency identification (RFID) chip directly implanted in one's own hands.[25]

Yet is "capitalist realism" all there is?[26] According to Deleuze, the shift to the societies of control was, at least partially, due to technological changes; however, that was not because "machines are determining, but because they express those social forms capable of generating them and using them"[27] – a theme that recurs throughout his two volumes of *Capitalism and Schizophrenia* with Félix Guattari. In contrast to Deleuze's observation, this thesis argues that we should take more seriously the 'modes of existence' of the digital – as object, relation, and platform – not only for an understanding of the present political-economic juncture, but also for a reorganization of socio-cultural formations. Before delving into that, however, it is necessary to effectuate a brief detour into the relation between money and the digital, in order to be able to furnish a definition of money that goes beyond the naturalized form that it has

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[22] Ibid., 11.
[23] Ibid., 17. Genosko further explains that for Guattari "diagrammatic part-signs are dynamic and productive (capable of multiple articulations) but rigorously constrained – meaning is not essential in this activity but specific codes, algorithms, materials and standards are." Ibid., 18.
[24] As Genosko explains "a dividual is an informatic diagram pointing at the virtual but dropping a line to an offline individual who is merely one of its actualizations because nobody totally corresponds to their data double or silhouette." In other words, a dividual is an informatic profile – an assemblage of disparate data and other part-signs gathered from different online sources that find only a partial correspondence with the 'offline' counterpart they are supposed to stand for. Ibid., 17.
[25] Hannah Francis, "Chip Implants beneath the Skin Bring a New Meaning to 'Pay Wave,'" *The Sydney Morning Herald*, May 30, 2015, http://www.smh.com.au/digital-life/digital-life-news/chip-implants-beneath-the-skin-bring-a-new-meaning-to-pay-wave-20150528-ghbq71.html; Mal Fletcher, "Chips Under the Skin - 'Convenient' But Not Wise," *2020Plus*, May 26, 2015, http://2020plus.net/Editorial-362-Mal-Fletcher-Chips-Under-The-Skin-Convenient-But-Not-Wise.aspx.
[26] Mark Fischer defines capitalist realism as "a pervasive *atmosphere*, conditioning not only the production of culture but also the regulation of work and education, and acting as a kind of invisible barrier constraining thought and action." Mark Fisher, *Capitalist Realism: Is There No Alternative?* (Winchester: Zero Books, 2009), 16 (emphasis in original).
[27] Deleuze, "Postscript on the Societies of Control," 6.

acquired in the contemporary media ecology. In the following section I provide a review of scholarly literature that contributes to an understanding of the relation between money and the contemporary technological apparatus. Subsequently, I present the novelty of Bitcoin that, by proposing a radically new monetary-financial infrastructure, has profoundly shaken the foundations of the modern economy. In doing so, my goal here is to introduce the themes that will be explored in this thesis and provide some preliminary justifications for the necessity of an investigation of contemporary money and its relation to the digital networked infrastructure that, as Deleuze observed, has allowed for profound changes in the nature of power.

0.2 The Digitality of Money

Starting with Aristotle's problem of commensurability,[28] the role and functions of money – in its social, political, and symbolic character – have exerted a fascination on philosophers and critical thinkers up to this day, to the point that it would be unfeasible to provide an extensive outline of all the literature in the field. As Pierre Vilar notes, money raises important historical and philosophical problems, yet any attempt to historicize it has stirred more confusion than clarifications.[29] As is well known, in much of human history, money has played a crucial, if sometimes implicit, role as the driving force behind wars, conquest, social conflicts, and geographical explorations.[30] In the romanticized history of human civilizations, money has often been an 'absent presence' – the unspoken and unseen element without which, however, the evolution of civilizations would not have happened, at least not in the same way. Incarnated in different materials and forms – from shell to gold to paper to plastic to algorithms[31] –

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[28] See: Philip Mirowski, *More Heat than Light: Economics as Social Physics, Physics as Nature's Economics* (Cambridge: Cambridge University Press, 1991); Spencer J. Pack, *Aristotle, Adam Smith and Karl Marx: On Some Fundamental Issues in 21st Century Political Economy* (Cheltenham: Edward Elgar Publishing, 2010), 11–14. The problem of commensurability is at the core of market exchange; it involves setting a principle that allows non-comparable goods to be traded in a fair manner.
[29] Pierre Vilar, *A History of Gold and Money: 1450-1920*, trans. Judith White (London: Verso, 2011), 7.
[30] As Randy Martin has demonstrated, the relation between war and finance still lies at the foundation of contemporary risk management, whose principles constitute the defining elements of both derivatives markets and American imperialism. Randy Martin, *An Empire of Indifference: American War and the Financial Logic of Risk Management* (Durham: Duke University Press, 2007).
[31] Nick Szabo, "Shelling Out - The Origins of Money," 2002, http://szabo.best.vwh.net/shell.html. Szabo provides a compelling account of the origins of money according to game theoretical evolutionary models. His argument is that money and its precursors (e.g. collectible items, such as beads made of eggshells and seashells) allowed "early modern humans to solve problems of cooperation that other animals cannot – including problems of reciprocal altruism, kin altruism, and the mitigation of aggression." Ibid.

money has operated under different guises. As Vilar observed in the 1970s, "money has never been less substantial, more nominal, and more built on paper promises. (Whose promises we may ask?)"[32] Since the 1970s, as I described above, money has progressively dematerialized, in parallel to the development and diffusion of digital networked technology. Fast-forward forty years, and the GFC has exacerbated the nominal and insubstantial character of money. Money appears and disappears. However, if money is increasingly disappearing,[33] capital is everywhere, more fleeting and evanescent than it has ever been – especially in financial markets.

While a history of money is an arduous and perhaps impossible task to accomplish, as Vilar notes, the same could be said of the philosophical and economic attempts to theorize money. Ole Bjerg observes that the history of modernity is marked by several, and at times contradictory, theories of money. In *Making Money* Bjerg traces a genealogy of the main theories of money – from commodity, to fiat, to credit, to post-credit money.[34] However, as Bjerg notes, the question is not so much which theory of money is the correct one, as *how* a certain understanding of money comes into being. The point this thesis aims to make is that such theories of money are the output of a certain a priori view of the world that, as I will begin to explain in chapter two, is related to advances in the physical sciences and corresponding technical paradigms.

From a semiotic perspective, Brian Rotman traces the parallel developments between art, money, and techno-science through an analysis of the origins and development of zero as both sign and meta-sign.[35] Rotman argues that the introduction of zero into the Western system of knowledge profoundly impacted not only arithmetic in the tenth century, but it also greatly influenced the arts (especially during the Renaissance, with the introduction of perspectival space) and was instrumental to the passage from feudalism to mercantile capitalism. Rotman also explains that, with the end of the Bretton Woods agreement and the rise of the 'eurodollar,' money underwent a profound transformation that resulted in the emergence of xenomoney. "Being floating and inconvertible, [xenomoney] is forced as a sign to create its own significance: one which

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32 Vilar, *A History of Gold and Money*, 15.
33 In May 2015 the UK Payment Council reported that 52 percent of the overall transactions effectuated in 2014 were digital. Kevin Peachey, "Cashless Payments Overtake the Use of Notes and Coins," *BBC News*, May 21, 2015, http://www.bbc.com/news/business-32778196.
34 Ole Bjerg, *Making Money: The Philosophy of Crisis Capitalism* (London: Verso, 2014).
35 Brian Rotman, *Signifying Nothing: The Semiotics of Zero* (Stanford: Stanford University Press, 1993).

is written in the only terms available to it, namely future states of itself."[36] In other words, xenomoney erased any anteriority of things to signs. In a similar vein, according to Franco Bifo Berardi "money and language have something in common: they are nothing and they move everything."[37] Both Rotman and Berardi concern themselves with the semiotic and symbolic dimensions of the written language. This thesis proposes instead that money is more than a sign but also, as will be clear later on, less (and at the same time, *more*) than finite object: it is a technology. As Rotman himself suggests, today zero finds its most pervasive realization in the binary formalism of Boolean algebra, which allows electronic circuits to transmit information. From this standpoint, zero and one become the expression of falsity and truth in computational logic.[38] Departing from Rotman's linguistic framework, however, it is important to note that the zeros and ones of Boolean logic are signs that perform what they say.

Indeed, as Marshall McLuhan puts it, "'Money talks' because money is a metaphor, a transfer, and a bridge."[39] As McLuhan continues:

> Money, however, is also a specialist technology … It gives great spatial extension and control to political organizations, just as writing does, or the calendar. It is action at a distance, both in space and in time. In a highly literate, fragmented society, 'Time is money,' and money is the store of other people's time and effort.[40]

Therefore, my standpoint in this thesis is that money is first and foremost a social machine. Georg Simmel defines money as "a pure means and tool in relation to a given end."[41] Similarly, Lewis Mumford argues that money, as a medium of power, is the institutional prerequisite of the modern megamachine.[42] In addition to this, it is worth noting that the etymology of the word 'money' derives from the Latin 'moneta,' one of

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36 Ibid., 95.
37 Franco "Bifo" Berardi, *The Uprising: On Poetry and Finance* (Los Angeles: Semiotext, 2012), 134.
38 Rotman, *Signifying Nothing*, 107.
39 Marshall McLuhan, *Understanding Media: The Extensions of Man*, Reprint edition (Cambridge: The MIT Press, 1994), 136.
40 Ibid.
41 Georg Simmel, *The Philosophy of Money*, ed. David Frisby, trans. Tom Bottomore and David Frisby (New York: Routledge, 2004), 211.
42 Lewis Mumford, *Pentagon of Power: The Myth of the Machine, Vol. II* (New York: Harcourt, Brace Jovanovich, 1974), 241.

the names of the goddess Juno, near whose temple money was coined. It is argued that 'moneta' shares an etymological root with 'monitor' – which means 'to warn, to advise, to be mindful of' – and 'mind.'[43] Thinking about money in these terms foregrounds the "mnemo-technical" origins of money, using Bernard Stiegler's vocabulary,[44] to indicate the function of money as an external support for the memory of an exchange; or, as McLuhan puts it in the above quote, for the storage of other people's time and effort. This reformulation provides the means to grasp money as an interface between creditors, debtors, and commodities, and to distance it from the contemporary notion of financial utility, thereby also opening up realms of possibilities for its redesign.

From a historical perspective, there seems to be a relation of mutual presupposition between the concept of the digital and money in its current form – that is, fiat money. Paolo Totaro and Domenico Ninno trace the intertwining of algorithmic logic with the invention of modern money back to the invention of calculus.[45] As they explain, modern money derives from the application of the concept of mathematical function in the theoretical sciences to the practical sphere; thus it provides an exemplary case of the mediatory role of algorithmic logic between the empirical world and theory. Expanding on Totaro and Ninno's argument, paper money could be considered one of the most ancient algorithmic media. This, according to the authors, has contributed to a certain gnoseological formation according to which the recursive function has shaped the socius by constituting "the premise to a conception of value as a quantitative *continuum*," which can be computed and accumulated.[46] Yet Totaro and Ninno's valuable insights cannot explain the contemporary logic and extension of financial power – a power that stems from automated processes that operate below and beyond the threshold of human perception and yet are nevertheless real, as is exemplified by flash crashes and the unfolding of liquidity crises.

Similarly, in the recently translated *Medium, Messenger, Transmission,* Sybille Krämer offers a fascinating account of money from a media perspective, as a channel for the

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[43] "Money," *Online Etymology Dictionary*, accessed February 28, 2015, http://www.etymonline.com/index.php?term=money.
[44] Bernard Stiegler, "Anamnesis and Hypomnesis: The Memories of Desire," in *Technicity*, ed. Arthur Bradley and Louis Armand (Prague: Litteraria Pragensia, 2006), 15–41.
[45] Paolo Totaro and Domenico Ninno, "The Concept of Algorithm as an Interpretative Key of Modern Rationality," *Theory, Culture & Society* 31, no. 4 (March 2014): 29–49.
[46] Ibid., 9 (emphasis in original).

transmission of goods and values through desubstantialization.[47] According to Krämer, "money is the standard that enables the similarity of the different, the homogeneity in the heterogeneous, to assume an objectifiable form. Money is, in the literal sense of the word, *unifying*, it synthesizes."[48] Further, Krämer emphasizes three aspects of money-mediated exchange: the sociality of money, its abstractness, and its structural properties. Krämer acknowledges the fact that money first and foremost binds people and not things. Further, she emphasizes the religious origins of money and its performativity as an "institutional fact."[49] Importantly, Krämer argues that money "*embodies the disembodiment of value; it desubstantializes values*. It is the objectification of an abstraction."[50] In other words, Krämer proposes that considering money as a medium may offer an important contribution to the philosophy of media, since it epitomizes the case of transmission through desubstantialization – of value, of matter, of relations. Krämer's theorization offers an entry point to discuss the materiality of the digital, the quantification of relations, the "indifference towards matters of difference"[51] and the new conception of quality that money foregrounds as "a *quantifiability that is unaffected by content*."[52] Furthermore, it provides an invaluable perspective on the implications of the character of money for some of the most prominent issues of the contemporary media ecology: the quantification of relations at the heart of digital exchange, the tendency toward abstraction and generality, the decline of the importance of content in digital communication, and the weird materiality enjoyed by the digital.

By following this trajectory, however, talking about 'digital money' would seem to be a tautology. Money, at least in its modern form, has always been digital just as the digital has always been about money: discrete desubstantialized units circulating in more or less open feedback loops that allow for the functioning of a system – or in Norbert Wiener's words, for its "control and communication."[53] As a matter of fact, the genealogy of cybernetics is intimately related to economics – for instance, John von Neumann and Oscar Morgenster's *Theory of Games and Economic Behavior* equates

[47] Sybille Krämer, *Medium, Messenger, Transmission: An Approach to Media Philosophy*, trans. Anthony Enns (Amsterdam: Amsterdam University Press, 2015), 108–16.
[48] Ibid., 109 (emphasis in original).
[49] Ibid., 111.
[50] Ibid., 113 (emphasis in original).
[51] Ibid., 111.
[52] Ibid., 116 (emphasis in original).
[53] Norbert Wiener, *Cybernetics: Or, Control and Communication in the Animal and the Machine* (Cambridge: The MIT Press, 1965).

‘numerical utility’ in games of strategy to the quantity of money.[54] In a way, the milieu in which the idea of the digital has developed was already imbued with an economic orientation. As economist and AI pioneer Herbert Simon and computer scientist Allen Newell put it: “physicists and engineers had little to do with the invention of the digital computer … the real inventor was Adam Smith,”[55] since his idea about the division between physical and mental labor at the foundation of economic principles “was translated into hardware through successive stages of development by two mathematicians, Prony and Babbage.”[56] Perhaps the two – the realm of economic exchange as a blueprint for digital systems, and vice versa – have always been related.

As a matter of fact, with the commercialization of the digital, we have witnessed an increasingly accelerated process of digitalization of commerce and hence of money, as well. While early computerized trading dates back to the mid-1970s, as mentioned above, the commercialization of cyberspace started in the late 1980s. This began with the evolution and growth of the NSFNET (which contributed to the closure of ARPANET in 1990) and subsequently, with the invention of the World Wide Web by CERN in 1991. This was initiated by the removal of the restrictions over the use of the Internet for commercial purposes by the National Science Foundation (NSF).[57] In addition to this, it is telling that the first proposal for a digital money was advanced in 1983, one year before the release of the Apple Macintosh, by David Chaum with DigiCash.[58] However, as the following section explains, there are certain specificities to the contemporary mode of existence of money that make it a worthwhile topic of investigation. My argument is that today such an investigation is crucial in order to understand, and overcome, contemporary power dynamics and their effects on collective formations and culture.

[54] See: Philip Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (Cambridge: Cambridge University Press, 2002), 127.
[55] Simon and Newell, “Heuristic Problem Solving,” 2.
[56] Ibid.
[57] Shane Greenstein, “Commercialization of the Internet: The Interaction of Public Policy and Private Choices or Why Introducing the Market Worked So Well,” in *Innovation Policy and the Economy, Volume 1*, ed. Adam B. Jaffe, Josh Lerner, and Scott Stern (Cambridge: The MIT Press, 2001), 151–86; Larry Press, “Commercialization of the Internet,” *Communications of the ACM* 37, no. 11 (1994): 17–21.
[58] Steven Levy provides a compelling and entertaining account of the intertwining of economic interests, political ideologies, cryptography, and the genesis of the Internet. Steven Levy, *Crypto: How the Code Rebels Beat the Government Saving Privacy in the Digital Age* (New York: Viking, 2002), 213–19.

0.3 The Singularity of Digital Money: Invention and Power

Although the above exposition seems to point to a common genealogy between fiat money and the digital, I think there is something to be said about the singularity of contemporary digital money and its role in the global ecosystem. As a matter of fact, the above-mentioned theories cannot explain the coming into existence, in 2009, in parallel with the unfolding of the GFC, of Bitcoin, the first truly "peer-to-peer electronic cash system," according to the definition of its still anonymous inventor(s) Satoshi Nakamoto.[59] As I will go on to explain, Bitcoin shook the foundations not only of the so-called economic discipline but also, and more importantly, of the very conception of money, markets, and networks thanks to the unprecedented logic that underlies it. For the purpose of this introduction, it is important to mention that the disruptive power of Bitcoin comes from being introduced as a form of electronic cash in antithesis to fiat currency. Specifically, the invention of Bitcoin challenged fundamental assumptions about the functional organization of the contemporary monetary and financial systems, and foregrounded the impact of the latter on the operative logic of power apparatuses. Furthermore, it opened up new possibilities for the creation of socio-economic organizations outside of the capture-all character of contemporary financial capital. The radical novelty of the Bitcoin protocol allegedly lies in the blockchain, a transparent transaction database shared by all nodes participating in the Bitcoin ecosystem – an open, anonymous, ledger that records all transactions effectuated by the network. In doing so, the Bitcoin stack offers a solution to the double-spending problem by eliminating the need to trust financial institutions and governments – something that struck a chord in the collective imaginary especially in the aftermath of the GFC.

[59] Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System" (Paper, 2008), https://bitcoin.org/bitcoin.pdf. At the beginning of 2016 Australian entrepreneur and inventor Craig Wright has been outed as the face and mind behind Bitcoin. Uncertainty remains following his refusal to provide the cryptographic proof that would confirm his being Satoshi Nakamoto. If that were the case, however, it would be a fairly ironic – and incredibly sad and telling – ending of the Nakamoto saga: the anonymous inventor of the most disruptive, peer-to-peer, stateless, and trustless e-cash system to date, being forced to reveal his identity due to financial pressures from the Australian Taxation Office and marketing maneuvers aimed at making him the product of his own blockchain enterprise. See: Andrew O'Hagan, "The Satoshi Affair," *London Review of Books*, June 30, 2016, http://www.lrb.co.uk/v38/n13/andrew-ohagan/the-satoshi-affair.

It is often argued that Bitcoin constitutes 'the future of money.'[60] This thesis proposes instead that Bitcoin highlights aspects of the current monetary form and corresponding mode of power that have been taken for granted up to its invention. In other words, Bitcoin may be better understood as the *present* of money, or more precisely, it provides the means to grasp the traces of possible futures that already inhabit the interstices of the present. This is because, since its coming into being, Bitcoin has changed the perspective on money and has recoded the past in light of its existence, which is precisely what the blockchain does by validating transactions and admitting them into its reality. For these reasons, the Bitcoin protocol can be conceptualized as an abstract machine, which "constructs a real that is yet to come, a new type of reality. Thus when it constitutes points of creation or potentiality it does not stand outside history but is instead always 'prior to' history. It is an Absolute, but one that is neither undifferentiated nor transcendent."[61]

By making a collective, automated, decision about which transactions are valid and which are not, the computers connected to the Bitcoin network create a synthetic temporality based on a radically alien conception of time (CPU time) and agency (computer power). In other words, the blockchain retroactively creates its own temporality based on the validation and recording of transactions.[62] As the blockchain progresses, it creates and reinforces its past – the more past is constructed on the blockchain, the more the transactions recorded on the blockchain become irreversible. At the same time, however, it is precisely the irreversibility of the Bitcoin ecosystem that allows for a certain reversibility in the way power operates. Bitcoin does so by responding to the black boxes of financial institutions and IT corporations with an operatory schema that is open and decentralized, based on a radically new, inverted, concept of privacy and secrecy – a "secret by transparency, as impenetrable as water, in truth incomprehensible."[63] In contrast to the black boxes of digital fiat money and financial trading, Bitcoin is a programmable money. That is to say, the spatiotemporal

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[60] Dominic Frisby, *Bitcoin: The Future of Money?* (London: Unbound, 2014); Don Tapscott and Alex Tapscott, *Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World* (New York: Portfolio, 2016).
[61] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 142.
[62] As Nick Land argues, Bitcoin constitute a new transcendental critique of ontology and reality that, interestingly, is based on a monetary invention. Nick Land, "Bitcoin and Philosophy" (The New Centre for Research & Practice, 2015).
[63] Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 290.

coordinates that compose it can be programmed through a tweaking of the software to meet the needs of interested parties. Since its inception, the Bitcoin protocol has been subjected to an enormous number of variations. At the time of this writing, there are 699 altcoins in circulation, all derived by a more or less rigorous manipulation of the Bitcoin open-source code – and the number keeps increasing.[64]

Therefore, this thesis starts by looking at money from the point of view of Bitcoin, and how its sheer existence can help us remap, or look at, the functions and ontology of money from a different perspective. For those of us who have participated in the cryptocurrency ecosystem, Bitcoin is a reality;[65] for the majority that only read about it in news reports, academic papers, or obscure blogs, it belongs to an accelerated abstract future, always ahead and hard to grasp – quite like contemporary financial markets. Thus this thesis starts by asking: how is one to make sense of the present in light of some possible/potential futures of which we have already seen a glimpse? In particular, Bitcoin asks us to reconsider some fundamental issues related to money, markets, and the social – in other words, how politico-economic modes of power and control operate today in the global digital networked environment.

To be sure, money has always been a technology. However, the invention of Bitcoin for the first time has demystified the foundations of the financial infrastructure, thereby allowing us to look at money from a new perspective. Looking back at the process of digitalization of monetary flows from the point of view of Bitcoin may provide the means to grasp the new features that the digital has endowed money with and, in particular, the possibilities that the digital offers for money to be reengineered. It is important to clarify, however, that this is not a thesis about Bitcoin. Rather, it discusses Bitcoin as one of the possibilities opened up by the novel technological apparatus to create new circuits of value creation and distribution. Therefore, while the Bitcoin experiment may have already reached a resolution following the wave of financialization it has become subjected to, as Bitcoin core developers Mike Hearn

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64 "Crypto-Currency Market Capitalizations," *Crypto-Currency Market Capitalizations*, accessed August 18, 2016, http://coinmarketcap.com/currencies/views/all/.

65 During this research I became actively involved with the Sydney Bitcoin community, Blockchain Professional, and Women in Bitcoin, in addition to the Women Who Code Sydney chapter. I further contributed to Darkcoin (now Dash) as both a miner and an active member of the Reddit community.

argued in January 2016,[66] this thesis looks at Bitcoin as a point of departure, rather than an end point, from which to build new ecosystems of value(s). For these reasons I believe that the paradigm it has established and the forms of relation it allows for are worth investigating.

A technical paper observes that Bitcoin "works in practice but not in theory."[67] My contention is that Bitcoin does not work in theory precisely because there is no theory of digital money, of which cryptocurrency is only but one instance. As a matter of fact, there seems to be a fundamental incompatibility between the two poles at the extremities of the spectrum of digital money: on the one hand, the seamless, automated extraction of monetary value below the threshold of perception by means of algorithmic operations; on the other hand, the actual production of monetary units by way of an operationally different assemblage of algorithmic processes. In light of these premises, how can it be possible to provide a unified definition of digital money? Digital money is a very shifting concept. In the absence of a commonly accepted definition, we could say that it encompasses online deposits and transfers, stocks and securities traded on financial markets (such as, equities, credit, currencies, etc.), proper digital cash (e.g. Bitcoin) and, one may add, personal data – since, as the neoliberal saying goes, 'there is no such a thing as a free lunch.'[68] In other words, the concept of digital money indicates the dematerialization and automation of the processes of production, circulation, and reproduction of economic value. Further it is characterized by the fact that it necessarily relies on digital networked systems in order to function.

This understanding of money as a digital object challenges monolithic understandings of money and instead opens money up to experiments in design and engineering. For these reasons, my proposition is that a theorization, and a rethinking, of what digital

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[66] Mike Hearn, "The Resolution of the Bitcoin Experiment," *Medium*, January 14, 2016, https://medium.com/@octskyward/the-resolution-of-the-bitcoin-experiment-dabb30201f7#---262-344.puwe6jpse.
[67] Joseph Bonneau et al., "SoK: Research Perspectives and Challenges for Bitcoin and Cryptocurrencies," *IEEE Security and Privacy*, n.d., 1, http://www.jbonneau.com/doc/BMCNKF15-IEEESP-bitcoin.pdf.
[68] The expression 'there ain't no such thing as a free lunch' (TANSTAAFL) is used in economics to indicate the opportunity costs (i.e. the trade-offs) sustained to make a decision. Chicago School economist and neoliberal Milton Friedman used the expression for the title of his 1975 book on public policy. Milton Friedman, *There's No Such Thing as a Free Lunch* (La Salle: Open Court Publishing Company, 1977). A treatment of the political economy of big data and data brokerage is too vast to be approached in this project. The New York-based research institute Data & Society provides excellent resources on these issues.

money is and how it functions in relation to modes of organization, control, and power formations is a task more pressing than ever in the contemporary media ecology. This is because, the moment in which culture turns into a series of surfaces of continuous topological change, it becomes really hard, if not impossible, to distinguish between what belongs to the market and what pertains to the social, given the deep interconnectedness of flows of money, data, economic calculative practices, digital computational operations, and communication exchanges. In light of these premises, this project proposes that the digital radically impacted not only the operative logic of financial markets but also the ontological constitution of money and markets. These, I argue, have in turn affected the ways in which power operates and, importantly, the ways in which power is perceived – what, in the unfolding of this thesis, I will call 'the sense of power.' But how can we reconceptualize money in order to fully grasp its cultural function and to divorce it from its equivalence with neoliberal financial logic and differential accumulation? How can we 'free' money from the assumptions entrenched in our understanding of money? In other words, how can we free money from the 'sense' that the long capitalist era has endowed it with?

In order to answer these questions, this dissertation proposes to investigate the impact of the digitalization of monetary and financial flows on the contemporary political-economic sphere in order to provide a novel perspective on the relations between economic and technical forces at the present global juncture. Through an exploration of the fleeting materiality and multifaceted character of digital money, the social power of algorithmic financial logic, and the possibilities offered by the invention of the Bitcoin protocol, this research aims to challenge some of the bedrocks of the economic orthodoxy – economic and monetary value, liquidity, market rationality – in order to map the "mutation of capitalism"[69] detected by Deleuze in the *Postscript* and move beyond the overarching narrative of capitalist power as a monolithic system. In doing so, the thesis aims to foregrounds the techno-historical contingencies that have led to the contemporary power formation and argues that the ontogenetic character of algorithmic technology opens up novel possibilities for the speculative engineering of alternative networks of value creation and distribution that have the potential to reverse the current balance of power.

[69] Deleuze, "Postscript on the Societies of Control," 6.

0.4 A Techno-Cultural Approach to Digital Money

For the reasons outlined above, this thesis proposes that the problematic of digital money may be better approached following a techno-cultural perspective, rather than an economic one, precisely because 'The Economy' and much of economics are incapable of accounting for the complex set of real relations that compose and are composed by today's algorithmic environments. I therefore propose to focus on the 'ecosystemic' dimension of the contemporary political economy by starting from its elementary component: digital money. The rationale for this project is that rethinking the 'present-past' of the political economy (capitalism) in light of one of its possible 'present-futures' (Bitcoin) may help us look at the future-present differently. In order to unravel the complex issues presented by the digitalization of money and contemporary power, I want to depart from two of the tenets of Deleuze and Guattari's political-economic theory. First of all, I suggest that we question and rethink what Deleuze and Guattari consider to be an irreducible duality between payment-money and credit-money.[70] Secondly, I propose that we take more seriously the 'becoming,' or ontogenesis, of contemporary technological networks in the individuation of power formations and social organizations.

In order to do so, and change the perspective on money, I am drawing on the thought of Gilbert Simondon – a philosopher who made a change of perspective a central tenet of his work. Simondon's philosophy of individuation was central to Deleuze's philosophy. It is his thoughts on technics, however, that may enlighten some aspects of the problematic posed by the digitalization of money. In particular, in spite of Simondon's seeming lack of rigorous engagement with political-economic issues – or better, his categorical rejection of economic utilitarianism in favor of the freedom of technics – his philosophy already contains a program for the realization of a universal cybernetics,

[70] Christian Kerslake, "Marxism and Money in Deleuze and Guattari's Capitalism and Schizophrenia: On the Conflict Between the Theories of Suzanne de Brunhoff and Bernard Schmitt," *Parrhesia*, no. 22 (2015): 38–78. As Kerslake explains, Deleuze and Guattari's implicit theory of money is founded on an irreducible dualism between payment-money and financing-money, rooted in the theories of economists Suzanne de Brunhoff and Bernard Schmitt. My argument in this thesis, instead, is that, especially since the digitalization of monetary flows, there is only one kind of money that performs all of these functions at once.

which is also a 'general praxeology', that is, a general theory of forms and information, as he stated in the closing paragraphs of *Imagination et Invention*.[71]

Specifically, I believe that Simondon's philosophy may be the most apt to approach the task that this thesis sets itself – that is, to furnish an account of contemporary money in technological terms, and to understand its implications for finance, power, and collective formations. This entails providing a rigorous account of the mode of existence of the *medium* of money not only in its generic features, as I explained above, but also in its *genetic* and normative character, as instrumental to the individuation of the capitalist mode of relation between humanity and the world and also, precisely for this reason, as a key for the reengineering of the technics of exchange. As I will make clear in the following chapter, Simondon never openly discussed money as a technology. However, his treatment of technical objects, within the larger context of his theory of individuation, can enlighten important aspects of the monetary medium and its evolution in parallel with changes in the psycho-collective sphere. At the same time, Simondon also provides the means to divorce technology from political-economic power by insisting on the radical indeterminacy and autonomy of technics. As a note to the reader, I shall specify that the task of this dissertation entails an irreducible complexity. As will be made clear in the literature reviews provided in each chapter, so far scholarly attention has focused on either the relation between markets and the social,[72] or technology and the social[73] or, in certain cases, on technology and markets.[74]

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[71] Gilbert Simondon, *Imagination et Invention (1965-1966)* (Chatou: Éditions de la Transparence, 2008), 191. "The study of the mental image and of invention led us to *praxeology* 'the science of the most universal forms and the most elevated principles of action in the ensemble of living being' according to the definition given in 1880 by Alfred Espinas … Praxeology, in the researches conducted by Slusky and Bodganov (*Tectology*, Moscow, 1922) has developed in the sense of economy and organization of human activity. … But we have the right to think that after having separated the human from animals and useful action from general action, praxeology could become a general praxeology, incorporating the study of the most elementary forms of activity… In this moment, the cycle of the mental image progressing toward invention will perhaps appear as an elevated degree of the living being into consideration, same in the most primitive forms, as an autokinetic system in interaction with a milieu. The autokinetic character, which manifests in the motor initiative in the less elevated forms, translates, by the forms of a complete nervous system, in the spontaneity of the functioning that primes, before the encounter with the object, the cycle of the image and which translates in invention." Ibid. (emphasis in original).

[72] I will discuss these theories separately in chapter five: Amato and Fantacci, *The End of Finance*; Dick Bryan, *Capitalism with Derivatives: A Political Economy of Financial Derivatives, Capital and Class* (Houndmills: Palgrave Macmillan, 2006); Jonathan Nitzan and Shimshon Bichler, *Capital as Power: A Study of Order and Creorder* (London: Rutledge, 2009). In addition to these, I shall add the recent philosophies of finance formulated by Elie Ayache and Jon Roffe that I will present in chapter four: Elie Ayache, *The Blank Swan: The End of Probability* (Chichester: Wiley, 2010); Jon Roffe, *Abstract Market Theory* (Houndmills: Palgrave Macmillan, 2015).

However, I have not encountered any work that discusses these three realms together; this will be the project of this thesis. My goal in fact is to provide a common treatment of markets, technology, and the social guided by Simondon's work. In doing so, I will avail myself of several disparate theories in media and software study, economic history, finance, cultural economics, and will aim to resolve their seeming incompatibilities through Simondon's philosophy. From this standpoint, complexity is an unavoidable, albeit unintended, consequence of this approach, because the whole that derives from the common investigation of these aspects is much greater than the sum of the elements, while at the same time each element is also "always more than one."[75]

Because of the lack of English translations of Simondon's work and its complex thought, I will devote the next chapter of this thesis to an outline of his philosophy of individuation and technics in order to reframe money in techno-logical terms and to look at political-economic power as an aspect of the individuation of the system composed by the human and the world.[76] Specifically, in chapter one I will outline the tenets of Simondon's allagmatics, or theory of operations. As Simondon explains, allagmatics corresponds to a universal cybernetics – that is, a non-reductive theory of 'control and communication' – that will allow me to desubstantialize and relativize financial power precisely by focusing on the technical operations that allow it to function. Further, allagmatics could be considered a minimal techno-social theory, since it differentiates beings on the basis of the relative degree of both internal and external consistency and not according to ideal schemas that are themselves, as Simondon's philosophy suggests, individu(aliz)ations of previous relations and forces. Simondon's cosmology only accounts for modes of thought – technical, scientific, religious,

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[73] Here I refer to theories that focus on the ontology of computation and its impact on processes of individuation that I will discuss particularly in chapter three, five, and six: Yuk Hui, *On the Existence of Digital Objects* (Minneapolis: University of Minnesota Press, 2016); Parisi, *Contagious Architecture*.
[74] The work of Donald MacKenzie is emblematic in this respect: MacKenzie, *An Engine, Not a Camera*; Donald MacKenzie, "Be Grateful for Drizzle," *London Review of Books*, September 11, 2014, http://www.lrb.co.uk/v36/n17/donald-mackenzie/be-grateful-for-drizzle; Donald MacKenzie, "How to Make Money in Microseconds," *London Review of Books*, May 19, 2011, http://www.lrb.co.uk/v33/n10/donald-mackenzie/how-to-make-money-in-microseconds.
[75] As Erin Manning notes, "Every resolution of a process—every actual occasion—carries within itself the more-than of its taking-form." This will become clearer from the following chapter, with the explanation of Simondon's theory of individuation. Erin Manning, *Always More than One: Individuation's Dance* (Durham: Duke University Press, 2013), 17.
[76] In this thesis, all direct quotations of Simondon's work are translated from the French by me, unless stated otherwise in the bibliographical references. The same applies to the translations of François Laruelle's early writings. I will also avail myself of supporting secondary literature on these authors in French and Italian. As above, all the translations are mine unless specified otherwise.

political, and aesthetic – that redouble as they individualize into occasions of experience according to the changes in their milieux of reference. For these reasons, Simondon's theory is very relevant to grasp both the irreducible complexity and the singular points of the techno-social system of power that some call computational capitalism, others neoliberalism, and others again the anthropocene (or its variation, capitalocene) or simply Skynet. Thus the following chapter provides an in-depth discussion of Gilbert Simondon's philosophy, before delving into the core of the thesis.

Chapter two begins the enquiry into the development of the capitalist ecosystem through an investigation of the relations between economic paradigms and technical paradigms in science, in light of Philip Mirowski's history of economic thought and Simondon's schema of the birth of technology. This chapter illustrates how capitalist power became concretized through the amplification of the 'value' embodied by money since the introduction of paper money, which marked the invention of fiat currency, in the seventeenth century. It further discusses the Darwinian imperative of teleological 'progress' and how this is also reflected in the economic realm. Ultimately, the chapter examines the paradigmatic shift introduced by cybernetics and gestures toward the technical value of what Simondon calls "post-industrial technical objects,"[77] of which digital networked technology is the emblem.

Following on the previous chapter, chapter three investigates the modes of existence of digital money in terms of the strange materiality, or concrete abstraction, of data structures and algorithmic operations. Reflecting on the previous chapter, it foregrounds the way in which the technical value immanent to digital money hereby formulated inflects (i.e. *in*-forms) and modulates monetary value. Specifically, the chapter compares the markup languages and semantic standards used in the communication of financial exchanges with the example of a Bitcoin unit. In doing so, this chapter aims to emphasize the radical indeterminacy of digital technology in relation to its milieu, which is, as will be made clear in the unfolding of the thesis, the technical value proper to digital technology.

[77] Gilbert Simondon, "La Mentalité Technique," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 311.

Chapter four shifts register to the event of price in the taking-consistency of financial markets. Specifically, the chapter discusses liquidity – one of the foundational concepts of economic theory – in order to investigate the relation between flows and contingency in algorithmic markets. It does so through a conversation between recent theories of finance that emphasize the contingency of price and recent arguments on the ontology of computation. The chapter proposes that the contingency immanent to computation profoundly impacts the ontological structuration of algorithmic markets and the concept of rationality upon which the economic orthodoxy is postulated. As a consequence of this shift, the chapter suggests that price is not an adequate metric of value because it is instantiation of the incomputability of exchange.

While the previous three chapters are concerned with the internal axiomatic structure of digital money – in relation to the taking-consistency of capitalist power and to markets, respectively – chapter five explores the power of social ordering of contemporary algorithmic finance that, in the unfolding of this thesis, I will call 'algo-financial power.' In order to do so, the chapter investigates the application of computational technics of recursive sorting – specifically, the divide-and-conquer paradigm, and the 'greedy' approach – in the case of financial derivatives and in the recording of bank transactions. Through Simondon's allagmatic theory, it further elucidates how such technical dynamics are amplified to the social sphere. In doing so, the chapter aims to uncover the axiontology of contemporary algo-financial power – that is, the value system upon which the operations of structuration of the financial architecture are founded.

In light of the operations of algo-financial power illustrated above, chapter six approaches the problem of the unrepresentability of this mode of power through a discussion of the ways in which the novel spatiotemporalities introduced by genetic and high-frequency algorithms affect the perceptual and cognitive processes of the human. Renouncing the impossible goal of furnishing a representational mapping of power, this chapter formulates instead a techno-aesthetic theory founded on 'hapticality,' in order to advance an explanation for the ways in which the ontogenetic power of algorithmic finance is felt without being sensed. The chapter further advances some hypotheses on how to make sense of this mode of power, not by attempting to represent it but through a direct engagement with the technology. This is what, according to Simondon, can lead to a veritable invention.

Drawing on the findings of the previous chapters, chapter seven continues the exploration of the Bitcoin stack started in chapter three and explores the possibilities offered by the invention of Bitcoin to reengineer the contemporary algo-financial paradigm. The chapter argues that the true novelty of Bitcoin, as both an economic and an organizational metamodel, does not lie in the blockchain *per se.* Instead, it lies in its unique logic of value creation (mining) and circulation (through an inversion of the operations of reification and recursion) – in other words, in its technical value, which constitutes an instance of ontological design. While the chapter acknowledges that Bitcoin may have already been subsumed into the seemingly all-encompassing wave of financialization, the chapter insists that the novelty introduced by Bitcoin here to stay.

Ultimately, because algo-financial power is unrepresentable, chapter eight proposes that the best way to understand it is through its relation to the cultural sector – in particular in relation to contemporary art. Following Simondon, in this chapter I discuss art as a metastable field of forces insofar as it encapsulates the contradictions of culture. Through an exploration of art platforms that specifically engage with the materiality of the digital and of blockchain technology, the chapter suggests that the dynamics that compose the heterogeneous ensemble of contemporary art may not be too dissimilar from the logic of derivatives exposed in chapter five. Further, the chapter discusses other kinds of experimentations with the blockchain that, while not identifying themselves as art, display an 'artfulness' and aesthetic yield that have the potential to set the foundations for a technical culture. In doing so, this chapter aims to foreground the priming of algo-financial power in the techno-cultural realm but also points to the potential immanent to art to invent a new logic of perception through imagination.

The conclusion recaps the argument of the thesis and reflects on both the socio-political and the economic value of technics. In doing so, it argues for the need to account for the value of technics in economic decision-making practices. Furthermore, continuing from the exposition of chapter one and informed by a recent thermodynamic theory of evolution, the concluding remarks hint at the possibility of a novel theory of economic value based on 'dissipation,' instead of 'storage,' and suggests ways in which the technical value of the Bitcoin protocol may provide the means to realize that. Ultimately it points toward certain meta-propositions for the realization of art-based blockchains for cultural production.

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As this thesis was taking its final shape, a series of new contributions have been published that invoke the end of capitalism through technology – most notably Nick Srnicek and Alex Williams' *Inventing the Future*,[78] and Paul Mason's *Postcapitalism*.[79] While this thesis does not engage with these texts, it acknowledges that there are certainly similarities of intents and a shared sensibility to the profound changes that the new technological infrastructure has introduced in political-economic dynamics and social formations. Further, like the above authors, this project aims to engage with the universal scope of contemporary power, materially instantiated by the architecture of planetary finance. However, in contrast with their emphasis on a Marxist perspective and a certain technological determinism that transpires from these projects, this thesis insists on Simondon's claim for the autonomy and ultimately contingent character of technical objects – of which digital money is but one instance. Furthermore, it distances itself from a Marxist approach that, following Simondon, possesses a reductive understanding of both technical objects[80] and of the complexities of social reality.[81]

Thus this thesis argues that individuation provides a pathway for moving beyond the political-economic, and techno-cultural, system of power known as capitalism. However, this can only be achieved through a technical effort, one that entails an alliance between humans and machines, as Simondon puts it – what Bernard Stiegler,

[78] Nick Srnicek and Alex Williams, *Inventing the Future: Postcapitalism and a World Without Work* (Brooklyn: Verso, 2015).
[79] Paul Mason, *Postcapitalism: A Guide to Our Future* (New York: Farrar, Straus and Giroux, 2016).
[80] Simondon, *Du Mode*, 118–19.
[81] As Pascal Chabot observes, Simondon shifts the focus from labor to "technical mediation [*mediation technique*]." Pascal Chabot, *La Philosophie de Simondon* (Paris: Librairie Philosophique Vrin, 2003), 44. Furthermore, in relation to the issue of social individuation, Simondon critiques Marx's division between superstructure and infrastructure and instead affirms the existence of a multiplicity of structures of relation, of which labor, he insists, is only but one instance. Specifically, Simondon insists on the existence of the mode of transindividual relation, which cuts across social groups and brings to the encounter with a 'real collective.' Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 293–94. This is an important topic I will further explain in the unfolding of the thesis.

drawing on Simondon, and also N. Katherine Hayles, have dubbed a technogenesis.[82] Ultimately, as Hayles makes particularly clear, this project does require the acquisition of a new literacy and its commingling with previous forms of literacies – which is today lacking in formal education curricula but that is largely available in the digital milieu itself. During the research process for this thesis, I myself developed skills that have allowed me to improve my digital and computational literacy – from engaging with financial computational models, as a rehashing of my background in quantitative economics, to building my own mining rig to mine Darkcoin (a spin-off of the original Bitcoin protocol that I will briefly present in chapter seven). As Simondon observes, the individuation of knowledge proceeds in parallel with the individuation of the object of enquiry; and if the object of enquiry is technical individuation itself, the only way to explore it is through an engagement with the technology. As Simondon puts it:

> We cannot, in the habitual sense of the term, *know individuation*, we can only individuate, individuate ourselves, and individuate within ourselves; this understanding [*saisie*] is – at the margins of what is properly considered knowledge – an analogy between two operations, a certain mode of communication. The individuation of the reality that is exterior to the subject is grasped by the subject thanks to the analogical individuation of the knowledge within the subject; but it is *through the individuation of knowledge*, and not through knowledge alone, that the individuation of non-subject beings is grasped. Beings could be known by the subject's knowledge, but the individuation of beings can only be grasped by the individuation of the subject's knowledge.[83]

[82] Drawing on Leroi-Gourhan and Simondon, in *The Fault of Epimetheus* Stiegler argues for a unified theory of anthropogenesis and technogenesis, that is, of the co-individuation of humans and machines. Bernard Stiegler, *Technics and Time, 1: The Fault of Epimetheus*, trans. Richard Beardsworth and George Collins (Stanford: Stanford University Press, 1998), 45. Later, Hayles takes up this concept and shifts the focus on the effects of technics and the "'new unconscious' (or 'adaptive unconscious')" on the neural plasticity of the brain, especially in Western countries. N. Katherine Hayles, *How We Think: Digital Media and Contemporary Technogenesis* (Chicago: University of Chicago Press, 2012), 14. See also: Holger Pötzsch and N. Katherine Hayles, "FCJ-172 Posthumanism, Technogenesis, and Digital Technologies: A Conversation with Katherine N. Hayles," *The Fibreculture Journal*, no. 23 (2014), http://twentythree.fibreculturejournal.org/fcj-172-posthumanism-technogenesis-and-digital-technologies-a-conversation-with-katherine-n-hayles/.

[83] Simondon, *L'Individuation*, 36 (emphasis in original).

1. The Heterodox Political Economy of Gilbert Simondon (by way of François Laruelle)

All our hopes, that go against this time, rest on the invention of a new Form of theoretical order, and not only theoretical –
François Laruelle[1]

And it struck me, then, that there's only one commodity that is going to appreciate in value as time continues: reversibility –
Sirhan, Accelerando[2]

1.1 A Change of Perspective

As I explained in the introduction, this thesis endeavors to provide a novel perspective on the relation between economic and technological forces at the contemporary global juncture. It does so through an investigation of the digitalization of monetary and financial flows in the context of the topological turn of culture that, as I described in the opening section following Lury et al., corresponds to "a new order of spatio-temporal continuity for forms of economic, political and cultural life."[3] In the past decade, a series of global events has demonstrated the profound impact of the digitalization of economic relations not only on the political economy but also on the socio-cultural sphere – for instance: the 2007-08 US subprime mortgage crisis that led to the global financial recession and to the concomitant rise of Occupy movements all over the world; the invention of cryptocurrency in 2009, which challenged the assumptions underlying the present monetary and financial system; and the 2010 Flash Crash that emphasized the black-boxed nature of financial markets. In light of these events, an increasing number of scholars have highlighted the immanence of market logic to cultural and social life.[4] This dissertation complements these approaches by stressing the need to pair the critical study of finance with scholarship in the philosophy of

[1] François Laruelle, *Au-delà du Principe de Pouvoir* (Paris: Payot, 1978), 9.
[2] Charles Stross, *Accelerando* (New York: Ace, 2006), 300.
[3] Celia Lury, Luciana Parisi, and Tiziana Terranova, "Introduction: The Becoming Topological of Culture," *Theory, Culture & Society* 29, no. 4/5 (2012): 3.
[4] Melinda Cooper and Martin Konings provide a brilliant review of the main positions in this debate. I will review these positions in the unfolding of the thesis. Melinda Cooper and Martijn Konings, "Contingency and Foundation: Rethinking Money, Debt, and Finance after the Crisis," *South Atlantic Quarterly* 114, no. 2 (April 1, 2015): 239–50.

technology that emphasizes the value immanent to technics and technology – that is, the normative and genetic role of ubiquitous algorithmic networks in the organization of markets and socius. In order to explore these topics, in this first chapter I propose an interdisciplinary theoretical framework informed largely by Gilbert Simondon's philosophy of individuation and technics. By means of Simondon's philosophy I aim to offer a change of perspective on the relation between political-economic power, digital networked platforms, and collective formations, starting precisely from a reformulation of value in technical terms.

While Simondon's philosophy offers fruitful resources for approaching the problem of the relation between humanity and digital networked technology, the validity of his method is significantly undermined by the seeming lack of a rigorous critique of political economy and by the strong normativity at the core of his idea of technical invention. This makes it difficult to adapt Simondon's thought to the all-encompassing capture performed by contemporary power apparatuses. In order to overcome the 'wall' at which Simondon's philosophy seems to leave us,[5] I propose not to inscribe Simondon's thought in a political-economic framework, but to step into his philosophy and look at the political economy itself *as* an aspect of the individuation of the ensemble constituted by humanity and nature. Further, by retaining the primacy that Simondon attributes to technical operations as co-productive of epistemological and ontological ground, I propose that the normativity that is generally criticized in Simondon's philosophy can be productively reworked as a theory of value, precisely through his concept of technical invention.

In order to elucidate these issues, the first section of this chapter provides an introduction to Simondon's thought through secondary sources that emphasize both the strengths and the alleged limitations of Simondon's approach for an analysis of the present. Secondly, I offer a glossary of Simondonian terms in order to explain the tenets of his philosophy. Thirdly, I provide a theorization of power that I believe is implicit in Simondon's philosophy by coupling it with François Laruelle's early writings on political materialism. Further, I outline the foundations of Simondon's allagmatic theory

[5] Here I paraphrase Elie During's article, titled in French "Simondon Au Pied Du Mur," which precisely deals with the problems posed by the concept of technical invention. Elie During, "Simondon Au Pied Du Mur," *Critique*, no. 706 (2006), http://www.ciepfc.fr/spip.php?article41.

that, in the context of his larger schema of individuation, provides a speculative pragmatic methodology to investigate the operations of technics and their impact on larger domains, such as the psychic and the social. Allagmatics will allow me to approach monetary technology, markets, and networks as technical systems characterized by relative degrees of complexity. In the last section, I apply Simondon's allagmatics to a reformulation of some of the fundamental operations in software programming – reification and recursion. Attending to such operations will provide the methodological lens through which to explore the financial, social, and technical relations that constitute the contemporary political-economic ensemble. Given the novelty and originality of Simondon's thought and the lack of English translations of his work, this lengthy introduction to his philosophy is a necessary step before delving into the investigation of the impact of the digitalization of monetary and financial flows on the techno-cultural ecosystem that constitutes the core of this project. Through this reformulation of Simondon's work in political-economic terms, my goal is to test, and hopefully prove, the genericity of Simondon's universal cybernetics – a universal Turing machine for techno-cultural inquiry that doesn't shy away from issues that at first may be considered beyond its original scope. In doing so, this thesis embraces Isabel Stengers' invitation to put Simondon's concepts to work in ways that would go beyond his lifetime, since they were never tested then, and ask "how these ideas may 'function' not 'for him' but 'for us.'"[6]

1.2 Simondon 2.0: A Heterodox Political Economist?

Gilbert Simondon's philosophy has remained relatively unknown to the Anglophone academic world until recently. As Muriel Combes explains, "Simondon was greeted as a 'thinker of technics' rather than as a philosopher whose ambitions lay in an in-depth renewal of ontology."[7] Although his writings have provided inspiration to a wealth of renowned French authors since the mid-twentieth century (e.g. Gilles Deleuze, Félix Guattari, François Laruelle, Bernard Stiegler), only in the last decade has his philosophy on individuation and technics risen to international attention, thus initiating a renewed interest in his philosophy. For instance, Tiziana Terranova draws on Simondon's notion

[6] Isabelle Stengers, "Pour Une Mise a l'Aventure de La Transduction," in *Simondon*, ed. Pascal Chabot, Annales de l'Institut de Philosophie de l'Université de Bruxelles (Paris: Vrin, 2002), 137.
[7] Muriel Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, trans. Thomas LaMarre (Cambridge: The MIT Press, 2013), xxi.

of milieu to interrogate the politics of networked cultures in times of dynamic informational environments;[8] Olga Goriunova borrows Simondon's foundational concept of ontogenesis to investigate the processes of individuation across digital platforms in terms of aesthetic and vernacular practices;[9] Adrian Mackenzie repurposes Simondon's analogical method and concepts to articulate the modes of existence of software,[10] the transductive nature of the mutual influence between bodies of code and flesh,[11] and the contemporary condition of wirelessness felt in urban environments;[12] Erich Hörl discusses Simondon's universal cybernetics to propose a general ecology of media and technics;[13] Yuk Hui adopts Simondon's method to provide a novel compelling account of the existence of digital objects.[14]

Brian Massumi observes that while the constructivist models of the 1990s were still too preoccupied with language and rhetoric to fully appreciate Simondon's groundbreaking ideas, today the times are ripe for a Simondonian revival.[15] This is testified by recent global events, such as: the 2010 Flash Crash caused by algorithmic failure; the beginning of a new geological era, the Anthropocene, determined by the increased (and mostly negative) impact of human activity on Planet Earth since the automation of production; the 2013 NSA scandal as a confirmation of the lack of security and ethics in digital networked communication. These are just some of the contemporary events that reopen the question of the relation between human and technological systems or, as Massumi puts it, that raise "the issue of the immanence of the non-human to all of the vicissitudes of the human"[16] – the question at the heart of Simondon's thought. In this sense, amidst the at times sensationalistic claims for post-, trans-, non-humanism that animate the current philosophical debate, Simondon's philosophy offers fruitful resources to speculate upon the natural, technical, and cultural processes that constitute

[8] Tiziana Terranova, *Network Culture: Politics for the Information Age* (Ann Arbor: Pluto Press, 2004).
[9] Olga Goriunova, *Art Platforms and Cultural Production on the Internet* (London: Routledge, 2013).
[10] Adrian Mackenzie, *Cutting Code: Software and Sociality* (New York: Peter Lang, 2006).
[11] Adrian Mackenzie, *Transductions: Bodies and Machines at Speed* (London: Continuum, 2002).
[12] Adrian Mackenzie, *Wirelessness. Radical Empiricism in Network Cultures* (Cambridge: The MIT Press, 2010).
[13] Erich Hörl, "A Thousand Ecologies," in *The Whole Earth: California and the Disappearance of the Outside*, ed. Diedrich Diederichsen and Anselm Franke (Berlin: Sternberg Press, 2013).
[14] Yuk Hui, *On the Existence of Digital Objects* (Minneapolis: University of Minnesota Press, 2016).
[15] Brian Massumi, "'Technical Mentality' revisited: Brian Massumi on Gilbert Simondon," *Parrhesia* 7 (2009): 36–45.
[16] Ibid., 38.

the current ecosystem, thus providing the means to account for "a humanism without the human to be built on the ruins of anthropology."[17]

However, applying Simondon's perspective to economic concerns may be considered quite a challenge. In particular, one of the main critiques of Simondon's idea of technical invention is the seeming lack of a rigorous engagement with the political and economic conditions that allow for the development of a technological lineage.[18] Moreover, his central concept of transindividuation – synthesized by Muriel Combes as a relation of relations that is both internal to the individual (defining its psyche) and exterior to the individual (defining the collective)[19] – is problematic for it seems to justify the rhetoric of flow and pre-programmed interaction supported by second-order cybernetics upon which contemporary forms of control thrive.[20] For instance, referring to the domain of programming, "where certain forms of hacking and open-source may be viewed as Simondonian 'transindividual collectives'," Alberto Toscano observes that:

> Contemporary work on "cognitive capitalism" … cannot but cast some doubt on the dichotomy of work and invention as the all-purpose key to the emergence of a non-alienated technical culture. Is it really enough that the genesis and existence of the technical object not be sundered for us to speak of non-alienation, and of interactions that would communicate and actualize our preindividual "human nature"?[21]

In a similar vein, Andrea Bardin and Giovanni Menegalle critique "the position of power taken for granted in [Simondon's] pedagogical project, and a certain faith in the

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[17] Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, 50.
[18] See: During, "Simondon Au Pied Du Mur"; Chateau in Gilbert Simondon, *L'Invention Dans les Techniques: Cours et Conférences*, ed. Jean-Yves Chateau (Paris: Seuil, 2005).
[19] Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, 26.
[20] Simondon's work has lent itself to misuses and misinterpretations because of its uncritical account of economic and political forces in the individualization of digital objects to the point of seemingly justifying technocratic stances and the Silicon Valley ideology characteristic of neoliberalism's creative power. See, for example: Melanie Swan, "Digital Simondon: The Collective Individuation of Man and Machine," *Platform: Journal of Media and Communication* 6 (2015): 46–58.
[21] Alberto Toscano, "Technical Culture and the Limits of Interaction: A Note on Simondon," in *Interact or Die!*, ed. Joke Brouwer and Arjen Mulder (Rotterdam: V2 Pub./NAi Publishers, 2007), 204–5.

neutrality of political institutions with respect to social antagonism"[22] that, according to the authors, seem to justify the alliance between global capitalism and technological systems.

Yet Simondon's rigorous engagement with technics in the context of his effort to establish the contours of a new science – a mechanology[23] – provides key concepts and methods that may help unravel the socio-technical relations that constitute power formations. As Yuk Hui and Harry Halpin note, "it is true that the philosophical approaches of Simondon can become tools to analyze social relations, but one must go beyond the limit to grasp that these theories are not merely tools of analysis, and recognize that these concepts are also tools for transformation."[24] In the specific context of the relation between economy and technology, Thomas LaMarre also observes that Simondon's philosophy does offer the means to explore the "fraught and tense relation" between these realms precisely by "insisting on the 'equality' of the technical vis-à-vis the economic":

> In the context of the evolution of technical individuals, Simondon's account implies an analogy between external factors and economic concerns. Thus the overemphasis on external factors within adaptationist theories of biological development is analogous to economic determinism in the context of technical development. In effect, implicit in his analogy between the focus on external factors in sociobiological determinism (adaptationism) and in economic determinism (economism) is a prescient critique of economism as a retooling of social Darwinism in the form [of]

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[22] Andrea Bardin and Giovanni Menegalle, "Introduction to Simondon," *Radical Philosophy*, no. 189 (February 2015), https://www.radicalphilosophy.com/article/introduction-to-simondon.

[23] "In order to endow culture with the truly general character it lost, we ought to reintroduce in it an awareness of the nature of machines, of their mutual relations and their relations with the human, and of the values implied in such relations. This awareness necessitates the existence, next to psychologist and the sociologist, of the technologist or *mechanologist.*" Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 13 (emphasis in original). Simondon also discusses mechanology – "the comparative study of machines" – in an interview with Jean Le Moyne from 1968. Gilbert Simondon, "Entretien Sur La Mécanologie: Gilbert Simondon et Jean Le Moyne (1968)," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 405. Andrew Iliadis provides a survey of mechanological theories developed in the mid-twentieth century in France, discussing Jacques Lafitte, who coined the term mechanology, Raymond Ruyer, and Gilbert Simondon. Andrew Iliadis, "Mechanology: Machine Typologies and the Birth of Philosophy of Technology in France (1932-1958)," *Systema* 3, no. 1 (2015): 131–44.

[24] Yuk Hui and Harry Halpin, "Collective Individuation: The Future of the Social Web," in *Unlike Us Reader: Social Media Monopolies and Their Alternatives*, ed. Geert Lovink and Miriam Rasch (Amsterdam: Institute of Network Cultures, 2013), 111.

> economic Darwinism. While Simondon does not deny that there are times and places where economic concerns do indeed determine the direction of technical developments, he wishes to show the severe limitations of thinking technical evolution exclusively in terms of a subordination of the technical to the economic.[25]

In light of LaMarre's remarks, I believe that Simondon's philosophy is indeed the most suited to account for the ubiquitous role of digital networked technologies in the constitution of collectives – whether markets or social formations – especially in light of the contemporary intertwinement of economic and social issues, even at the level of software design.[26]

Coupled with Laruelle's conceptualization of power, that I will illustrate in the unfolding of this chapter, my proposition is that Simondon's work may lay the foundations for a novel approach to the study of the intricate relations among the elements of the heterogeneous ensemble that constitutes contemporary political-economic power (that is, markets, technics and technologies of exchange, institutions, humans and environment). This is an approach that is eminently, immanently technical, without resulting in technological determinism; that replaces a linguistic approach with a focus on concrete operations of morphogenesis of relations; that neither opposes the concept of the market to the social, nor flattens the two onto a single plane; that acknowledges the singularity of the technical vis-à-vis the human, without relinquishing the responsibility of human individuals; that may offer the foundations for a new theory of value that is collectively built on the basis of technical inventions. Thus this dissertation proposes to consider both markets and socius as immanent, heterogeneous dimensions of a nature-culture system in which no element enjoys any substantial primacy over the others – what Simondon calls "technical culture."[27]

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[25] LaMarre in Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, 102.
[26] David Easley and Jon Kleinberg's textbook, aptly called *Networks, Crowds, and Markets*, offers a thorough study of the engineering of software platforms that is both economic and social. This theme will be further developed in the following chapters to outline the role of data structures and algorithmic operations in the individuation of the system human-world. David Easley and Jon Kleinberg, *Networks, Crowds, and Markets: Reasoning About a Highly Connected World* (New York: Cambridge University Press, 2010).
[27] Simondon effectuates a distinction between culture and technical culture. Culture, according to Simondon, is "that by which the human regulates its relation to the world and to himself." Simondon, *Du Mode*, 227. The need for technical culture stems from the fact that "if culture doesn't incorporate technology, this will imply obscure zones and [technology] would not be able to provide its regulatory

It is difficult to sum up Simondon's unique theory of individuation in a few paragraphs. As Gilles Deleuze put it, Simondon's theory of individuation "entails an entire philosophy."[28] While an in-depth exposition will follow in the unfolding of this project, in the following section I outline the foundations of his complex and effervescent thought. Subsequently, I couple it with an unexpected ally – François Laruelle, whose early writings on political materialism display uncanny resonances with Simondon's own philosophy and will help unground Simondon's implicit theory of power.

1.3 A Brief Simondonian Glossary: Tenets of a Universal Cybernetics

Simondon is best known for his philosophy of technics, which postulates that technical objects evolve progressively from element to individual to network and possess an increasing level of autonomy, culminating in the establishment of a technical mentality with the introduction of post-industrial technical objects.[29] However, to fully grasp its relevance for the present project, Simondon's technical theory can only be understood within the larger framework of his philosophy of individuation. Here I will briefly sketch out the principal elements of Simondon's philosophy that will provide the groundwork for an explanation of his theory of operations. Specifically, after introducing Simondon's theory of individuation and the methodological tenets of his philosophy – the reliance on the physical paradigm and the realism of relations – I will discuss the concepts of information, signification, technics and technology, and invention. These will be key in order to outline the methodology that I will adopt to analyze the relations between technical and economic forces at the contemporary juncture.

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normativity on the coupling of the human and the world" (ibid., 227). As Jean-Hugues Barthélémy observes: "As one can see here, that which Simondon calls 'technical normativity' … is always, as such, a normativity *of culture through technics* – in other words, it is a normativity of culture thanks to 'technical culture.'" The theme of the normativity of technics will be further explored in the following chapters. Jean-Hugues Barthélémy, "Fifty Key Terms in the Works of Gilbert Simondon," in *Gilbert Simondon: Being and Technology*, ed. Arne De Boever et al., trans. Arne De Boever (Edinburgh: Edinburgh University Press, 2012), 210 (emphasis in original).

[28] Gilles Deleuze, "Review of Gilbert Simondon's L'Individu et Sa Genèse Physico-Biologique (1966)," *PLI* 12 (2001): 43.

[29] Simondon, *Du Mode*, 15; Gilbert Simondon, "La Mentalité Technique," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 295–313.

1.3.1 Individuation

The novelty of Simondon's philosophy lies in his formal approach to the problem of individuation – that is, of how things come into being, which is one of the crucial concerns of every philosophy. By doing so, Simondon's work calls for a "reformation of our understanding,"[30] as Muriel Combes aptly puts it. By replacing the notion of an ontology of being with an ontogenesis of becoming, Simondon reverses the view by which the individual has always been studied, not stopping his enquiry at the principle of individuation, which presupposes matter and form as a priori givens, but traversing it, thus "*grasp[ing] the individuated being from the viewpoint of individuation, and individuation from the viewpoint of preindividual being*, each operating at many different orders of magnitude."[31] For Simondon, individuation is the single process underlying the ontogenesis of physical, biological and technical beings, and it is the sole process that allows for the conservation of being through becoming, thus allowing for evolution.[32] Individuation presupposes the existence of a "disparation"[33] between at least two orders of magnitude or two scales of heterogeneous reality "in non-interaction between each other,"[34] in a state of metastable equilibrium.

Crucial to Simondon's formal approach to individuation are operations, as the following sections will explain. The operation of individuation resolves the incompatibility between disparate states by giving rise to both the individuated being and its milieu of individuation. Furthermore, attending to the operational dimension of individuation provides the means to formally manipulate the relational axiomatic that, as I will explain below, is both internal and external to the individual. "Affectivity and perception" both constitute the center of individuality and are the ground for "emotion

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[30] Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, 1.
[31] Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 31–32 (emphasis in original).
[32] Ibid., 25.
[33] The notion of disparation corresponds to a fundamental discontinuity between orders of magnitude in a system that provides the energetic potential for the resolution of such incompatibility through further individuation. Muriel Combes explains that disparation "designat[es] a tension, an incompatibility between two elements of a situation, which only a new individuation can resolve by giving birth to a new level of reality. Vision, for instance, is described by Simondon as the resolution of a disparation between the image perceived by the left eye and the image perceived by the right eye. These two disparate two-dimensional images call forth a three-dimensional dimension as the only way to unify them." Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, 111. See also: Simondon, *L'Individuation*, 67–77.
[34] Simondon, *L'Individuation*, 30.

and science”[35] that connect the individual to the external world, delineating its milieu. The technical operations that contribute to the relation between individual and milieu will be the main focus of this thesis. It is important to note here that in Simondon’s ontogenetic theory matter and form are not ontologically pre-constituted but instead are two dimensions that result from a unified process of individuation. Thus Simondon opposes individuation to hylomorphism – the Aristotelian mode of thought, also adopted by modern Gestalt psychology, that sees the constitution of individuals through the imposition of an active form upon a passive matter. Understanding this is fundamental in order to reconceptualize digital money and the system it contributes to creating. The argument here will be that a reformulation of the economy in terms of relations and becomings, rather than in terms of discrete exchange between commodity-beings, may offer novel insights into the transactional (and, I will argue in the following paragraphs, *transductional*) nature of exchange.

1.3.2 Physical Paradigm

Simondon’s schema of individuation is founded on the physical paradigm. Like the encounter between a supersaturated solution and a crystal seed,[36] individuation – modeled analogically upon the becoming of physical individuals – happens at the brink of a situation filled with potential; it is an event that resolves the precarious metastability that constitutes the preindividual. Physics, for Simondon, provides the “metamodel”[37] for the individuation of physical, psychic, collective, biological, and technical systems. More specifically, Simondon takes up physics as informed by quantum theory and nonlinear systems.[38] The concept of the wave-particle duality used

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[35] Ibid., 29.
[36] Ibid., 78.
[37] As I will explain in more detail in the unfolding of this thesis, the concept of metamodeling (or metamodelization) was developed by Félix Guattari. As Guattari puts it, “theoretical activity” needs to be “reorientated towards a metamodelisation capable of taking into account the diversity of modelising systems.” Félix Guattari, *Chaosmosis: An Ethico-Aesthetic Paradigm*, trans. Paul Bains and Julian Pefanis, Reprint edition (Sydney: Power Institute, 2006), 22. Luciana Parisi clarifies that metamodeling is “defined by diagrammatic rather than hierarchical relations between signs and things.” Luciana Parisi, *Contagious Architecture: Computation, Aesthetics, and Space* (Cambridge: The MIT Press, 2013), 264.
[38] Simondon’s use of thermodynamics reflects, and even precedes, recent discoveries in the field of dissipative-driven structures. Ezra Atamer brilliantly draws a comparison between Ilya Prigogine’s concept of dissipative structures and Simondon’s individuation. Following on from Prigogine’s research, Jeremy England’s recent theory of evolution also resonates with Simondon’s approach. See: Esra Atamer, “Dissipative Individuation,” *Parrhesia* 12 (2011): 57–70. Jeremy England, “Dissipative Adaptation in Driven Self-Assembly,” *Nature Nanotechnology* 10 (2015): 919–23; Jeremy England, “Statistical Physics of Self-Replication,” *The Journal of Chemical Physics* 139, no. 121923 (2013).

to describe quantic entities, in particular, offers the means to conceive of the genesis of an event both in probabilistic and in non-probabilistic terms.[39] Simondon's conceptualization of the physical paradigm will be crucial for challenging some of the fundamental assumptions of the economic orthodoxy that, as Philip Mirowski demonstrates, is founded on a misunderstanding of the concept of energy in physics, as the following chapter will illustrate. Furthermore, as will be made clear in the unfolding of this project, Simondon's physical paradigm may offer a metamodel for a novel ecosystemic theory of value.

1.3.3 Realism of Relations

Simondon's ontogenetic theory relies on the postulate of the 'realism of relations' that provides the core of his genetic theory. As Jean-Hugues Barthélémy explains, "the *realism* of relations consists in *desubstantializing the individual without, however, derealizing it.*"[40] In Simondon's theory, relations precede the terms that constitute the individual; yet, Simondon states, the individual is "itself a node of informative communication … entailing *in itself* the mediation between two orders of magnitude."[41] In other words, the individual *is* a relation. The realism with which Simondon endows relations will allow me to explain the taking-consistency of contemporary markets and organizations through the algorithmic operations that constitute them – in other words, this methodology corresponds to an 'operational realism.' The physical paradigm and the realism of relations, as postulates of Simondon's philosophy, will be central to the outline of his theory of operations.

Because matter and form are not ontologically constitutive, but a dimension of individuation, everything departs from an undifferentiated being, defined as a "primitive magical unity"[42] or *apeiron*, in which there is no distinction between subject and object, human and nature. Being subsequently individuates under different guises – crystals, animals, humans, thought, technology, knowledge, and even relations.[43] For Simondon,

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[39] As Barthélémy states in regard to this issue: "This is the epistemological heart of his work, the insight with which it is shot through, which yields a programme rather than a complete theory." Barthélémy, "Fifty Key Terms in the Works of Gilbert Simondon," 215.
[40] Ibid., 225 (emphasis in original).
[41] Simondon, *L'Individuation*, 28 (emphasis in original).
[42] Simondon, *Du Mode*, 162.
[43] Simondon, *L'Individuation*, 26.

"true knowledge is … not a relation between a substance object and a substance subject, but a *relation between two relations* in which one is in the domain of the object and the other in the domain of the subject."[44] Thus the realism of relations is at the core of Simondon's epistemology. This is also important in order to clarify Simondon's conception of politics. For Simondon politics is a mode of individuation of thought that departs from the aforementioned *apeiron* in accordance with a system of signification that affects, via its milieu, the process of individuation of other beings; it is a specific mode of relationality between the human and the world. As Alberto Toscano explains, Simondon's formal method "sets aside the idea of a political disposition, of an originary sharing out of politics, in favour of a study of the conditioned contingency of political invention"[45] that results from the process of individuation across disparate fields. Such an individuation, and individualization, of the system of power relations that is known as capitalism is the central concern of this thesis. Before delving into that, however, it is worth clarifying some of the core concepts of Simondon's philosophy that are operationalized by physics and the realism of relations, and that underlie Simondon's theory of operations.

1.3.4 Information

In Simondon's philosophy "information is the formula of individuation, a formula which couldn't pre-exist individuation."[46] Before being a technical concern, information is what allows for the perceptual engagement with an ensemble via the structuration of an axiomatic of signification. Both the concepts of information and axiomatic of signification, which I will discuss below, are central to an understanding of Simondon's philosophy and will be key to an analysis of the taking-consistency of the present power configuration through technology. Although they are distinct concepts, they cannot be explained apart from one another, as will be made clear in the following section. With its reliance on probabilistic models, Simondon argues, the mathematical theory of information had divorced information from signification thereby reducing the concept of information to a merely statistical concern. Without aiming to disprove the scientific

[44] Ibid., 83 (emphasis in original).
[45] Alberto Toscano, "The Disparate: Ontology and Politics in Simondon" (Society for European Philosophy/Forum for European Philosophy, University of Sussex, 2007), 4, http://www.after1968.org/app/webroot/uploads/Toscano_Ontology_Politics_Simondon.pdf.
[46] Simondon, *L'Individuation*, 31.

theory of information, and instead enriching it through quantum physics, Simondon claims that his concept of information as the dynamic operation of taking-form involves what is to be considered a "primary information"[47] which pre-exists and makes possible the communication between the sender and the receiver. As mentioned above, Simondon opposes the unified process of information to the Aristotelian hylomorphic schema. While hylomorphism takes the separation of form and matter as pre-requisite for interaction, for Simondon information is an interactive process that itself produces form and matter. In his philosophy, "notions of substance, form, and matter are substituted with the more fundamental notions of primary information [*information première*], internal resonance, metastability, energetic potential, orders of magnitude."[48] Further, Simondon argues that through the analogical principle one could apply the concept of information in order to explain the individuation of psycho-collective reality – an issue to which I will return in the following sections. Simondon's concept of information will be crucial throughout this work, as it provides the means to overcome the limitations of the cybernetic theory of information. Furthermore, this formulation also underlies Simondon's allagmatic theory that provides the methodological lens for this project, to which I will turn in the following sections.

1.3.5 Axiomatic of Signification

The notions of signification and axiomatic, together with information, provide the means to grasp the reformative importance of Simondon's philosophy. As discussed above, Simondon proposes an expanded concept of information as a unified theory of individuation. This is at once an ontogenetic principle and an epistemology, which directly corresponds to the operations of the becoming of knowledge that, as explained above, is a 'real relation' between relations. In Simondon's theoretical framework, signification is a "criterion of individuation," as David Scott remarks.[49] In a rather abstract manner, Simondon describes signification as the event of the discovery of an axiomatic that allows for the "initial resolution … of the tensions that result from the confrontation of the *primitive tropistic or taxonomic unities.*"[50] As Simondon explains,

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[47] Ibid.
[48] Ibid., 32.
[49] David Scott, *Gilbert Simondon's Psychic and Collective Individuation: A Critical Introduction and Guide* (Edinburgh: Edinburgh University Press, 2014), 94.
[50] Simondon, *L'Individuation*, 30 (emphasis in original).

this axiomatic, which appears from within the very process of individuation, gives a direction [*sens*] to the collective, physical, psychic individuation of being in relation to its milieu. It is both internal and external to the individual: internally, it connects the individuated being to the preindividual reality, by structuring affectivity and emotivity; externally, it connects taxonomic units to the environment, thereby structuring perception.[51] As Simondon further argues, the axiomatic of signification is always incomplete because "the system world-subject is an overdetermined, or supersaturated field."[52] This is due to the margin of indeterminacy that stems from the metastability of an individuating system within the preindividual dimension of being: "it may be that ontogenesis is not axiomatizable, which would explain the existence of philosophical thought as perpetually marginal in relation to all other studies."[53] Thus, an act of perception resolves, albeit partially, the incompatibility between orders of magnitudes while at the same time it allows for novel couplings between the subject and the world. The signification that emerges via the process of communication between different orders of reality "is a relation of beings, not a pure expression … [it] is relational, collective, transindividual, and cannot be provided by the encounter of expression and subject."[54] Thus signification need not be conflated with language. Rather, it must be understood as the morphogenetic process that constitutes "the very dimensionality of being."[55]

Importantly, according to Simondon, signification is first and foremost a process that occurs in physical individuation. The natural world therefore underlies technical form-taking by providing a specific configuration of "matter, form and energy, singularity."[56] For Simondon, "technical form-taking uses natural form-taking anterior to itself, that could be termed a haecceity of raw materials,"[57] thereby overcoming the hylomorphic distinction between form and matter. Signification does not therefore only relate to

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51 Ibid.
52 Ibid., 240.
53 Ibid., 228.
54 Ibid., 298.
55 Ibid., 227.
56 Ibid., 52.
57 Simondon, *L'Individuation*, 52. Haecceity defines the 'thingness' of an individual. Deleuze and Guattari further take up the notion of haecceity to describe the cartography of becoming according to intensities and degrees: "between substantial forms and determined subjects, *between the two,* there is not only a whole operation of demonic local transports but a natural play of haecceities, degrees, intensities, events, and accidents that compose individuations totally different from those of the well-formed subjects that receive them." Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 253 (emphasis in original).

perceptual and cognitive individuation; it also underlies any process of individuation: "one can say that there is information from [*à partir de*] signification, but not signification from information."[58] Thus, signification is more than a mere epistemology. It doesn't simply concern knowledge but encompasses the very foundations upon which knowledge emerges – that is, sense perceptions, direction, and emotion. Signification is involved in the constitution of the system of resonance both internal and external to the individual for the organization of a system. This is why Simondon claims that there is no information without signification. More specifically, one should say that there is no *new* information – new ontogenesis – without a previously constituted, yet incomplete, axiomatic of signification. The fact that such an axiomatic is always incomplete allows for further information – hence individuation – through the insertion of novel 'haecceities,' or singularities.

This clarification will allow me to move beyond phenomenological accounts of sense perception and instead discuss sense both in terms of the orientation of a system (that is, the haecceities and tropistic units that characterize a system) and of a perceptual apparatus. Simondon's concept of signification as the *foundation* of perception and cognition, rather than as the 'meaning' that arises from perceptive and cognitive processes, will be key to a reformulation of the operational logic of contemporary power. Furthermore, it will provide the means to explain how power is felt without being explicitly sensed, as would be assumed in a phenomenological account. Coupled with Laruelle's conceptualization of power, this understanding of signification will be fundamental in grasping how power orients perception and cognition via the structuration of the axiomatic through which the individuation of a system unfolds.

1.3.6 Technicity, Technics, and Technology

The technical mode of being, which is immanently relational, is central to the individuation of complex systems. This is manifested according to different stages of concretization, beginning with the "real-material-but-incorporeal"[59] dimension of relationality. Specifically, below I discuss three instantiations of the technical mode of

[58] Ibid., 298.
[59] Brian Massumi, *Parables for the Virtual: Movement, Affect, Sensation* (Durham: Duke University Press, 2002), 5.

being: technicity, which is the more abstract, yet real, mode of relationality between human and the world and, as I will explain below, is characterized by specific features; technics, that instead refers to more concrete and 'corporeal' technical gestures; and technology – that is, the taking-consistency of technics into objects in relation to specific scientific paradigms that define the 'mode of existence of technical objects.'

Simondon devotes the third part of his doctoral thesis, published under the title of *Du Mode d'Existence of Objects Techniques*, to an exploration of the genesis and evolution of technical objects and their relations to human beings. However, before being able to understand technics and technical objects, it is necessary to define the concept of 'technicity.' Simondon only defines technicity in the third part of *Du Mode;* yet it is technicity that underlies the manifestation of technics and the concretization of technical objects. "Technicity … may be conceived as occurring in a structuration that resolves temporarily the problems posed by the primitive and original phase of the relation of the human to the world [*rapport de l'homme au monde*]."[60] In other words, technicity corresponds to one of the most primeval modes of relationality between human beings and the world – the other being, "religiosity."[61] While technicity, or technical thought, aims to "represent the point of view of the element,"[62] religiosity "universalizes the function of totality."[63] These two modes of mediation provide the means for the genesis of objective and subjective realities, respectively, and cannot be considered apart from each other. At the "neutral point"[64] between these two modes of relation, "aesthetic thought" emerges, which I will discuss in the last chapter of the thesis. Both technicity and religiosity further redouble in a theoretical and a practical mode – the "distance between the two theoretical modes gives birth to scientific knowledge,"[65] while the distance between the two practical modes of technicity and religiosity provides the conditions for the emergence of ethical thought.

As Simondon explains, technicity manifests itself in the practical use of tools. However, it doesn't exhaust itself in the object. On the contrary, "the inherence of technicity to

60 Simondon, *Du Mode*, 156.
61 "Technicity and religiosity … stem from the redoubling of the magic primitive complex, [that is the] reticulation of the original human milieu, in figure and ground." Ibid., 173.
62 Ibid., 174.
63 Ibid., 172.
64 Ibid., 160.
65 Ibid.

technical objects is temporary; it doesn't constitute but a moment of genetic becoming."[66] In other words, technicity "is a partial and transitory reality, both a result and a principle of genesis."[67] It is technicity that provides technical objects with a genetic and evolutionary power to affect the ensemble constituted by the relations between humans and the world. Simondon maintains that "one must start from individuation, with being grasped at its center according to spatiality and becoming";[68] similarly, the individuation of the system human-world can only be studied via an analysis of "the object, intermediary between the world and the subject, whose first form is that of the technical object."[69] This understanding of the mediatory role of technical objects will be crucial in order to conceptualize the role of the monetary technology in the taking-consistency of the capitalist mode of relation between human beings and the world.

In a seminar from 1970, Simondon explains that technics are an autonomous mode of being that is radically different from the human, which serves the purpose of instituting a "code of correlation that allows the system human-nature [*système homme-nature*] to work in a state of internal resonance."[70] In other words, technics refer to the gestures according to which the technicity that already inhabits the world is manifested. In Simondon's thought, 'technology' corresponds instead to the synthesis of the inductive mobilization of technics and the deductive process of the theoretical and mathematical sciences.[71] For Simondon, "technology replaces technics"[72] when these two separate means of discovery – technics and science – develop a synergy with each other. The nuances between technicity, technics, and technology will be key to providing an understanding of money as a technology, both in relation to the *technics* of exchange that presupposes it and in relation to the genetic evolutionary character of *technicity* concretized in money. Furthermore, the autonomy and "margin of indeterminacy"[73] that Simondon grants to machines as the concretization of the technicity of the world into

[66] Ibid., 157.
[67] Ibid.
[68] Simondon, *L'Individuation*, 30.
[69] Simondon, *Du Mode*, 170.
[70] Gilbert Simondon, "Naissance de La Technologie (1970)," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 176.
[71] Ibid.
[72] Ibid.
[73] Simondon, *Du Mode*, 11. Simondon explains that "it is this margin [of indeterminacy] that allows the machine to be sensible to external information." Also, "the machine that is endowed with a high technicity is the open machine." Ibid.

objects, particularly in the context of the mechanist paradigm of scientific development that I will explain in the unfolding of this project, will be crucial in divorcing economic forces from technical ones. As Simondon remarks:

> If technical objects evolve toward a small number of specific types, it is in virtue of an internal necessity and not because of economic influences or practical exigencies; it is not the assembly line [*travail à la chaîne*] that produces standardization, but it is the intrinsic standardization [of technical objects] that allows for the assembly line.[74]

However, Simondon also acknowledges that "there exists a convergence between economic constraints … and properly technical exigencies."[75] Mapping how this convergence unfolds in the contemporary ecosystem will also be one of my goals in this project.

1.3.7 Invention and Technical Value

Simondon explains that the genesis of a technical object starts with an "act of synthetic invention,"[76] which brings about a new technical essence.[77] As will be clear, Simondon identifies at least two paradigms of technological development – that is, two principles of 'technical essence': the Cartesian mechanist schema and the cybernetic schema.[78] As Simondon explains, the concretization (that is, the individualization)[79] of a new technical object consists in "the physical translation of an intellectual system."[80] The

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[74] Ibid., 23–24.
[75] Ibid., 26.
[76] Ibid., 43.
[77] Simondon defines technical essence as that which "remains stable through the evolutionary line, and not only stable, but also productive of structures and functions according to internal development and progressive saturation." In other words, a technical essence corresponds to a regime of functioning proper to a specific class of technical objects. To clarify this, Simondon gives the example of the technical essence of an internal combustion engine, which, as he explains, can become the essence of the Diesel engine, "by means of a supplementary concretization of functioning." Ibid., 43–44.
[78] Simondon, "La Mentalité Technique," 297.
[79] As Yuk Hui notes, Simondon only refers to the concretization of technical objects in terms of individualization, and not individuation. While individuation "concerns the genesis and resolution of tensions to arrive at a metastable equilibrium passing by a restructuralization of relations," individualization entails an "overdetermination." This "refers to the process of imposing constraints and conditions so as to maturate the functionalities of the technical objects." However, the two are not opposed to each other but "would be better viewed as two separate orders of magnitude of being." Hui, *On the Existence of Digital Objects*, 55.
[80] Simondon, *Du Mode*, 46.

passage from the scientific cognitive schema to the schema of concretization of the machine opens up further gaps of indeterminacy that can produce novelty within the technical system. This point will be crucial to study how the concretization of financial models is manifested in the actual functioning of algorithmic markets. Furthermore, Simondon also clarifies that "the consequences of this concretization are not only human and economic (for instance in authorizing decentralization), they are also intellectual."[81] This is because technical invention is in itself "a seed of thought [*un germe de pensée*]."[82]

In a course from 1968, *L'Invention et le Développement des Techniques,* Simondon clarifies that there exist three types of invention: adaptive and relational invention, both of which allow for a mode of continuous progress, and discontinuous invention, which instead corresponds to "the discovery of an auto-correlation that renders a system viable."[83] The latter is what Simondon takes as a veritable invention, one which disrupts the previous order and establishes "a new regime of functioning."[84] Invention is purely technical and possesses a normativity "intrinsic and absolute"[85] that inserts itself within a community by instituting a new function that modifies collective values and beliefs on the basis of its own internal design, thereby modifying its associated milieu and impacting collective and psychic individuation. The normative and genetic character of technical invention corresponds to the value(s) immanent to technicity – that is, technical value. It is then up to socio-economic factors to establish whether to take up the invention and welcome it into their community.[86] However, the true, discontinuous, invention does not aim to be integrated in the pre-existing social system. Rather, it creates new ways of being together:

> There is something in the invention that goes beyond the community and institutes a transindividual relation, going from individual to individual without passing through the communitarian integration guaranteed by a collective mythology. The immediate relation between individuals defines a social existence in the proper sense, since the communitarian relation

[81] Ibid., 47.
[82] Simondon, *L'Individuation*, 342.
[83] Simondon, *L'Invention Dans les Techniques*, 103.
[84] Simondon, "La Mentalité Technique," 301.
[85] Simondon, *L'Individuation*, 341.
[86] Ibid.

> doesn't allow individuals to communicate directly with each other but constitutes a totality via whose intermediary individuals communicate indirectly, and without a precise conscience of their own individuality.[87]

The technical invention originates in the thought of an inventor-designer, yet it can only take consistency through a technical effort that opens a new channel of communication between human and nature – a transindividual technical relation. This produces an "irradiation of values"[88] that departs from the individual and "inserts itself into an *élan* of universal communication."[89] In this context, a close reading of Simondon's theory offers transindividuation as a form of radical xenocommunication,[90] a mode of communication that always already implies an alien component drawn from the preindividual dimension of being. This reformulation challenges the supposedly all-encompassing and smooth extraction of coded information operated by so-called cognitive capitalism. Instead, it provides the means to uncover gaps of resistance to programmed interaction that allow for the encounter with a 'real collective' in the form of contagious transindividual thought.

This perspective will allow me to approach the invention of cryptocurrency as the establishment of a novel regime of functioning of the financial machine, the technical value of which extends to the psychic and collective domains and has the potential to radically impact culture. In addition to this, Simondon's focus on technical effort, instead of labor, and discontinuous invention, instead of continuous progress, will provide the conceptual tools for a project concerned with the speculative engineering of novel socio-economic systems, characterized by different modes of production and circulation of the values irradiated by technics.

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[87] Ibid., 342.
[88] Ibid.
[89] Ibid., 341.
[90] McKenzie Wark uses the term 'xenocommunication' to indicate the "mediation of the alien" that subtends communication. Alexander R. Galloway, Eugene Thacker, and McKenzie Wark, *Excommunication* (Chicago: University of Chicago Press, 2014), 21. As Wark puts it, xenocommunication can take two forms: "It can be the irruption within a mundane communication of something inhuman. Or, it can take the form of an alien mode of communication itself, which nevertheless seems legible, at least to someone within the sphere of communication" (ibid., 161). Simondon's notion of the preindividual reality encompasses both modes, as I will further discuss, particularly in chapters four and six.

1.4 A Note on Power: Sense and Reversibility

To recap, individuation rests upon an analogic operation of exchange across different domains of being within the preindividual realm of existence. In living beings this creates an internal resonance "requiring permanent communication and maintaining a metastability that is the precondition of life."[91] Individuation is thus an operation of communication between at least two orders of magnitude non-compatible with each other carried out by a process of *in*-formation. Acknowledging the radical incompatibility between the technical and the economic orders, this thesis specifically takes aim at the processes involved in the taking-consistency of the current political-economic ecosystem through the resolution of such incompatibilities. In contrast with much information and communication theory, for Simondon information is a pure difference without content, structure, or meaning. Instead, it is information itself that allows content, structure, and meaning to emerge from the process of structuration of an axiomatic of signification that organizes perception and cognition in a milieu. From this standpoint, information could be defined, following Gregory Bateson, as "any difference that makes a difference."[92] Signification instead corresponds to the dynamic structuration of such differentials so as to provide the foundations for the internal and external individuation of a being. As a matter of fact, information is not quantifiable; instead, it provides the means for the discretization and quantification of objects through the taking-consistency of form and matter.[93] In this view, the 'quantity of information' is rather a question of an ontogenetic and morphogenetic power that the *process* of information carries within itself. Information and signification underlie the individuation of a complex system. However, this wouldn't be possible without the mediation of technics and technology. In this context, technical objects are intermediaries in the system constituted by the human and the world and, through their autonomous becomings, instantiate changes in value systems and modes of organization that affect not only human and economic affairs but also psycho-collective dynamics. The normative and genetic role of the technology of fiat money in the development of the capitalist mode of relation between humanity and nature, and its technical evolution from paper to digital object, will be the focus of the next two chapters of this thesis.

[91] Simondon, *L'Individuation*, 30.
[92] Gregory Bateson, *Mind and Nature* (London: Fontana Paperbacks, 1980), 242.
[93] See: Simondon, *L'Individuation*, 236–41.

Before moving to an exposition of Simondon's allagmatic theory, which will furnish the methodological basis of this thesis, I want to discuss the concept of power that I believe is implicit in Simondon's philosophy. This is because the issue of power, specifically political-economic power, is crucial to this enquiry. This dissertation aims in fact to provide an answer to the problematic posed by the persistence of the current configuration of political-economic power – what some call capitalism, others neoliberalism, others financial power – in light of the numerous evidences of the inner contradictions and incompatibilities that subtend its individuation. In other words, how is it possible that economic power, in its uneasy alliance with digital networked technologies, has been able not only to survive the profound crises – financial, cultural, and environmental, as I will explain in the following chapter – it has created but also to emerge from such crises invigorated? How can we make *sense* of the current political-economic juncture, and how can we make a *new* sense of it?

In order to provide the groundwork to answer these questions, I now couple Simondon's formal treatment of individuation with François Laruelle's early writing on political materialism. For the purpose of this project, I am mainly referring to Laruelle's book from 1978 *Au-delà du Principe de Pouvoir,* which could be considered the political complement to Simondon's project.[94] Here Laruelle outlines his political materialism, which is precisely concerned with going beyond the principle of the individuation of power. For Laruelle, traditional political theory conflates power [*pouvoir*] with forces of production that are not able to explain "the production of the process of production of power"[95] but that, on the contrary, already inhabit the "onto-theo-politics"[96] that constitute the *sense* of power. Instead Laruelle defines power in genetic terms, as "the

[94] François Laruelle was one of the thinkers to immediately recognise Simondon's genius, as some of his writings testify. Laruelle helped Simondon edit and publish the second volume of his oeuvre on individuation, *L'Individuation Psychique et Collective*. To my knowledge not many authors have put the two thinkers in conversation before. An exception is Nandita Biswas Mellamphy, who, in "Nietzsche's Political Materialism: Diagram for a Nietzschean Politics," discusses Nietzschean politics as "the operation of an elementary and fundamentally non-signifying force-mechanics" by ways of François Laruelle's political materialism cross-referenced with a Simondonian account of "forces" as "pre-individual affective 'potentialities.'" Nandita Biswas Mellamphy, "Nietzsche's Political Materialism: Diagram for a Nietzschean Politics," in *Nietzsche as Political Philosopher*, ed. Barry Stocker and Manuel Knoll (Berlin: De Gruyter, 2014), 82. See also: François Laruelle, "Le Concept d'une 'Technologie Première,'" in *Gilbert Simondon: Une Pensée de L'Individuation et de La Technique*, ebook (Paris: Albin Michel, 1994); Thierry Bardini, "Simondon, Individuation and the Life Sciences: Interview with Anne Fagot-Largeault," *Theory, Culture & Society* 31, no. 4 (July 2014): 141–61.
[95] Laruelle, *Au-delà du Principe de Pouvoir*, 35.
[96] Ibid., 15.

general process both quantitative and qualitative of the social actualization of differential intensities [*differences d'intensité*]."[97] From this standpoint the Principle of Power is defined as "the annulation or the resolution of these differences" via normalization, while the "'Beyond of Power' is what produces such differences and partially contributes to their reproduction."[98] In other words, while the Principle of Power corresponds to an individuated power, its Beyond corresponds to the individuating and genetic forces that allows for power to reproduce itself through the generation of new difference, new metastability. Laruelle's move precisely consists in approaching power from its Beyond – through what "a certain silliness, always too modest, denounces as 'speculation.'"[99]

For Laruelle there exists an immanent duplicity – a reversibility – between Power and its Beyond. This corresponds to the margin of indeterminacy immanent to each and every function, whether linguistic, discursive or, I may add, computational. The relation between Power and its Beyond is a relation of sense, which is not to be confused with its imaginary representations, or conceptual meaning. Sense is directional, vectoral and can be understood in terms of Simondon's concept of signification.[100] The sense of power, which literally *in*-forms the operations of the circulation of knowledge – the latter understood, once again, in relational terms, as a relation between relations – can only be countered by a "power [*pouvoir*] of the senses", that is the "ensemble of technologies that the West comprehends under the name of 'interpretation.'"[101] This corresponds to a "minor hermeneutics" which directly refers to the "interpretation" of the machinic (i.e. axiomatic) dimension of power.

Laruelle's full thesis is beyond the scope of this work. In this project I will interlace Laruelle's concept of the duplicity and immanent reversibility of power found within its sense, with Simondon's schema in order to make explicit the structuration of a 'sense of power' (that is, of the axiomatic of signification woven through digital networked

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[97] Ibid., 44.
[98] Ibid.
[99] Ibid., 3.
[100] The discussion of power as directionality resonates with McKenzie Wark's definition of vectoral power. Discussing the navigational technics that allowed Captain Cook to arrive to Australia in the eighteenth century, Wark explains that "in the development of the vectoral regime of power, everything depended on the development of technologies of perception." McKenzie Wark, *Telesthesia. Communication, Culture and Class* (Cambridge: Polity, 2012), 32.
[101] Laruelle, *Au-delà du Principe de Pouvoir*, 5.

technologies) vis-à-vis the 'power of the senses' (what Simondon calls invention and technical effort). As Simondon's philosophy offers us the means to move beyond the principle of individuation, so a thorough engagement with the technologies of power may allow us to go 'beyond the power principle.' Laruelle's unified duplicity between the sense of power and the power of the senses will provide the narrative around which this thesis will unfold. This will allow me to move beyond phenomenological accounts of power through the mapping of the processes that together enable the taking-consistency of the principle of contemporary power but will also offer the means to move beyond such a principle.

It is true that such a conceptualization of power is already implicit in Simondon's schema, which is indebted to cybernetics. Through the methodological postulate of the realism of relations, Simondon's philosophy allows for an understanding of Power as immediately relational and contextual.[102] Furthermore, like Laruelle's immanent duplicity of power, Simondon's allagmatic theory – that, as I will explain below, corresponds to a "universal cybernetics" [103] – provides the means to overcome the dichotomy between *pouvoir* (the power *over*) and *puissance* (the power *to*, which exists in potential)[104] by recasting the issue of power as the problematic of the control over the individuation of forms of relation – precisely following the trajectory opened by Norbert Wiener's cybernetics.[105] The term cybernetics famously comes from the Greek κυβερνήτης (*kybernetes*) – that is, 'steersman' or governor – a term associated with κυβερνητική (*kybernetike*), 'governance.' A cybernetic understanding of power entails a

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[102] Moreover, as will be clear in the thesis, Simondon's understanding of individuation in chrono-topological terms offers the means to expand the notion of context, or milieu, in a way that is able to encompass the planetary scale of the contemporary mode of power.
[103] Simondon, *L'Individuation*, 531.
[104] In the opening notes on the translation of *A Thousand Plateaus,* Brian Massumi clarifies that Deleuze and Guattari use two words for power. As Massumi explains "*puissance* pertains to the virtual (the plane of consistency), *pouvoir* to the actual (the plane of organization). The authors use *pouvoir* in a sense very close to Foucault's, as an instituted and reproducible relation of force, a selective concretization of potential." Massumi in Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, xvii (emphasis in original). In his focus on the functional organization of an ensemble, Simondon does not grant the same importance to *puissance.* On the contrary, he seems to demote it. For instance, as Pascal Chabot notes while discussing alienation in Simondon vis-à-vis Marx: "[a]lienation, for Simondon, is rooted in this intellectualism, which possesses the knowledge and the idea of power [*puissance*] while lacking any concrete power [*pouvoir*], apart from that which it appropriates from others for its own ends." Pascal Chabot, *La Philosophie de Simondon* (Paris: Librairie Philosophique Vrin, 2003), 48.
[105] Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (New York: Avon Books, 1967); Norbert Wiener, *Cybernetics: Or, Control and Communication in the Animal and the Machine* (Cambridge: The MIT Press, 1965).

notion of control and communication, as Wiener puts it,[106] but also points to a concept of navigation and orientation (the 'steering' of the ship). However, unlike Wiener's cybernetics – that can be understood as a top-down 'science of government' – the notion of power that I have outlined here through Simondon's and Laruelle's philosophies can be better conceptualized as an art of governing oneself, an emergent, open-ended process of collective individuation within and across technical systems. This is an important nuance to which I will return in chapter seven when discussing the challenges and opportunities offered by the Bitcoin protocol in terms of 'governance-by-design.'

In contrast with traditional conceptualizations of power,[107] Simondon's and Laruelle's philosophies offer a more nuanced understanding of the intricate relation between capital and technology by demystifying capitalist power as *fait accompli*. Specifically, they provide the means to understand power as the structuration of an axiomatic of desubstantialized forms of relation that contributes to the establishment of a certain orientation for the individuation of perception in a system. Following their formulations, in this thesis I understand political-economic power as a matter of individuation and of the technologies that allow for the operational and relational circulation of knowledge, in accordance with the structuring of a specific axiomatic of signification, or sense.[108] And it is ultimately a matter of how such a system of

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[106] Wiener, *Cybernetics*.
[107] I am referring here to capitalism, understood as the socio-economic system based on the private ownership of the means of production, capital accumulation, profit as ultimate goal, and market competition; and neoliberalism, that, according to some, constitute a 'new' phase in the evolution of capital relations and governance. See: Philip Mirowski, *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown* (London: Verso, 2014).
[108] As will be clear in the following section, Deleuze and Guattari's discussion of the "capitalist axiomatic" is not too different from Simondon's especially because it necessarily entails "undecidable propositions": "This is not a dispersion or a fragmentation: we are instead back at *the opposition between, on the one hand, a plane of consistency and, on the other, the plane of organization and development of capital and the bureaucratic socialist plane.* There is in each case a constructivism, a 'diagrammatism,' operating by the determination of the conditions of the problem and by transversal links between problems: it opposes both the automation of the capitalist axioms and bureaucratic programming. From this standpoint, when we talk about 'undecidable propositions,' we are not referring to the uncertainty of the results, which is necessarily a part of every system. We are referring, on the contrary, to the coexistence and inseparability of that which the system conjugates, and that which never ceases to escape it following lines of flight that are themselves connectable. The undecidable is the germ and locus par excellence of revolutionary decisions. Some people invoke the high technology of the world system of enslavement; but even, and especially, this machinic enslavement abounds in undecidable propositions and movements that, far from belonging to a domain of knowledge reserved for sworn specialists, provides so many weapons for the becoming of everybody/everything, becoming-radio, becoming-electronic, becoming-molecular. Every struggle is a function of all of these undecidable propositions and constructs *revolutionary connections* in opposition to the *conjugations of the axiomatic.*" Deleuze and

signification allows for the circulation of the value introduced by technical objects. The point of departure for my investigation of the contemporary 'sense of power' – that is, the onto-theo-politics that give a certain directionality to power – is what Brian Massumi's calls "ontopower," the creative mode of governing characteristic of neoliberal market ideology. This is a preemptive 'soft power' that operates by priming, "the royal way to the modulation of events before they fully emerge."[109] Starting from these premises, following Simondon's and Laruelle's approaches, in this thesis I will analyze the logic of the contemporary 'ontopower' according to the technical operations of algorithmic finance – what I will often refer to as 'algo-financial power.' This way, I will be able to overcome substantialist approaches to power and focus instead on the technical operations that enable the taking-consistency of a certain axiomatic of signification – or sense of power – but also provide the means to intervene in such an axiomatic formation in order to reverse the sense, or 'direction,' of power. From this standpoint, Simondon's focus on technicity and technical effort as an instance of Laruellian minor hermeneutic may provide the means for the speculative engineering of new forms of relation as a political gesture.

However, how is the axiomatic thus conceived materially produced? In the next section I outline the aspect of Simondon's philosophy that will allow me to map the individualization of the contemporary sense of power – allagmatics. Simondon's allagmatic theory will allow me to uncover how the 'sense of power' is constituted through the technologies that provide the relational infrastructure for the socio-financial machine to function. Further, it also provides the means to map the contemporary technological developments that are undermining the sense of capitalist power by awakening the 'power of the senses' through an *act* of speculative engineering.

Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 473 (emphasis in original). However, my argument is that Simondon's project, through its focus on the indeterminacy and openness of technical objects, provides the means for the development of a constructive, speculative engineering program that, I believe, is lacking in Deleuze and Guattari's schizoanalytic approach.

[109] Brian Massumi, *The Power at the End of the Economy* (Durham: Duke University Press, 2015), 39. To Massumi, ontopower is precisely the creative mode of neoliberal power, of which priming is an instance: "Every little choice exerts, to some degree, a power of local-global becoming: an *ontopower*. What has been lost to the system and to individuals in terms of knowability, calculability, and predictability is regained in resonant ontopower. An ontopower, as a power of becoming, is a creative power. The economic model, Foucault said, is now one of existence itself. Existence itself: where being is becoming" (ibid., 23 (emphasis in original)). This is resonant with Luciana Parisi's conceptualization of postcybernetic control, according to which: "the question of control is now as follows: how can that which relates to itself become? To put it crudely, postcybernetic control is now concerned with the programming of events." Parisi, *Contagious Architecture*, 79.

1.5 Operations, Structures, and Gestures: Fundamentals of Allagmatics

Simondon devotes a supplementary section of *I'Individuation à la Lumière des Notions de Forme et d'Information*[110] to an extensive explanation of allagmatics – the "theory of operations."[111] With its focus on operations, Simondon explains, allagmatics complements the theories of structure, such as those that corresponds to individual sciences (e.g. physics, biology, chemistry, astronomy). For Simondon the operation is "the ontological complement of the structure,"[112] and vice versa, but also "a conversion of a structure into another structure."[113] In the context of physical individuation, Simondon also defines allagmatics as the "theory of metastability, envisaging the process of exchange between spatial configurations and temporal sequences."[114] In sum, allagmatics is concerned with the energy exchange among structures – transduction – that allows individuation to unfold.[115] Or in Simondon's words:

> The principle of individuation is the operation that carries out an energy exchange between matter and form, until the system reaches a state of equilibrium. One could say that the principle of individuation is the common allagmatic operation of matter and form through the actualization of potential energy.[116]

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[110] Simondon, *L'Individuation*, 529–36.
[111] Ibid., 529.
[112] Ibid., 533.
[113] Ibid., 531.
[114] Ibid., 234.
[115] Interestingly, allagmatics shares the same root with the Greek word catallactics – allage, αλλαγή (i.e. change). The term catallactics – καταλακτικά, 'the art of exchange' – was popularized by Ludwig von Mises' treatise on *Human Action*, one of the fundamental texts of the Austrian School of Economics and libertarian ideology. Drawing on Richard Whately's *Introductory Lectures on Political Economy* (1831), von Mises defines catallactics as the "science of exchange." For von Mises, catallactics has to be understood as the method of the theory of human action, or "praxeology." Ludwig von Mises, *Human Action: A Treatise on Economics* (San Francisco: Fox & Wilkes, 1996), 3. Coincidentally, Gilbert Simondon provides a critique of praxeology in *Imagination et Invention*, arguing for the need of a "general praxeology" – a study of action devoid of its human connotations. Gilbert Simondon, *Imagination et Invention (1965-1966)* (Chatou: Éditions de la Transparence, 2008), 191. While this line of enquiry will not be explicitly pursued here, this testifies to the remarkably subtle nuances between methodological individualism and a rigorous, universal theory of individuation. In Simondon's allagmatics one could read a critique of libertarian's catallactics and its narrow focus on 'human action.'
[116] Simondon, *L'Individuation*, 48. In the discussion of the difference between moulding and modulation through the example of the taking-consistency of a brick, Simondon overcomes the dichotomy between matter and form by affirming that the relation between form and matter occurs "through an energetic system of form taking." Ibid., 47.

For Simondon it is the abstraction and autonomy of operations from their own terms that grants operations their universality.[117] This provides the means to explain, speculatively, the non-physical, non-transcendental, non-empirical relations between processes and milieux that are ontologically different but operatively analogous and that together contribute to the constitution of a single spatiotemporal and perceptual axiomatic that orients collective formations. Simondon explains that structures and operations are ontological complements to each other, allowing one to focus on either according to the perspective from which one looks at the process of individuation. Focusing on the operational side allows one to grasp a system as open-ended and characterized by the dynamic interplay between form and force – that is, as an "individuating individual" moving from an "analytic state to a syncretic state" according to the operation of modulation.[118] Conversely, focusing on the passage from the "syncretic state to the analytic state,"[119] allagmatics provides the means to grasp the "individuated individual,"[120] such as in the case of the process of crystallization. While the latter case is exemplified by physical and chemical processes, the former case – modulation – is epitomized by the theory of information. My wager is that attending to the interplay between operations and structures occurring within the algorithmic-financial system may provide the means to grasp the taking-consistency of contemporary algo-financial power as an aspect of the individuation of the system human-world.

According to Simondon, operation and structure come together through an 'act' – a gesture. The doubling of an act as both operation and structure provides the means to grasp the "axiontology" immanent in an act. Simondon gives the example of an "act of thought,"[121] which is endowed with a reflexivity that provides the means to think "the being of the act of thought itself."[122] According to Simondon, it is at this point that one becomes aware of both the structural (objective) and the operational (subjective) side of an act (of thought) – of its normative and metaphysical sense, respectively, that together

[117] Ibid., 529.
[118] Ibid., 536.
[119] Ibid.
[120] Ibid. As will be clear in the following discussion, for Simondon transduction has spatial connotations and corresponds to the taking-consistency of a form and a matter, while modulation is predominantly temporal, since it allows for the conservation of such form-matter configuration through time. As I will explain, however, such operations cannot exist apart from one another.
[121] Ibid., 530.
[122] Ibid.

constitute the axiontology of an act. As Simondon states, allagmatic theory "initiates both the theory of knowledge and the theory of values. It is axiontologic, because it grasps the reciprocity between the axiological dynamism and the ontological structures."[123] Focusing on both the structural side of the process of individuation and on the operational side will allow me to foreground the axiontology of contemporary power – that is, the mutual relation between the onto-epistemological structures and the value systems advanced by the current power configuration. This is what, as I mentioned before, François Laruelle calls the 'sense of power,' or what Brian Massumi today defines as the 'ontopower' of neoliberal logic. Before delving into that, it is worth explaining another fundamental aspect of allagmatics – the theory of the analogical act, which provides the conceptual tools with which to understand the amplification of an act to other realms of experience.

Allagmatics is based on the notion of operatory analogy. Simondon distinguishes between operatory analogy and structural analogy and defines the analogical act as the putting into relation of two operations, or of an operation and a structure. More precisely, while structural analogy is a matter of mere resemblance between entities, operatory analogy is an "identity of relations, but not a relation of identity"[124] and the one that Simondon considers more important. Here lies Simondon's critique of cybernetics – while Simondon praises cybernetics because it marked the beginning of a "general allagmatics,"[125] to him cybernetics is founded on a mere "affective resemblance"[126] between the structure of the brain and computational processes. Therefore, it fails to grasp the genetic and analogical character of information. As Simondon states in *Communication et Information*: "information is not a thing, but the operation of a thing arriving in a system and producing a transformation. … Information cannot be defined apart from this *act* of transformative incidence and of operation of reception."[127] In other words, information is the axiontological act that allows for the

[123] Ibid., 535.
[124] Ibid., 533.
[125] Ibid., 531.
[126] Ibid., 533. Simondon further clarifies that "true transductive thought avails of *analogical* reasoning, but never of reasoning by *resemblance,* that is to say according to affective and emotive partial identity." Ibid., 119 (emphasis in original).
[127] Gilbert Simondon, *Communication et Information: Cours et Conférences*, ed. Nathalie Simondon and Jean-Yves Chateau (Chatou: Éditions de la Transparence, 2010), 159 (emphasis added).

taking-consistency of a system through the operatory analogy between operations and structures.[128]

To sum up, operatory analogy provides the means to overcome onto-epistemological divides by emphasizing a certain identity of relations among different realities, inserting itself into what Simondon calls the' key points' of the reticulate that constitutes the relation between human beings and the world, and operating by way of a transduction.[129] Maintaining a focus on the changes that local reality undergoes by way of the impact of processes of information,[130] operatory analogy does not advance any claims to universality but precisely for this reason becomes a universal method for discovery. From this perspective, focusing on specific technical operations, the notion of operatory analogy will provide the means to map the process of information occurring among financial, social, and psychic structures, in order to explain how the logic inherent to automated financial markets has become the metamodel for social life – as Simondon himself puts it: "the model of a triode is the functional analogue to a

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[128] It is also important to note that, in doing so, Simondon's method eschews a certain 'pan-operationalism' that posits a mechanical understanding of epistemological formations. More precisely, Simondon emphasizes that, if such a mechanical epistemology exists, it is because of the technical interfaces that bind together a technical system – specifically, the mechanisms of the industrial paradigm.

[129] Simondon claims that the use of operatory analogy begins in the scientific field. Simondon, *L'Individuation*, 533. Daring to transpose the discussion onto the field of mathematics, Simondon's operatory analogy could be considered akin to the notion of analogy in category theory. One of the tenets of category theory is that "a functor is an analogy." In his "Categorical Manifesto," Joseph Goguen explains functors as the second postulate of category theory: "To any natural construction on structures of one species, yielding structures of another species, there corresponds a functor from the category of the first species to the category of the second." Joseph A. Goguen, "A Categorical Manifesto," *Mathematical Structures in Computer Science* 1, no. 1 (March 1991): 54. In other words, A is to X as B is to Y. Ronald Brown and Tim Porter further clarify the difference between analogy and comparison in an analogous way to Simondon's distinction between operatory analogy and structural analogy. Analogy, they explain, is the "flip-side of comparison." Ronald Brown and Tim Porter, "Category Theory: An Abstract Setting for Analogy and Comparison," in *What Is Category Theory?*, ed. Giandomenico Sica (Monza: Polimetrica Scientific Publisher, 2006), 259. Contrarily to the notion of comparison, that involves a quantity, analogy is "nearly a 'that reminds me of' situation": "The partial matching, via a comparison, of the properties of A and B leads to an analogy, a test, experiment or an attempt at a proof and perhaps an extension of the comparison, or perhaps the beginning of an abstraction process. … The important point is that we are not saying that knots and numbers are somehow comparable, but that what is comparable are the *relations* between knots and the *relations* between numbers. This situation arises widely in category theory, in comparing categories of particular structures" (ibid., 259–60 (emphasis in original)). While category theory still uses the term 'structure,' the primacy it grants to the operations of mapping over structures reveals its operational focus. Simondon, on the other hand, is careful to differentiate such terms. The result is a further operation of individualization, or concretization – or in Fernando Zalamea's mathematical terms, a "gluing" of different realities; in other words, a *trans*-duction. See: Fernando Zalamea, *Synthetic Philosophy of Contemporary Mathematics* (Falmouth: Urbanomic, 2012); Fernando Zalamea, "Peirce and Latin American 'Razonabilidad:' Forerunners of Transmodernity," *European Journal of Pragmatism and American Philosophy* 1, no. 1 (2009).

[130] Simondon, *Communication et Information*, 159.

social structure."[131] Furthermore, the allagmatic focus on the dynamism of operations will allow me to map turning points in the architecture of algo-financial power. Before moving to that, I want to clarify Simondon's concept of amplification, which will be key to such an endeavor.

In *Communication et Information* Simondon distinguishes between three types of amplification: transductive amplification, modulative amplification, and organizing amplification.[132] Transductive amplification is the most elementary operation of information, and could be identified with the process of crystallization occurring in a metastable solution. Examples of transductive amplification are the processes of "self-regulation, adaptation, level adjustments, and oscillations."[133] For Simondon, transductive amplification can provide an explanation for psycho-social processes such as ethical attitudes and national sentiments, that precede the taking-consistency of more complex and structured social phenomena such as industrial development, population, and types of education.[134] While in transductive amplification the passage from a metastable state to a stable state is perpetually engendered, again and again, in modulative amplification such a phase-change produces a fixed stable state. As Simondon explains, a modulator is precisely concerned with putting into relation the extreme terms of an energetic series and a local series, thereby realizing a "privileged space of equivalence between extreme terms"[135] – in other words, a differential engine. Importantly, modulation entails a notion of iteration and feedback – or "structure of relay"[136] – which allows for the dynamic control of the level of energy and information within a system in order for it to reach stability. This operation is exemplified by a triode. Transposed to the biological and social domains, modulative amplification is what allows for a system to reach a stable state amidst the random variations of

[131] Ibid., 171.
[132] Yuk Hui brilliantly explains the differences between these three kinds of amplification in order to overcome the *aporia* of Gilles Deleuze's concept of modulation in the societies of control. By retrieving Simondon's notion of modulative amplification, Hui aims to rehabilitate modulation as a useful metaphysical category, for "modulation can offer us some insights into more creative and positive means of reconstituting the social through technical means, which would themselves constitute a technical means of realising the philosophical critique of hylomorphism and its legacies." Yuk Hui, "Modulation after Control," *New Formations: A Journal of Culture/Theory/Politics* 84, no. 84 (2015): 89.
[133] Simondon, *Communication et Information*, 164.
[134] Ibid.
[135] Ibid., 166.
[136] Ibid., 167.

energetic and informational charges[137] – for instance, the polarization of social groups, phenomena of ritualization, and the establishment of social codes.[138] Ultimately, organizing amplification corresponds to the combination of both transduction and modulation into a single regime of functioning allowing a system to concretize and orient itself toward a purpose. Simondon explains this latter kind of amplification through the example of the integration of visual information in the right and left eye.[139]

In short, transduction, modulation, and organization are the three stages of the amplification produced by the process of information that, starting from a local technical reality, extends to social and psycho-collective realities. Simondon sums up these stages in terms of "positive increase [*recrutement*], limitation, and discovery of a system of compatibility."[140] Specifically, "transductive amplification is essentially positive … it is auto-position, and it is not self-limited";[141] modulation "inscribes itself negatively in the actualization of a potential energy, and diminishes the output [*rendiment*] of the possible transformation";[142] ultimately, organization "corresponds to the stability of the present … since transduction is an instant impulse toward the future, and modulation a fixed repetition of the past under the kind of conservation."[143]

Simondon's allagmatics provides the means to grasp the importance of the combination of the processes of transduction (positive feedback) and modulation (negative feedback) for the structuration of organizations. This formulation will allow me to explain how value is produced in an organization (e.g. a market) through the production of differential relays generated by the interactions of such processes. According to this formulation, technical value can be understood as the predisposition to taking consistency according to a certain combination of form and matter through the operations of transduction and modulation. The next section reformulates two fundamental computational operations – reification and recursion – in allagmatic terms. As will be clear in the unfolding of this thesis, these operations underlie every aspect of

[137] Ibid., 168.
[138] Ibid., 169.
[139] Simondon also uses this example to explain how individuation resolves incompatibilities between different orders of magnitude. From this standpoint, organizing amplification explains how individuation occurs in a system.
[140] Simondon, *Communication et Information*, 173.
[141] Ibid.
[142] Ibid.
[143] Ibid.

the individuation of the socio-financial ecosystem – from the concretization of digital money and the open character of the latter, up to the rhythms imposed by the financial machine on the becoming of the social. While below I deal with reification and recursion as separate operations, in the reality of digital systems the two cannot be separated but, like transduction and modulation, together contribute to the organization of a system.

1.6 Reification, Recursion, and Speculative Engineering: From Markets and Networks to Allagmatic Architectures of Value

The operations of reification and recursion are two key concepts in computer programming that can be said to underlie most, if not all, of the architecture of the visible Web. Below I present these operations separately, from a computer science perspective. Further, I reformulate them through an allagmatic lens in order to overcome some of the limitations of such conceptualizations. In computer science, reification is the process by which an abstract idea about a program or an implicit aspect of a programming language is made explicit and turned into a data model. Most software engineering manuals define reification as simply the process of making an abstract concept into a concrete data structure. In other words, reification consists in extracting simple structures from complex phenomena. For instance, in Java, reification consists in the "explicit representation of a type – that is, run-time type information,"[144] which is information about an object's data type that is only exposed during the execution of a program. Through reification it is easier to identify data types syntactically.[145] On the Semantic Web, however, reification consists in statements that describe other statements. For instance, within the Resource Description Framework (RDF), which I will discuss in chapter three, this takes the form of subject, predicate, and object.[146] It is important to note that reification qua computation is more nuanced than the Marxist understanding of reification as the objectification of social relations through the commodity-structure.[147] As a matter of fact, reification qua computation

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[144] Maurice Naftalin and Philip Wadler, *Java Generics and Collections* (Sebastopol: O'Reilly Media, 2006), 73.
[145] For instance, in Java reifiable types correspond to primitive, raw types, such as int, List, and those arrays whose components are reifiable, such as List[ ], int[ ]. Ibid., 74.
[146] Shelley Powers, *Practical RDF* (Sebastopol: O'Reilly Media, 2003), chap. 4.
[147] In Marxist thought, reification is a specific form in which the alienation of the human condition under capitalism becomes manifested in the particular form of commodity fetishism. As Georg Lukács puts it,

acquires new connotations in light of the concrete abstraction of algorithmic processes, and cannot be reduced to a mere ‘thingification.’ Instead, reification is a *functional* process that allows for complex computational architectures to operate.

In contrast to the standard approaches to reification, Andrei Sorin argues that reification, together with abstraction, is based on a fundamental fallacy in contemporary approaches to both software programming and language, owing to an understanding of the world still indebted to Cartesian mechanics – a theme I will come back to in the following chapter.[148] For Sorin, the problem with reification and recursion is that, by extracting finite simple structures from complex phenomena, these two operations cause a drastic reduction of the world.[149] According to Sorin, in order to create efficient, complex interactive software architectures, one needs to start from the low-level elements of a software system (such as the operating system and hardware drivers) and work one’s way into complexity. For Sorin, this is better than limiting oneself by the initial adoption of standardized high-level abstractions and isolated structures that rely on a few reified low-level applications in order to pursue abstraction further (as it occurs in the case of databases, video games, word processors).

> The two mechanistic fallacies, abstraction and reification, are usually committed together. … We are tempted to abstract because we want to start from higher levels; but to abstract we need simple structures, so we

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reification entails the extension of the ‘commodity-structure’ as a model of objectivity, thus becoming “a kind of second nature” that leads to the fragmentation of human experience and the alienation from one’s labor. Georg Lukács, *History and Class Consciousness: Studies in Marxist Dialectics*, trans. Rodney Livingstone (Cambridge: The MIT Press, 1972), 128. Through the mechanization and specialization of labor, Lukács argues, the commodity-structure has become the “structural problem of capitalist society in all aspects.” Ibid., 83.

[148] According to Sorin, software is akin to language. However, it needs to be specified that, for him, software, like language, is first and foremost performative and operational. It is directly implicated in the weaving of signifying and semantic structures, upon which our understanding of the world and ourselves is based. To clarify the consequences of the application of the fallacies of abstraction and reification, Sorin gives the example of Newspeak – the impoverished language described by George Orwell in *1984* used to limit knowledge structures and to control populations. Andrei Sorin, *Software and Mind: The Mechanistic Myth and Its Consequences* (Toronto: Andsor Books, 2013), 398–407.

[149] Sorin’s critique of reification is radical: “By restricting ourselves to simple structures, we are becoming a closed, deterministic society, where only certain alternatives can exist. The danger posed by our software ideology, therefore, is not just the loss of alternatives in software-related matters, but the degradation of minds. Our non-mechanistic capabilities do not simply exist – they develop; and they can develop only when we are exposed to low-level elements, because this is the only way to create all possible alternatives in our minds. If we restrict ourselves to mechanistic knowledge – to simple knowledge structures and high-level starting elements – our minds cannot develop above the intellectual level of machines.” Ibid., 833.

> first reify the complex structure. Reification impoverishes the complex structure by eliminating the interactions between its component structures; and abstraction impoverishes each structure by reducing the number of levels. Each fallacy contributes its own kind of impoverishment, but the result is the same: a reduction in the number of alternatives for the values of the high-level elements.[150]

Importantly, Sorin notes that, "while reification can be committed even without abstraction, abstraction always entails reification."[151] This is because, in order to abstract finite structures from low-level operations, one needs first to extract them through the process of reification described above. According to Sorin, reification and abstraction are endemic to programming as a whole, and have "given rise to the theories of software engineering, to concepts like structured programming and object-oriented programming."[152] Object-oriented programming can be considered the apotheosis of the mechanist approach to software. For instance, Casey Alt observes that, "in producing and consuming object-oriented digital media, we, the users, are positioned as just another set of objects within object orientation's distributed field of operations."[153] For Sorin, object orientation, and reification in general, are inadequate "for software-related phenomena":

> … because these phenomena consist, not of processes *within* processes, but of *interacting* processes. In an application, the various software processes interact with one another, and also with the personal, social, and business processes affected by that application. A software process is not a structure *within* other software processes, or *within* a business process; nor is a business process a structure *within* a software process. Thus, software-related phenomena can only be represented with *complex* structures. … We *can* acquire programming expertise; but, like other difficult skills, this takes a long time.[154]

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[150] Ibid., 122–23.
[151] Ibid., 123.
[152] Ibid., 121.
[153] Casey Alt, "Objects of Our Affection: How Object Orientation Made Computers a Medium," in *Media Archeology: Approaches, Applications and Implementations*, ed. Erkki Huhtamo and Jussi Parikka (Berkeley: University of California Press, 2011), 298.
[154] Sorin, *Software and Mind*, 193 (emphasis in original).

However, precisely for these reasons, reification offers a fruitful entry point into the complexities of computation and the low-level, lowly connections that have been erased through this process. Specifically, my wager is that looking at reification through the lens of transductive processes may provide the means not only to recover such relations but also to foreground their necessary role in the individuation of a system. Similar to the process of crystallization described by Simondon, reification in software engineering allows for the concretization of an entity according to a topological structure and a "temporal energetic schematism."[155] As I will explain in chapter three, the statements that define and standardize (or attempt to standardize) the data structures of digital money, including over-the-counter (OTC) derivatives, are instantiation of the process of reification. However, as chapter three and four further explain, by looking at digital money as a technical object, according to the operations of transduction that allow for the concretization of digital money in relation to its associated milieu, it is possible to grasp the immanent openness of the digital and the fact that a digital object is never only a thing *hic et nunc*.[156]

In contrast to the spatial focus of reification – that is, the taking-consistency of a structure in a defined spatial configuration – recursion emphasizes the temporal element of repetition.[157] Recursion is the operation that lies at the core of intuitive concepts such as 'mechanical', 'computable' and 'algorithmic,' as Paolo Totaro and Domenico Ninno note.[158] In other words, recursion is responsible for the discretization of continuous relations. As Niklaus Wirth puts it in his seminal *Algorithms + Data Structures = Programs*:

> The power of recursion evidently lies in the possibility of defining an infinite set of objects by a finite statement. In the same manner, an infinite

[155] Simondon, *L'Individuation*, 530.
[156] Simondon, *Du Mode*, 20.
[157] As will be made clear below, this mirrors Simondon's understanding of transduction and modulation. In *Allagmatique* Simondon explains that transduction emphasizes, but is not limited to, the taking-consistency of a "spatial structure … and an operatory function expressing its active form organized according to an energetic temporal schematism." In contrast modulation "orders a temporal *operation* according a morphological structure." Yet again, the two operations cannot be considered separately. Instead, their respective spatial and temporal focuses together allow for the organization of a spatiotemporal individual. Simondon, *L'Individuation*, 536 (emphasis in original).
[158] Paolo Totaro and Domenico Ninno, "The Concept of Algorithm as an Interpretative Key of Modern Rationality," *Theory, Culture & Society* 31, no. 4 (March 2014): 35.

> number of computations can be described by a finite recursive program, even if this program contains no explicit repetitions.[159]

Not only is recursion a manifestation of the iterative nature of certain programs or phenomena, it is also the abstract operation that provides the a priori conditions for the discretization of phenomena and the repetition of steps in time and space – whether computational or physical. Recursion, as a modulative operation, entails a repetition from a past result and proceeds according to 'if – then – else' logic. As observed above, contrarily to transduction, for Simondon modulation entails the ordering of a temporal operation according to a morphological structure and can be best expressed by the theory of information, "and in particular of the relation between *signal*, *alimentation energy*, and *structure of the modulator*."[160] In computing, sorting algorithms exemplify the technic of temporal ordering through modulation. Chapter five investigates this in relation to the modulative amplification of computational paradigms to the reality of algorithmic finance and social dynamisms. Further, as chapter six discusses in the context of high-frequency trading, modulation provides the means to understand how the ordering logic of contemporary power works at an aesthetic level too, organizing perceptions and cognitions in a way that is not directly sensed but only felt.

Following Simondon's allagmatic theory, it is important to note that the relation between the operations of transductive reification and modulative recursion is never stable – on the contrary, it gives rise to a metastable organization, pulled between the futurity immanent in transduction and the past orientation of iterative repetitions. As such, a system is never a monolithic structure but becomes a dynamic architecture – that is, an assemblage of allagmatic operations that amplify their tendencies to more and more aspects of the world. Moving from the local reality of computation to the larger technical ensemble composed by digital money, algorithmic markets, and 'social networks' with this clarification in mind it becomes possible to conceptualize markets, as much as social networks, as technical systems of exchange. By this, I understand markets and networks not so much as structural entities ontologically differentiated from one another, as they are customarily thought of, but as 'allagmatic

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[159] Niklaus Wirth, *Algorithms + Data Structures = Programs* (Englewood Cliffs: Prentice Hall, 1976), 126.
[160] Simondon, *L'Individuation*, 536 (emphasis in original).

architectures.'[161] With this term I identify systems of exchange (αλλαγή) founded on ontogenetic operations rather than structures, and symmetric to the latter.[162] This clarification will allow me to foreground the transductive and modulative forces immanent to algorithmic finance and begin to question contemporary market structures by focusing on the 'act' of information as it unfolds within the system thus allowing for further individualizations – of monetary and financial value, prices and further, digital money. The reticulation that these operations weave through the concretization of singular spatiotemporal points (by which I mean specifically digital money) will provide the means to map the material axiomatic of signification of the computational financial ecosystem – the *sense* of algo-financial power. The progressive taking-consistency of individuated points at higher levels of abstraction enables the increasing individualization of the overall system, concealing the low levels operations. Focusing on transductive and modulative operations also makes it possible to identify what escapes axiomatization and can instead contribute to the production of metastable states that in turn can further modify the power axiomatic.

To recap, allagmatics foregrounds the ontogenetic character of a technical system and gives primacy to the act of information as the determining factor establishing the direction [*sens*] of its further individualization. The act of information inserts itself in the zones of radical indeterminacy – neither deterministic nor indeterministic[163] – between operations and structures and, through a technical effort, it allows for invention. Reification and recursion are two of the forms that the act of information takes in the computational ecosystem. In spite of the numerous critiques they have received, these operations are *functionally* necessary to programming and therefore cannot be eliminated. However, as I will show, the openness and participatory character of digital objects provide the condition for the recombination of these functions in novel and unexpected ways, thereby allowing for experiments in the speculative engineering of novel systems of value creation and exchange. Therefore, this thesis takes seriously

[161] Léopold Lambert has advanced a reconceptualization of architectural practice in allagmatic terms. Léopold Lambert, "For an Allagmatic Architecture: Introduction to the Work of Gilbert Simondon," *The Funambulist*, November 25, 2013, http://thefunambulist.net/2013/11/25/simondon-episode-01-for-an-allagmatic-architecture-introduction-to-the-work-of-gilbert-simondon/.
[162] As for Simondon allagmatic is symmetric to the theories of structures, such as the singular sciences (e.g. astronomy, physics, biology, chemistry), so here I complement the theory of market structures, with an operational focus on the operations across the socio-economic domain. See: Simondon, *L'Individuation*, 529.
[163] Ibid., 149.

Simondon’s theory and investigates the allagmatic character of the computational operations of reification and recursion according to the amplifying processes of transduction and modulation. In doing so, it aims to explain the taking-consistency of contemporary algo-financial power through an emphasis on both the normative and the genetic autonomy of the algorithms that give a form to technics of exchange. The following chapter begins this endeavor by showing how the monetary architecture of fiat money has been directly implicated in the establishment of the sense of capitalist power through the amplification of the operations of ‘storage’ and ‘transmission’ of economic value reified in the technology of fiat money.

2. "Start Making Sense": A Mechanist Approach to Money, Value, and Capitalist Power

It is less and less legitimate that only a profit-based market should regulate financial and prestige-based rewards for human social activities, for there is a range of other value systems that ought to be considered, including social and aesthetic 'profitability' and the values of desire –
Félix Guattari[1]

2.1 Technology, Economy, Ecology: A Three-Fold Crisis of Value(s)

August 13, 2015, marked Earth 'overshoot day' – the moment in which human demands on the planet surpassed Earth's ability to regenerate itself; in other words, "the point at which humanity goes into ecological debt."[2] According to estimates, we would currently need approximately 1.64 planet Earths to satisfy the global demand for natural resources, and the clock keeps ticking.[3] While the problem of depletion is today extremely pressing – water, oil, and forests being the most endangered natural assets and also the most vital to our ecosystem – economic activity continues to impose a strenuous demand on the Planet. Economist E.F. Schumacher already observed in the 1970s that the problem of modern production is the inability to grasp the value of the capital constituted by natural assets,[4] thereby accounting for natural resources as a free income rather than acknowledging their value in the larger planetary ecosystem – a position today echoed by Jason Moore.[5] Moore argues that the current ecological crisis

[1] Félix Guattari, *The Three Ecologies*, trans. Ian Pindar and Paul Sutton (London: The Athlone Press, 2000), 64.
[2] Emma Howard, "Humans Have Already Used up 2015's Supply of Earth's Resources – Analysis," *The Guardian*, August 13, 2015, http://www.theguardian.com/environment/2015/aug/12/humans-have-already-used-up-2015s-supply-of-earths-resources-analysis.
[3] According to The World Counts – a Danish project that provides live statistics on the effects of human consumption on Earth – "If Earth's history is compared to a calendar year, modern human life has existed for 23 minutes and we have used one third of Earth's natural resources in the last 0.2 seconds." The World Counts, "Number of Planet Earths We Need - to Provide Resources and Absorb Our Waste," *The World Counts*, accessed June 4, 2016, http://www.theworldcounts.com/counters/shocking_environmental_facts_and_statistics/what_is_the_environmental_footprint.
[4] E. F. Schumacher, *Small Is Beautiful: Economics as If People Mattered* (London: Blond & Briggs, 1973), 11.
[5] Jason W. Moore, "The End of Cheap Nature. Or How I Learned to Stop Worrying about 'The' Environment and Love the Crisis of Capitalism," in *Structures of the World Political Economy and the Future of Global Conflict and Cooperation*, ed. Christian Suter and Christopher Chase-Dunn (Berlin: LIT Verlag, 2014), 285–314.

reflects a more profound crisis – that is, the exhaustion of the historical relation that produced "cheap nature." Moore explains that cheap nature, constituted by the "Four Cheaps" of cheap labor-power, food, energy, and raw materials,[6] was produced through exploitation – the strategy that allowed capitalism to thrive. Today, Moore argues, the end of cheap nature is not so much a manifestation of the "external 'limits to growth'"[7] but more importantly, marks the internal limit of capitalism itself. As a matter of fact, nature is not so cheap anymore, if it ever was. According to a recent study the estimated value of "global ecosystem services" in 2011 equated to $125 trillion per year.[8] In a process of 'radical accounting,' this was the price that Costanza et al. put on ecosystem services. However, this was not for the purpose of privatization; on the contrary, the authors did so in order to raise awareness of the value of Earth's resources for the 'real economy' in a globally understood metric – money. At the same time, because markets are not the most suited institutional framework to value the global commons, they call for a different basis for more sustainable relations between natural and human capital.[9]

As all these studies suggest, a great paradox underlies the contemporary economic paradigm – the one between the rhetoric of teleological progress promoted by the neoclassical orthodoxy and the depletion of natural resources that, according to scientific authorities, is leading to the sixth mass extinction.[10] As Ole Bjerg observes, contemporary capitalism faces at least two fundamental crises: an economic crisis, which is manifested in declining rates of growth and in the expansion of global debt, and an ecological crisis, manifested by global warming, resource depletion, and pollution.[11] However, according to some authors, the factual environmental disaster is only one instance of a larger, more profound catastrophe – an existential and metaphysical one: "the exhaustion of natural resources is probably less advanced than the exhaustion of subjective resources, of vital resources, that is afflicting our contemporaries."[12] This position echoes Félix Guattari's proposition in *The Three Ecologies*. Drawing on Gregory Bateson, Guattari observes that the intense techno-

[6] Ibid., 285.
[7] Ibid.
[8] Robert Costanza et al., "Changes in the Global Value of Ecosystem Services," *Global Environmental Change* 25 (2014): 152–58.
[9] Ibid., 154.
[10] Anthony D. Barnosky et al., "Has the Earth's Sixth Mass Extinction Already Arrived?" *Nature*, no. 471 (March 3, 2011): 51–57.
[11] Ole Bjerg, *Parallax of Growth: The Philosophy of Ecology and Economy* (Cambridge: Polity, 2016), 9.
[12] The Invisible Committee, *To Our Friends*, trans. Robert Hurley (South Pasadena: Semiotext, 2015), 33.

scientific transformations the Planet has been undergoing, coupled with the deterioration of “human modes of life,” are profoundly impacting the ecological equilibrium on Earth. Yet political and economic authorities are unable or unwilling to fully grasp the implications and mutual imbrication of these issues. As Guattari notes, the “global market … destroys specific value systems and puts [them] on the same plane of equivalence: material assets, cultural assets, wildlife areas, etc.”[13] To him “only an ethico-political articulation – which I call *ecosophy* – between the three ecological registers (the environment, social relations and human subjectivity) would be likely to clarify these questions.”[14]

What all these positions highlight, in different historical moments and contexts, is the problematic at the heart of the current political-economic, but also cultural, impasse: that of the *perception* of *value* in contemporary economies – specifically, in the techno-cultural system known as capitalism or, broadly speaking, in market-based societies, particularly after the topological turn of culture that I discussed in the introduction. The hypothesis this second chapter aims to test is that the “continuity for forms of economic, political and cultural life”[15] identified by Lury et al. may be due to the amplification of economic ‘value’ to aspects of culture that were previously exempt from economic considerations. From this standpoint, Guattari’s prescient intuition acquires a new meaning: the financial crisis and accompanying crises of Western democracy, the environmental catastrophe, and the cultural *aporia* underlying the lack of effective responses to the politico-economic juncture are different manifestations of the same problematic – a three-fold crisis of value across the ecological, cultural, and subjective realms. It is precisely this impasse, Philip Mirowski explains, that allows for neoliberal contingents to perpetuate their control.[16]

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[13] Guattari, *The Three Ecologies*, 29.
[14] Ibid., 28 (emphasis in original).
[15] Celia Lury, Luciana Parisi, and Tiziana Terranova, “Introduction: The Becoming Topological of Culture,” *Theory, Culture & Society* 29, no. 4/5 (2012): 4.
[16] With regard to global warming, for example, Mirowski illustrates that “‘science denialism,’ ‘carbon permitting trading,’ and the nascent science of ‘geoengineering’ … together constitute the full-spectrum neoliberal response to the challenge of global warming” as these measures leave the solution of the environmental catastrophe to the market. Philip Mirowski, *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown* (London: Verso, 2014), 337. Referring to carbon emission trading, for instance, Mirowski observes that “money that might have been used productively to alter the energy infrastructure instead gets pumped into yet another set of speculative financial instruments, leading to bubbles, distortions of capital flows, and all the usual symptoms of financialization.” Ibid., 339–40.

In light of the methodology outlined in the previous chapter, the issue of the perception of value entails two distinct but interconnected problematics: on the one hand, that of the individuation of economic value itself; on the other hand, that of the perception of such value in the service of the dominant power formations. These interconnected problematics present the following questions: how does economic value comes into being? And how does economic value thus constituted impact the perception, and sense, of power? In order to answer these questions, here I want to first recast the problematic of the perception of value in relation to power formations in terms of the relation between technology, value, and sense (of power) – in other words, in terms of the ways in which certain techno-cultural interfaces, and the value(s) they embody organize sense perception in a way that favors the taking-consistency of specific power formations. By dealing with these disparate issues together my proposition is that power, value, and perception cannot be accounted for separately from each other. Instead they come together in the individuation of a specific politico-economic and cultural configuration – in this case, what Guattari calls "Integrated World Capitalism."[17]

Informed by Guattari's observation that "the only true response to the ecological crisis is on a global scale, provided that it brings about an authentic political, social and cultural revolution, reshaping the objectives of the production of both material and immaterial assets,"[18] this chapter approaches the issue of the perception of value according to a techno-cultural perspective that aims to grasp the global and multifaceted character of the *oikos* in which we live – an *eco*-system. By embracing an ecosystemic view, I take seriously Bjerg's claim that "we should resist the temptation of simply choosing the easy option of ecology over economy or even the cheap compromise between the two."[19] At the same time, however, by adopting a Simondonian perspective, I also want to foreground the always already technical character of the relations that make up the world. In order to start to problematize the relation between economic value and the ecosystemic crisis identified above, this chapter focuses on an

[17] "Post-industrial capitalism, which I prefer to describe as Integrated World Capitalism (IWC), tends increasingly to decentre its sites of power, moving away from structures producing goods and services towards structures producing signs, syntax and – in particular, through the control which it exercises over the media, advertising, opinion polls, etc. – subjectivity." Guattari, *The Three Ecologies*, 47. While Guattari concerns himself with the semiotic dimension of capitalism, following Simondon my aim here is to focus on the technical operations that allow for the world-capitalist machine to function.
[18] Ibid., 28.
[19] Bjerg, *Parallax of Growth*, 13.

elementary technology that, I argue, has contributed greatly to the taking-consistency of the current ecosystemic configuration of power – fiat money.

Drawing on Gilbert Simondon's philosophy of individuation and technics, the argument of this chapter is that a discussion of the technological developments of the monetary medium is fundamental for an understanding, and a rethinking, of what money is and what it does in relation to contemporary modes of power and organization. This complicates the overarching narrative of capitalism as a monolithic system and provides the conceptual tools to move "beyond the power principle."[20] In other words, this chapter argues that, in order to *trans*-form the financial system, one needs to start by taking seriously the functions and modes of existence of its elementary technology, as Gilbert Simondon would have it. In the case of finance, this elementary technology is fiat money.[21] As Simondon states, "it is in the elements that technicity exists in the most pure manner" endowing them with a "transductive property."[22]

As I explained in the introduction, this thesis starts from an understanding of money as a technology. From this standpoint, fiat money – the kind of money that simultaneously performs the functions of medium of exchange, unit of account, and store of value[23] – can be understood as a technology of storage and transmission of value. In order to understand the kind of *value* that is 'stored' in monetary technology, and how that

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[20] François Laruelle, *Au-delà du Principe de Pouvoir* (Paris: Payot, 1978).

[21] Undeniably, the history of capitalism "is written in the annals of mankind in letters of blood and fire." Karl Marx, *Capital: A Critique of Political Economy. Volume 1*, trans. Ben Fowkes, Reprint edition (London: Penguin Classics, 1992), 875. This entailed a 'transition' (albeit discontinuous and not gradual at all) that occurred through several reforms between the thirteenth and seventeenth centuries and an obligatory passage through agrarian capitalism. Silvia Federici illustrates this with a focus on the policies to which the female body became subjected as a site of reproduction and accumulation of labor, and the role of the witch-hunt as instrumental to the development of capitalism. This is a field of enquiry that goes beyond the scope of this thesis and certainly necessitates further investigations. Silvia Federici, *Caliban and the Witch: Women, the Body and Primitive Accumulation* (New York: Autonomedia, 2004). In this thesis, by looking at fiat money as the most elementary capitalist technology my goal is instead to shift the focus on the technological infrastructure involved in the concretization of the modern capitalist paradigm of power. As Federici explains, for instance, the "*commutation* of labor services with money payments" was fundamental to the process of social division that brought to the dismantling of the feudal village and the move to agrarian capitalism (ibid., 28 (emphasis in original)). As will be made clear in this chapter, the introduction of fiat money in the seventeenth century marked the shift to the modern mode of financialized warfare underlying the development of late capitalism.

[22] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 73.

[23] To these three characteristics Ole Bjerg adds the function of "standard of deferred payment." Ole Bjerg, *Making Money: The Philosophy of Crisis Capitalism* (London: Verso, 2014), 8. Informed by Massimo Amato and Luca Fantacci's argument that I will explain in the unfolding of this chapter, instead, I view this fourth function as the outcome of the conflation of the functions of medium, unit, and store. As a matter of fact, only by being a store of value can money become the standard medium and measure of deferred payments.

contributes to a certain amplification of *values* and corresponding perception of power, in this chapter I first present a genealogy of economic theories of value informed by Philip Mirowski's historical investigation. Secondly, I inscribe this genealogy into Simondon's schema of the mechanist paradigm of technological development in order to trace parallels between the development of economic theories of value and the shifts in the conceptualization of money throughout the three centuries that mark the taking-consistency of the modern capitalist ecosystem. Then, through a discussion of information and entropy, I focus on the paradigmatic shift announced by cybernetics that, while on the one hand may have intensified the sense of capitalist power, on the other hand has introduced novel possibilities for the establishment of a *new* sense of power, as will be discussed in the following chapter. Through this exploration, my goal is to provide the groundwork for the divorce of the technical value inherent to money from the notion of economic value theorized according to rational mechanics. As this and the following chapter will show, paradoxically, while economic value is transduced and amplified by the elementary monetary technology, the latter can never be axiomatized by economic considerations. As Simondon puts it:

> The relation between the technical domain and the economic domain occurs at the level of the individual or the system, but very rarely at the level of the element; in this sense, we could say that technical value is largely independent from economic value and can be appreciated according to independent criteria.[24]

The goal of this chapter is to begin a contribution toward an 'appreciation' of the technical value of money and toward the speculative engineering of new media of exchange – a theme that will be reproposed throughout the thesis. As Bjerg exhorts us: "rather than trying to change the habits of consumers, ignoring the ecological crisis and letting capitalism work itself out, or sitting back and hoping that science will solve our problems, we should think through the things that may be achieved by changing our monetary system."[25]

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[24] Simondon, *Du Mode*, 75–76.
[25] Bjerg, *Parallax of Growth*, 199–200.

2.2 Economic Value in Historical Perspective: The Concept of Energy in the Evolution of Economic Thought

Philip Mirowski astutely expounds the long and contested relation that Western economic thought has entertained with the physical sciences, with specific reference to the relation between the development of the concept of energy in the natural sciences and changes in economic theories of value.[26] Mirowski's argument is two-fold. On the one hand, he argues that the concept of the conservation of energy in physics has always been imbued with economic connotations, in particular in terms of symmetries, transfer, profit and loss, and in the equivalence between a physical entity and its mathematical counterpart. As the author puts it:

> Energy served a lot of functions: It tagged the identity of natural phenomena; it defined "process" by counterposing it to continuity; it was impregnated with all the language used in Western theological discussions; it was part and parcel of the application of extremal principles; it was in the vanguard of classical determinism; it was the One in the Many; it was conflated with causality itself; and most important, it decreed "something cannot arise from nothing." It is this last theme, the conviction that nature is *economical,* that ushers us into the world familiar to the economist. It is the world of debit and credit, of profit and loss, of productive citizens and beggars and thieves.[27]

On the other hand, however, Mirowski demonstrates that, at least since modernity, Western economics has modeled its theory of value precisely on the concept of energy in physics in order to satisfy the imperative of 'conservation-through-exchange.' Today economic theories of value are associated with pricing mechanisms. Yet Mirowski – and more recently philosopher Jon Roffe,[28] as I will discuss in the following chapters – is careful to differentiate between value theory and price theory: "Value theory is indeed concerned with prices and the mathematical expression of chrematistical relationships,

[26] Philip Mirowski, *More Heat than Light: Economics as Social Physics, Physics as Nature's Economics* (Cambridge: Cambridge University Press, 1991).
[27] Ibid., 100 (emphasis in original).
[28] Jon Roffe, *Abstract Market Theory* (Houndmills: Palgrave Macmillan, 2015). I will discuss Roffe's work in chapter four.

but it is a mistake to regard that as exhausting the purview of value theory."[29] Specifically, Mirowski explains the genesis of value theory by inscribing it into "the metaphorical simplex of energy, motion, body, and value, and … regard[ing] it as part and parcel of the same structures that undergird Western physics."[30]

Mirowski shows that, since Aristotle, the concept of energy has itself rested on a series of metaphors that have persisted to the present: the metaphor of motion (physics), of the body (human), and of value (economics).[31] Motion, body, and value are the three constituent corners of a pyramid at the core of which lies the concept of energy itself:[32] the motion-value relation provided the conceptual milieu that allowed for the quantification and mathematization of energy; the body-motion connection constituted the a priori of the symmetry inherent to energy; finally, the body-value dimension "is responsible for the less acknowledged anthropomorphic and social character of the energy concept, the religious overtones and the cultural influences so often spurned as the opposite of scientific argument."[33] The understanding of economic value as intertwined with theories of motion and energy is deeply related to and influenced by the prevalent theory of the body, Darwinian evolution. As will be clear in the unfolding of this thesis, the orthodox ideology of teleological progress in economics owes a great deal to Darwin's theory of evolution. Today this is epitomized by computational evolutionary economics, an experimental branch of the neoclassical orthodoxy that seeks to study and model markets according to computational paradigms that mimic organic evolution on the basis of the 'survival of the fittest.'[34] As Mirowski explains, Darwin's theory of evolution presents a "structural resemblance"[35] with economic

[29] Mirowski, *More Heat than Light*, 141.
[30] Ibid., 142.
[31] As we shall see, something like this constellation of metaphors began to unravel, according to Simondon, with the mechanist era of technological development.
[32] Mirowski, *More Heat than Light*, 107.
[33] Ibid., 108.
[34] See: Philip Mirowski, "Inherent Vice: Minsky, Markomata, and the Tendency of Markets to Undermine Themselves," *Journal of Institutional Economics* 6, no. 4 (2010): 415–43; Philip Mirowski, "Markets Come to Bits: Evolution, Computation and Markomata in Economic Science," *Journal of Economic Behavior & Organization*, Markets as Evolving Algorithms, 63, no. 2 (June 2007): 209–42.
[35] Mirowski, *More Heat than Light*, 116. This structural resemblance is a case of what Simondon, in his allagmatic theory, calls a 'structural analogy.' For Simondon, structural analogy is based on an affective and emotive resemblance between structures and, for this reason, it is limited in accounting for the analogical operations that allow for evolution across different ontological realms. Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 119, 533.

theories of value and motion, postulated on the imperative of the conservation of energy in a body within an environment for the purpose of preserving stability.[36]

Mirowski suggests that the economic theory of value, and the formulas it produces, serve the function of resolving the problem of the commensurability of commodities in a market economy. They do this by allowing for a quantitative and causal analysis of value according to a scientific conservation principle justified within the triadic structure of body/motion/value. As the following section will discuss, money serves the purpose of concretizing the technic of exchange into a fully-fledged technology. Notwithstanding this, however, Mirowski shows that economics never pursued the metaphor of energy in physics fully, with important repercussions for the contemporary conceptualization of economic and monetary value. While physics, especially in the twentieth century, expanded the boundaries of experience to encompass quanta, micro- and macro-temporalities and spatialities, until the second postwar period neoclassical economics remained rooted in a concept of value indebted to Hamiltonian mechanics[37] that excluded the fundamental notion of entropy and most of the developments of twentieth century physics – thermodynamics, general relativity, quantum mechanics, and chaos theory.

As I will discuss in more detail below, entropy enters economic discourse after World War II and only through its fortuitous association with information theory and cybernetics. Yet, as Mirowski shows, economics misappropriated entropy, thereby impacting the notion of economic value up to today, with profound consequences for the 'evolution' of the social sphere. In order to understand the establishment of the current perception of value – that is, the assumptions underlying the contemporary understanding of value – and how that has impacted power formations, in the next section I turn to an analysis of the *medium* that instantiates such conceptualizations of

[36] In relation to the principle of the survival of the fittest, Mirowski further observes that "it is no accident that the overall framework resembles the principle of least action in physics, or indeed, the principle of the maximization of utility in neoclassical economics." Mirowski, *More Heat than Light*, 118.
[37] Hamiltonian mechanics is a reformulation of classical mechanics first articulated by William Hamilton at the end of the nineteenth century. While it predicts the same results as non-Hamiltonian classical mechanics, it relies on a different formalism that allows for a more abstract understanding of the theory. Hamiltonian mechanics differs from Newtonian mechanics as it describes energy in terms of potentials, and not in terms of substances and phenomenal quantities. See: Brian William Montague, "Basic Hamiltonian Mechanics" (CAS - CERN Accelerator School: 5th Advanced Accelerator Physics Course, Geneva: CERN Accelerator School, 1995), https://cds.cern.ch/record/399399/files/p1.pdf.

economic value as outlined by Mirowski – fiat money. Conceptualizing fiat money as the elementary technology of the capitalist ecosystem provides the means to grasp the transductive power of money in relation to the individual(iza)tion of economic thought and value systems. In the next section, after an introduction to Simondon's schema of the birth of technology and his analysis of the mechanist paradigm, my goal is to map out what kinds of relations with the world money embodies and how that has influenced perceptions of value.

2.3 Technics, Money, and Power: A Mechanist Approach to Value 'Storage' and Transmission

As I explained in the previous chapter, for Simondon technics[38] serve the purpose of instituting a code of correlation that allows for the system humanity-nature to function in a state of internal resonance.[39] Simondon reminds us that the individual must be grasped at its center, according to the operations of becoming and spatiotemporal structuration that constitute it – similarly, the individuation of the system humanity-nature can only be studied via an analysis of the operations of technics. Although technics are initially free, the system they create initiates a progressive closure of their freedom, until a technical invention inaugurates a new system based on a new code. In *Naissance de la Technologie* Simondon explains that, contrary to technics – which, in spite of its close relation with human essence, is an autonomous, and automated, mode of being radically different from the human – technology is entirely human. As I explained in the previous chapter, technics are found through the world and correspond to the concretization of the technical mode of relation into the coupling of gestures and tools. In contrast, technology is the fruit of the encounter between the Eastern, or Egyptian, technics and the *logos* of the Greek contemplative and theoretical sciences.[40]

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[38] As we saw, Simondon defines technics as the practical uses of different utensils. Commenting on Bernard Stiegler's discussion of Simondon's theory in *Technics and Time,* Andrés Vaccari states that: "The essence of the human, it seems, is the technical; which is paradoxically the other of the human: the non-human, the manufactured, unnatural, artificial; the inhuman even." This observation fits in nicely with the problematic posed by contemporary algorithmic finance, as I will illustrate in the following chapters. Andrés Vaccari, "Unweaving the Program: Stiegler and the Hegemony of Technics," *Transformations*, no. 17 (2009).

[39] Gilbert Simondon, "Naissance de La Technologie (1970)," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 176.

[40] Simondon traces the birth of technology in the West back to in the city of Alexandria around the year 300 BC. Ibid.

Following Simondon's classification – according to which technology evolves from the stage of the element, to the individual, to the system (or ensemble)[41] – money can be considered an elementary, therefore abstract, technology (i.e. a tool), which substitutes and quantifies the technic of exchange between human beings and nature.[42] According to Simondon, this originates in the 'debt' that humans have toward nature:

> We are natural beings that have a debt of technics [τέχνη *(techne)*] to pay the nature [φύσις *(physis)*] that is within us; the seed of nature [φύσις] that is in ourselves must expand in technics [τέχνη] around us. We cannot achieve our essence without getting the organizers that are in us to shine.[43]

In his monumental study on debt, David Graeber demonstrates that the introduction of coinage during the Axial Age (approx. 600 BC) paved the way for the quantification of the values of pre-existing "human economies." This further allowed for the rise of a "military-coinage-slave complex"[44] that typically increased debt. Coinage was possible with the discovery of metallurgy that, according to Simondon, anticipates and introduces the industrial schema of production, based on the complete transformation of minerals into metal and on an idea of teleological progress that misunderstands the role of the technical object, by subjecting it to the imperatives of human finality and production.[45] Rooted in the discovery of metallurgy, the industrial mode of production progressively concretizes during *la mécanique* – the mechanist era of the relation between humanity and nature.[46]

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[41] Simondon, *Du Mode*, 15.

[42] Simondon explains that the evolution of technical objects proceeds from the most abstract form to the concrete form. The former case is exemplified by the form of the tool, in which the technical object serves only a specific function dictated by a "theoretical and material unity," that prevents the elements of the object to achieve a state of internal resonance. A concrete technical object is instead characterized by a higher degree of internal resonance that allows the technical object to be used in different contexts (ibid., 21). As we shall see, in the case of money, this corresponds to an initial unity of functions that allows money to serve as a substitute for the technic of exchange in a local context. Counter-intuitively, with the diffusion of economic exchange at a planetary scale, money becomes increasingly concrete as it abstracts itself from the reality of exchange.

[43] Gilbert Simondon, *Sur la Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 24.

[44] David Graeber, *Debt: The First 5,000 Years* (Brooklyn: Melville House, 2012), 229.

[45] Simondon clarifies that metallurgy already displayed an industrial mode of production in the transformation of minerals into metals, while it remains artisanal in the making of the objects. Gilbert Simondon, "La Mentalité Technique," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 303.

[46] To Simondon, *la mécanique* corresponds to a new phase of Hermetism, the obscure movement that started with alchemy and encompasses processes such as distillation and metallurgy. "Hermetism corresponds to the moment in which human operation must take place in order to assure the correspondence, with the conservation of life and communication, between the macrocosm and the

The system that mechanics inaugurates supplants the generative *code* of correlation between the human and nature with a *law* – "the law of conservation of movement, the law of conservation of work"[47] – as a direct consequence of the development of human language and the theoretical sciences. Simondon explains that the law aims only for the domestication and regularization of nature via the anticipation of natural phenomena and the exploitation of work, thereby introducing a conception of mechanic teleological progress. This has created a system that progressively incorporates the discontinuum into a continuum that annihilates the necessary action of *kairos* – the "relative unpredictability [*le caractère relativement aléatoire*] of nature" [48] – in favor of a 'sense' of the necessity of the prediction and anticipation of relations, while at the same time foreclosing the freedom of technics, until a new invention inaugurates a new code. As Simondon suggests, with the development of mathematics and theoretical sciences, the language of the human (be it literary, political, mathematical, or scientific) has imposed the mechanist imperative of the conservation of energy on the autonomous *logos* of technology (that is, the chain of operations that allow for a technical system to work). This has contributed to the establishment of a transcendental *nomos*, which has supplanted the eco-logic code of correlation with an eco-nomic code. The birth of technology therefore marks the shift from an ecologic reality to an economic one. However, as will be made clear in the unfolding of this thesis, the passage to an economic reality, as a mode of organization, should not be conflated with the emergence of capitalism.[49]

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microcosm; hermetism corresponds to the technics that have achieved a closure [*techniques qui se ferment*] but that do preserve a necessary coupling between the unpredictable [*aléatoire*] and productive character of nature; the status of the operator reflects the character of this extraordinary coupling." "Naissance de La Technologie (1970)," 167. See also: Dan Mellamphy, "The Birth of Technology from the Spirit of Alchemy," *Platform: Journal of Media and Communication* 6 (2015): 108–16.

[47] Simondon, "Naissance de La Technologie (1970)," 170.

[48] Ibid., 166.

[49] The etymology of the term "economy" – the management (*nomos*) of the household (*oikos*) – seems to point precisely to this movement of domestication of nature. This is evident today too; both classical and neoclassical economic theory share the goal of predicting economic agents' preferences and behaviors in order to forecast market dynamics and production/consumption. Furthermore, the anticipation of market behaviours is one of the central tenets of financial trading. In this context, it is also worth mentioning Gilles Deleuze and Félix Guattari's distinction between *logos* and *nomos* in *A Thousand Plateaus*: "The *nomos* came to designate the law, but that was originally because it was distribution, a mode of distribution. It is a very special kind of distribution, one without division into shares, in a space without borders or enclosure. The *nomos* is the consistency of a fuzzy aggregate: it is in this sense that it stands in opposition to the law or the *polis,* as the backcountry, a mountainside, or the vague expanse around a city ('either nomos or polis')." While the authors associate the *nomos* with the smooth space occupied and constituted by the war machine, the *logos* is, in contrast, a different mode of distribution, which

According to Simondon's analysis there exist three major phases of mechanist progress. Starting with Cartesianism in the seventeenth century, the process of mechanization and domestication of nature intensifies throughout the eighteenth and nineteenth century – with the Enlightenment and Marxism respectively – transductively expanding in a horizontal movement to encompass more and more aspects of the world, first at the level of thought (with deductive sciences), then at the level of the entire individual (with pedagogy), and ultimately humanity as a whole.[50] This period also coincides with the individuation of the long capitalist era in the West, made possible by the advances in calculus and commercial infrastructures that allowed for the development of banking systems and the invention of fiat money. My proposition is that the bond between social and economic relations at the foundation of the capitalist ecosystem can be understood by starting from an assessment of the technical evolution of money and the axiomatic of signification that money has woven around its usage.

As I explained in the introduction, for Simondon signification is an aspect of individuation, and need not be conflated with language. Specifically, signification allows for the structuration of perception in relation to its milieu by giving a direction [*sens*] to the taxonomic unities that make up the world. As chapter four will further clarify, signification must be understood in 'chrono-topological' terms, as the morphogenetic process that constitutes "the very dimensionality of being,"[51] and that allows for the structuration of the perceptual axiomatic upon which collective, physical, psychic individuation rests.[52] Further, signification is immediately technical, in that it allows for "technical form-taking" by providing a specific configuration of matter, form, and energy.[53] Precisely, my goal in this chapter is to foreground the role of the technology of fiat money in the taking-consistency of the capitalist axiomatic of signification. As I explained in the previous chapter, François Laruelle calls the capacity of technics to give direction [*sens*] to perception "the sense of power," which is directly

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corresponds to the striated space of enclosure. Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 380.

[50] Simondon, "Naissance de La Technologie (1970)," 174.

[51] Simondon, *L'Individuation*, 227.

[52] Ibid., 223–28.

[53] Ibid., 52.

implicated in the concretization of the "onto-theo-politics"[54] that constitute the Principle of Power.

Economists Massimo Amato and Luca Fantacci advance a compelling critique of the architectural foundation of the contemporary political economy, focusing precisely on the functions of fiat money. As they explain, fiat money was introduced in Britain at the end of the seventeenth century with paper money and the institution of national central banking (and right after, cemented with the introduction of the gold standard).[55] With fiat money, money becomes "the commodity capable of performing *simultaneously* the three functions of a *measure of value*, a *means of payment and exchange*, and a *store of value*."[56] Thus, for the first time, money can be traded for a price and accumulated as credit, thereby acquiring the status of a commodity and entering the books as such – as a current, or liquid, asset.[57] Amato and Fantacci show that this shift was due to the rise of the capitalist class in parallel with a change in the needs of banks, states, and markets – that is, the need "to reconcile political *warfare* with economic *welfare*"[58] without subtracting funds to national production and trade. The Bank of England was established precisely for this purpose and in 1694 started issuing securitizations of public debt, thereby increasing debt without necessarily aiming to ever pay it back.[59]

[54] Laruelle, *Au-delà du Principe de Pouvoir*, 15.
[55] Massimo Amato and Luca Fantacci, *The End of Finance* (Cambridge: Polity, 2011), 183–96.
[56] Ibid., 37 (emphasis in original). Fiat money put the system of imaginary money to an end. The system of imaginary money is interesting because it is radically different from our contemporary money, yet its existence has been almost entirely forgotten since the introduction of fiat money and the current monetary architecture. Thus imaginary money deserves a certain attention. In contrast to fiat money, the system of imaginary money ruled through Europe for about a thousand years, from Charlemagne to Napoleon, and was based on a clear distinction between a material medium of exchange and an immaterial unit of account; for instance, in England, the Pound sterling as a unit of account was related to a pound of silver, yet that didn't exist materially in any particular coin. For this reason, it is called imaginary money, or 'ghost money,' for the actual unit of account maintained a ghostly existence. Initially, imaginary money was essentially a system of 'counting coins' on the basis of an immaterial unit, which subsequently, from the thirteenth century, turned into a system of evaluating large coins actually made of gold and silver. In contrast to paper money, imaginary money therefore had a double-sided architecture: on the one hand, there was a relationship between the ghostly unit of account and small coins, fixed within the State by civil law; on the other, there was a stable relationship between large coin and metal established by international agreements; but never, on either side, that fixed parity between unit and metal, that would only later prevail as the unique, national and international, gold standard. See: Luca Fantacci, "The Dual Currency System of Renaissance Europe," *Financial History Review* 15, no. 1 (April 2008): 55–72.
[57] Amato and Fantacci give a great little example to illustrate the issue at stake in the conflation of money of exchange and of account. As they put it: "When I ask for a metre of material, I want a piece of cloth one metre long, not a metre made of cloth" which is instead what happens with the conflation of measure and value. Amato and Fantacci, *The End of Finance*, 38.
[58] Ibid., 186 (emphasis in original).
[59] Amato and Fantacci explain that the Bank of England was established with the purpose of funding the war with Spain at the end of the seventeenth century. In order to do so, the Bank of England was endowed with a sum of capital corresponding to the money to be financed to the Crown (that was £1.2 million).

The genetic relation between finance and warfare will be a recurring theme throughout this thesis.

For Amato and Fantacci, capitalism relies structurally on the form of payment characterized by the function of money as a store of value that, via its translation into price, allows for the quantification and capitalization of the imponderable risk inherent in economic exchange.[60] Although Amato and Fantacci's full thesis goes beyond the scope of this dissertation, it is worth reporting one of their passages at length:

> The institution of money as a store of value makes it possible for saving to be entirely unconnected with the concrete goods and to take place rather through the constant and indefinite accumulation of abstract purchasing power, in the precise sense of *power independent of the fact of being concretely exerted* – so independent as to jeopardize the very possibility of being exerted.[61]

According to Laruelle, this process of abstraction empties Power of any theoretical transcendental meaning. In doing so, it validates the concept of power as a social and political construct – largely indebted to the market dynamics that determine the circulation of knowledge: "Like the older terms of Existence or Structure, but with more facility because it expresses fewer theoretical requirements …, [power] has conquered the grand capitalist style: as a concept, its practical value is virtually null, it is instead its exchange value, to which it is reduced, that makes its only possible usage."[62] It is in this way that money becomes the form of expression (the *logos*) of capitalist value. Money is *pouvoir d'achat* – purchasing power – the purchase of Power upon reality. More than that, as Amato and Fantacci aptly observe, money is "rather purchasing *potential* that can remain indefinitely in the state of potentiality."[63] My proposition in this chapter is

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The bank then issued securities to private investors and the money raised immediately was employed to finance the Crown's military expenses. Importantly, Amato and Fantacci explain that, in addition to lending money to the state, the Bank was granted the power to issue paper banknotes up to the total amount deposited by investors. This allowed for "a *potential duplication* of the sum deposited, which would contemporaneously support, in the form of gold, the sovereign's military outlay, and, in the form of paper, commercial transactions at the private level." Ibid., 188 (emphasis in original).

[60] Ibid., 52.

[61] Ibid., 42 (emphasis in original).

[62] Laruelle, *Au-delà du Principe de Pouvoir*, 1–2.

[63] Amato and Fantacci, *The End of Finance*, 37 (emphasis in original).

that fiat money, as the capitalist technology *par excellence*, constitutes the technical interface that has allowed for the concretization of such conceptions of value through different stages of the development of orthodox economic doctrine.

2.4 Economic Value and the *Logos* of Technics

But what kind of 'value' was stored in early fiat money? And how did that contribute to the taking-consistency of the capitalist ecosystem? As I explained above, for Simondon technology is born out of the encounter between the practical uses of different utensils (*techne*) and the *logos* of the Greek contemplative and theoretical sciences.[64] However, as he further clarifies, the autonomy of technics from scientific theories makes it so that "there exists a certain difference between the technical schema of the object (which entails the representation of a human finality) and the scientific charting of the phenomena on which it seats."[65] For this reason, technical objects are always out of step with themselves, maintaining a margin of irreducible indeterminacy that prevents them from being entirely subsumed into the "schemas of efficient, mutual, or recurrent causality" that characterized scientific modeling.[66] The beginning of the mechanist phase of technological development marks this divergence of goals and, as will be clear, values, between technics and science. The mechanist era is marked by the introduction of Cartesianism and rational mechanics in scientific thought in the seventeenth century. This impacted conceptions of energy and started to progressively divorce energy from the anthropometric triad body-motion-value that Mirowski identified as the origin of theories of value in antiquity. In order to understand the kind of 'value' that is stored in and transmitted by the monetary technology, an excursus into the historico-scientific specificities of the different economic theories of value is needed, in order to map the shift in conceptualization of economic value in relation to monetary value.

Mirowski identifies as 'proto-energetics' the phase of development of economic thought that begins at the end of the eighteenth century and continues up to the so-called marginalist revolution in 1870. Starting with the Physiocrats, and continuing with classical political economy – whose major exponents were Adam Smith, David Ricardo,

[64] Simondon, "Naissance de La Technologie (1970)," 176.
[65] Simondon, *Du Mode*, 36.
[66] Ibid.

and Karl Marx – this stage is characterized by a substantialist conception of value that is reflected in the labor theory as a rehearsal of the triad of body, motion, value. The commensurability of substances in a market system was granted and formalized by the concept of energy as differentially specified in the process of production, a notion indebted to rational mechanics and Descartes' and Leibniz's natural philosophy. Mirowski defines this phase as 'proto-energetics' because, contrarily to thermodynamics that was developing in those years, these accounts of energy-value allow for a certain reversibility of phenomena and experience that lies in the fact that time was considered isotropic.[67] This means that the magnitude of energy-value would remain invariant when measured in different directions, therefore accounting for a kind of commensurability not only between substances but also between substance and process (e.g. labor, production) – the latter understood as time-independent and in substantial terms.

The 'relational invention' of fiat money fits well with Simondon's analysis of the mechanist phase of technological development. As a technic that embodied the theoretical *logos* of rational mechanics (that is, the 'proto-energetic view), fiat money served the purpose of 'conserving' energy through exchange. Further, through its circulation, it performed the function of the *perpetuum mobile* that rational mechanics still upheld, thereby shifting the focus onto the productivity of work, both for the machine and for the operator.[68] The 'proto-energetic' substantialist view is reflected in the conceptualization of the materiality of monetary value, which was rooted in gold and commodity – external substances that granted the commensurability of exchange and the continuation of the relations between energy, body, and motion.

The so-called marginalist revolution of 1870 – independently pursued by economists William Stanley Jevons (UK), Léon Walras (Switzerland) and Carl Menger (Austria) – marked instead the beginning of neoclassical economics. With marginalism, economics abandoned its previous sociological and substantialist perspective and instead began to adopt an eminently scientific method in order to acquire universal objectivity. This shift marks the mathematization of value, which corresponds to the conceptualization of energy in physics as an integral – that is, a function of which another given function is

[67] Mirowski, *More Heat than Light*, 63.
[68] Simondon, "Naissance de La Technologie (1970)," 170.

the derivative. In this framework, the commensurability between commodities is not grounded in external substances; instead it becomes equated with the mind, the latter conceptualized as a vector field of force in an independently constituted commodity space.[69] Under this scientific paradigm, Mirowski explains: "Utility became the analogue of potential energy; the budget constraint became the slightly altered analogue of energy."[70] Mirowski argues that such a strictly mathematical formalism, imbued with the nineteenth century "neo-Kantian mandate to see number as an outgrowth of the a priori,"[71] caused for the law of marginal utility[72] to become ontologically equivalent to money "because they may be extensively added together and conserved in the process. One is merely transformed at determinate ratios into the other, just as potential energy becomes kinetic, and vice versa."[73]

As will become clear in chapter four, it is perhaps at this moment that price entirely subsumes value as a metric of worth and, with the equivalence between economic value and the mind, value thus retroactively constituted becomes the "unconscious of the social."[74] As Marshall McLuhan observes, it is in the eighteenth century that "the West began to accept this form of extension of its inner life in the new statistical pattern of marketing," which led to "the fragmentation of the inner life by prices."[75] Furthermore, it needs to be noted that, in spite of the mathematical formalism, this model implicitly reproposes the 'proto-energetics' of classical political economy, due to its understanding of the principle of conservation of energy as time-independent. However, the neoclassical doctrine repressed these implications due to the desire to ground the marginalist program into a natural, scientific, principle beyond the artificial medium of

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[69] Mirowski, *More Heat than Light*, 231–36.
[70] Ibid., 9.
[71] Ibid., 234.
[72] Marginal utility indicates the degree in which a commodity satisfies a consumer's needs and desires. From this conceptualization of utility, the law of diminishing marginal utility is derived, which corresponds to the diminishing return that the consumption of each additional unit of a same product yields. A textbook example to illustrate this logic is that of a buffet-style restaurant – the more one eats the less satisfaction one derives from the food, until overconsumption hits the point of 'disutility' for the consumer. "Law of Diminishing Marginal Utility Definition," *Investopedia*, January 6, 2004, http://www.investopedia.com/terms/l/lawofdiminishingutility.asp. A precursor of the notion of marginal utility is found in the work of Adam Smith. In *The Wealth of Nations* Smith identified the paradox of water and diamonds: water possesses a much higher marginal utility than diamonds but its economic value is considered inferior. Jack Russell Weinstein, "Adam Smith (1723 - 1790)," *Internet Encyclopedia of Philosophy*, accessed July 21, 2016, http://www.iep.utm.edu/smith/.
[73] Mirowski, *More Heat than Light*, 231.
[74] Roffe, *Abstract Market Theory*, 61.
[75] Marshall McLuhan, *Understanding Media: The Extensions of Man*, Reprint edition (Cambridge: The MIT Press, 1994), 137.

money. As I will discuss in the unfolding of this thesis, this paradox is reflected in the capitalist tendency to measure worth in terms of profit; a profit that, however, is never 'stable' but is understood in terms of differential accumulation, while spending is only contemplated in view of future returns. I will come back to this issue in chapter five.

To recap, the substantialist conception of energy of early rational mechanics led to an understanding of the value of money as a commodity – epitomized by the gold standard and by the Ricardian labor theory of value that aimed at the reinstantiation of the law of perpetual motion. This coincides with the early capitalist era in which economic value was equated with the physical ownership of the means of production. Further, the mathematization of economics during the marginalist revolution, with its adoption of differential calculus and the formalism of field theory, led to a conception of economic value as potential energy. This resulted in a conceptualization of marginal utility as differential value. Marginal utility thus understood allows for the commensurability between commodities on the basis not of external substances, as was the case with classical political economy, but founded instead in the mind of the economic agent, conceptualized as a field of force in a commodity space. This is when value becomes increasingly conceptualized as the expression of a sovereign mind – a value by fiat.[76] Thus, the process of quantification, abstraction, and acceleration for economic purposes triggered by fiat money has favored the progressive individuation of the capitalist axiomatic of signification – that is, the sense of capitalist power based on a conception of economic value that is both progressively interiorized and amplified to other realms of existence.

Yet, as Simondon explains, one should not conflate technical value with economic value. Economic value relates to the *logos* of the mechanical sciences applied to the technic of exchange. As will be further clarified later on, however, the genetic and normative autonomy of technics in the relation between the human and the world cannot

[76] The Chartalist school of monetary theory, founded by Georg Knapp at the beginning of the twentieth century and supported by Keynes, marks the passage from the 'metallist' theorization of intrinsic monetary value to a conceptualization of monetary value established by fiat by the institution that issues it, that is, the State. See: Charles A. E Goodhart, "The Two Concepts of Money: Implications for the Analysis of Optimal Currency Areas," *European Journal of Political Economy* 14, no. 3 (August 1998): 407–32; Bjerg, *Making Money*, chap. 3.

be subsumed to human scientific schema and affective predispositions.[77] As previously mentioned, the development of neoclassical economics marks a rupture with the triadic equivalence of energy with body, motion, and value. Yet this is partly due to the incapacity of neoclassical economics to embrace the scientific precept of the formalism – the shifting conceptualization of the principle of the conservation of energy in physics. As a matter of fact, while thermodynamics was already well known in the scientific domain, the Neoclassicals neglected to appropriate its novelty and the implications of the second law, which postulates the irreversibility of time and energy transfer. The reasons for this oversight are mainly cultural, as Mirowski explains[78] – the notion of entropic disintegration and heat death of the universe were antithetical to the neoclassical doctrine of orderly 'natural' progress and Darwinian evolution. Furthermore, the second law of thermodynamics clashed with the neoclassical emphasis on exchange as a reversible process of value circulation. Neoclassical economics' cultural norms also constrained and inhibited the embrace of relativity and chaos theory: "Insofar as neoclassical economics is committed to the doctrine of scarcity and the denial of a free lunch, then it is bound to renounce the mathematical metaphor of a relativistic field."[79] This is because relativity and chaos theory suggest that, in certain cases, something *may* come from nothing – for instance, the theory of cosmic inflation explains the birth of the universe in these terms.[80] Thermodynamics enters the orthodoxy's research program only after the second postwar period, and only after entropy becomes recoded in terms of information and economics turns into a "cyborg science."[81]

Hence, the misunderstandings underlying the concept of economic value are reflected in the kind of 'value' that is stored in and transmitted by fiat money. However, as will be

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[77] As mentioned above, Simondon critiques the scientific mode of enquiry that relies on affective resemblance and structural analogy, instead of focusing on the operational and transductive nature of scientific thought. Simondon, *L'Individuation*, 119.
[78] Mirowski, *More Heat than Light*, 389–90.
[79] Ibid., 391.
[80] Mirowski reports a passage from Alan Guth, the theoretical physicist and cosmologist who, in the 1980s, formulated the theory of cosmic inflation, which illustrates this concept well: "Probably the most striking recent development in the study of cosmogeny is the realization that the universe may be completely devoid of all conserved quantum numbers. If so, then even if we do not understand the precise scenario, it becomes very plausible that our observed universe emerged from nothing or from almost nothing. I have often heard it said that there is no such thing as a free lunch. It now appears possible that the universe is a free lunch." Guth in ibid., 98.
[81] Philip Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (Cambridge: Cambridge University Press, 2002).

made clear later on, the technical value of the latter cannot easily be subsumed into the former. This is evidenced by the fact that, in the modern era, theories of commodity, fiat, and credit money constantly overlap, as I explained in the introduction. As Amato and Fantacci observe, this confusion is inherent to the monetary architecture of fiat money that, as mentioned above, allows for the fluidification of the relations of debt and credit while at the same time provides the means for their commodification, quantification, and capitalization.[82] In order to understand how the digital further complicates conceptions of monetary, and hence economic, value one needs to turn to an assessment of the scientific advancements introduced by cybernetics in the second postwar period, which will be the focus of the following sections.

2.5 Foundations of Cyborg Economics: Entropy, Information, and the Emergence of Schizo-Capital

The abstract circulation of value that fiat money affords has evolved with its underlying technological developments, weaving a signifying infrastructure of the sense of power that has progressively amplified to different fields of life. Cybernetics made important contributions to this evolution. In *La Mentalité Technique* Simondon explains that cybernetics introduces a "cognitive schema" radically different from Cartesian mechanics.[83] At the time of his writing, Simondon could only speculate about the paradigmatic shift cybernetics would bring about. However, he could sense the import of "this new macrocosmic closure":

> Its contours are still blurred; it contains elements of both science fiction and strategic concerns; it tends to become, if not a sacred art as the first hermetism, at least a monopoly of great powers [*puissances*] attempting to forecast their future.[84]

Interestingly, for Simondon, cybernetics gave a general intelligibility to the complex system in multiple states of equilibrium envisioned by Marx – that is, socialism. Yet in doing so, it also initiated the rhetoric of uncontested flow upon which contemporary

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[82] Amato and Fantacci, *The End of Finance*, 35–42.
[83] Simondon, "La Mentalité Technique," 296.
[84] Simondon, "Naissance de La Technologie (1970)," 171.

power thrives. Specifically, for Simondon, cybernetics constitutes the formalization of the Marxist cognitive schema, a third phase of mechanism. As Simondon explains, Marxist dialectics introduced a break in the continuum instantiated by the law of the human. However, by applying the concept of revolution to all social groups, “it integrated the discontinuous [into the continuum] … so much so that socialism could be considered as the completion of mechanist progress.”[85] Yet this completion also allows for the amplification of neoclassical economic value. As a matter of fact, the integration of the discontinuous into forms of continuity is also the main feature of the contemporary topological mode of control that I explained in the introduction. With the intertwining of neoclassical economics with cybernetics, the current conception of economic value further amplified to the whole planet and beyond in a horizontal movement – as the recent neoliberalization of space research demonstrates. Specifically, Simondon presciently noted that, with cybernetics, “as a consequence of the saturation of the Earth that became a microcosm, the real cosmos opens up to [*est plus vaste pour*] technics.”[86] The recent efforts of private space enterprises such as SpaceX and Deep Space Industries, just to name a few, constitute some of the most salient manifestations of this shifting configuration of powers: “it is no longer a State monopoly, but it is rather about the constitution of a network of small groups – scientists and technicians – that think the becoming of humanity in relation to the whole biosphere.”[87]

In order to understand the changes in the sense of power introduced by cybernetics, evidenced by these shifts in worldview and modes of organization, one needs to understand the conceptual changes that newer concepts of information and energy brought to the economic discipline and to the physical sciences themselves. As Mirowski demonstrates, “’information,’ ‘memory,’ and ‘computation’ become for the first time *physical* concepts”[88] and soon became almost synonymous with each other:

> In order to forge an alliance between entropy and information, Claude Shannon had to divorce information from any connotations of meaning or semantics and instead associate it with “choice” from a preexistent menu of symbols. “Memory” then became a holding pen for accumulated message

[85] Ibid., 174–75.
[86] Ibid., 171.
[87] Ibid., 175.
[88] Mirowski, *Machine Dreams*, 16 (emphasis in original).

> symbols awaiting utilization by the computational processor, which every so often had to be flushed clean due to space constraints. The association of this loss of memory with the destruction of "information" and the increase of entropy then became salient.[89]

In this kind of thinking during the second postwar period, cybernetics, operation research, and economics started to intermingle and exchange ideas, as Mirowski brilliantly describes in *Machine Dreams*. It is at this moment that the concept of entropy in thermodynamics entered the economic orthodoxy through the mathematical theory of information in a rather fortuitous way.[90] Before moving to information, however, it is important to grasp the understanding of entropy in cybernetics. Specifically, entropy in cybernetics was marked from the outset by a double meaning derived by Norbert Wiener's discussion in *The Human Use of Human Beings*.[91] In his explanation of entropy in the thought experiment of the Maxwell's demon, Wiener wonders whether the demon that defeats entropy is Manichaean or Augustinian:[92]

> The Manichaean devil is an opponent, like any other opponent, who is determined on victory and will use any trick of craftiness or dissimulation to obtain this victory. In particular, he will keep his policy of confusion secret, and if we show any signs of beginning to discover his policy, he will change it in order to keep us in the dark. On the other hand, the Augustinian devil, which is not a power in itself, but the measure of our own weakness, may require our full resources to uncover, but when we have uncovered it, we have in a certain sense exorcised it … The Manichaean devil is playing a

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89 Ibid.

90 Mirowski reports the genesis of the relation between entropy and information theory in the following anecdote: "In a widely circulated story, it is reported that von Neumann told Shannon to link his nascent theory of information to thermodynamics: 'You should call it 'entropy' for two reasons: First, the function is already in use in thermodynamics under that name; second, and more importantly, most people don't know what entropy really is, and if you use the word 'entropy' in an argument you will win every time!'" Tribus in Machlup & Mansfield in ibid., 68.

91 Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (New York: Avon Books, 1967).

92 The Maxwell's demon is a thought experiment in thermal and statistical physics devised by James Maxwell that suggested that the Second Law of Thermodynamics (the law that states that entropy in the universe tends to a maximum) could be violated. In the thought experiment, a demon controls a door between two rooms filled with gas particles. As the particles move close to the door, the demon quickly opens and closes the door so that only the fastest (hottest) molecules can pass into the other room, thus resulting in one hot room and one cold room and disproving the Second Law. This is explained by Mirowski in: Mirowski, *Machine Dreams*, 47.

> game of poker against us and will readily resort to bluffing … as von Neumann explains in his *Theory of Games* … Compared to this Manichaean being of refined malice, the Augustinian devil is stupid. He plays a difficult game, but he may be defeated by our intelligence as thoroughly as by a sprinkle of holy water.[93]

This double understanding of entropy – on the one hand, the unpredictable but benevolent forces of 'Nature' and, on the other hand, an enemy force to be countered through human cunning – marked the subsequent development of neoclassical 'cyborg' economics in several ways, as Mirowski further remarks.[94] With the conflation of entropy and choice by way of Shannon and Weaver,[95] traces of Augustinian entropy can be detected in the assumptions underlying, for example, Kenneth Arrow's Impossibility Theorem that proved the statistical incompatibility of democracy with collective rationality.[96] However, as it did so, such a theorem also provided a justification of the subsequent rise of neoliberal control through emergence (with a switch to Manichaean 'devilishness') that I will further discuss in chapter six. Indeed, the Manichaean version of entropy progressively pervaded more and more aspects of operation research especially during the Cold War – from game theory to monetary policy.

The conflation of information with (Manichaean) entropy turns money into a negentropic technology,[97] while markets started to be conceptualized in terms of information rather than prices, and the economic agent became conceptualized as a "processor of information."[98] From this standpoint, cyborg economics aimed to create order from the chaos and decay of economic exchange through negative feedback – an issue I will return to in chapter five when discussing contemporary markets. As Norbert Wiener put it, "life is an island here and now in a dying world. The process by which

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[93] Wiener, *Human Use of Human Beings*, 50–51 (emphasis in original).
[94] Mirowski, *Machine Dreams*, 55–58.
[95] As Mirowski shows, information appropriated entropy with certain caveats: "Another way of seeing how the metaphor of entropy does not carry over entirely unaltered into Shannon's version is to realize that thermodynamic entropy is a measure of the number of ways the unobserved (and therefore probabilistic) micro-dynamics of molecules can make up a measurable macrostate, like temperature. In Shannon's version, there is no macro-micro distinction, only a given probability of a particular symbol showing up, and a measure of the likelihood of strings of symbols. This is often rephrased by suggesting that Shannon's entropy is about 'choice' of symbols." Ibid., 72.
[96] Ibid., 302.
[97] This is evidenced also by classic economic textbooks, such as: Charles Goodhart, *Money, Information and Uncertainty* (Cambridge: The MIT Press, 1989).
[98] Mirowski, *Machine Dreams*, 7.

we living beings resist the general stream of corruption and decay is known as *homeostasis.*"[99]

Thus cybernetics inaugurated the process that would lead to the financialization of life by initiating economics to the "mantra of C^3I"[100] – communication, command, control, and information. Yet it did so with the utmost disregard for the natural resources that have allowed for the development of economic activity in the progress of humanity. By redefining the contours of what was to be considered 'natural' and *how* Nature operates – that is, by ways of codified, 'deceitful' algorithms operated by a Manichaean demon – the 'cyborg economics' born out of the encounter between neoclassical doctrine and cybernetic research severed much of the relation between humanity and world. It did so by leaving the world (that is, the Augustinian devil) out of the equation and replacing it instead with its simulation, thus treating technology as an end in itself rather than a *medium* between human beings and world. This may start to provide some explanation for the contemporary misalignment between the conception of value underlying economic progress and the ecological catastrophe identified at the beginning of this chapter. Specifically, the conceptualization of 'nature' as a Manichaean demon marks the moment in which nature is only *valued* as an 'enemy' to be fought at all *costs*.[101]

It is also important to note that Shannon and Weaver's theory of information, that cybernetics embraced uncritically, was profoundly reductive in Simondon's view as it was based on a probabilistic paradigm that eradicated any notion of signification from its calculation – or at least tried to, as Mirowski shows.[102] As already explained in

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99 Wiener, *Human Use of Human Beings*, 130 (emphasis in original). The presence of the concept of negative feedback in economics has been foregrounded by George Richardson. As he points out, the concept predates cybernetics and it is found in Adam Smith as one of the foundational mechanisms of laissez-faire economics. Further, it is present in Keynes and in Herbert Simon's theory of bounded rationality. George P. Richardson, "The Feedback Concept in American Social Science, With Implications for System Dynamics" (International System Dynamics Conference, Chestnut Hill, Massachusetts, 1983), http://www.systemdynamics.org/conferences/1983/proceed/plenary/richa001.pdf; George P. Richardson, *Feedback Thought in Social Science and Systems Theory* (Waltham: Pegasus Communications, 1999).

100 Mirowski, *Machine Dreams*, 158. As Mirowski shows, the C^3I mantra originally started in the military but was soon carried forward in science and economics in the second postwar period.

101 As Mirowski shows in the unfolding of *Machine Dreams*, the understanding of nature in Manichaean terms is mainly due to von Neumann's view. For Wiener instead "the devil whom the scientist is fighting is the devil of confusion, not of willful malice. The view that nature reveals an entropic tendency is Augustinian, not Manichaean." According to von Neumann, instead, entropy is instantiation of the Manichean demon. Wiener, *Human Use of Human Beings*, 259.

102 Shannon and Weaver's theory of information conflated information with the statistical definition of entropy and, in doing so, eliminated any notion of meaning from information. However, as Mirowski

chapter one, for Simondon information is a process – it is "the formula of individuation"[103] and cannot be reified into a finite object. The cybernetic understanding of information has persisted to this day and is what fuels the computational operations that have given rise to the complex network that makes up the World Wide Web. However, as Andrei Sorin observes, "our software-related pursuits – the so-called information technology revolution, the activities we identify with progress and the future – are steeped in a naive, seventeenth-century mechanistic mentality."[104] Ironically, the probabilistic conception of information, as a remnant of the mechanist paradigm of technological evolution, is what prevented some of the other groundbreaking discoveries of cybernetics to establish a radically new "mode of functioning"[105] at ecosystemic level.

Indeed, the attempts to reify information according to what Sorin identifies as the mechanist fallacy of reification, which I introduced in the previous chapter, have prevented the cybernetic cognitive schema from establishing a new 'hermetism' of technological development.[106] Interestingly, Sorin relates the fallacy of reification to the treatment of schizophrenia:

> The failure of schizophrenics to connect mental structures is described by psychiatrists with such terms as 'disconnectedness,' 'thought blocking,' 'concreteness,' and 'overinclusive thinking.' The term 'reification' is sometimes used – the term we adopted for the fallacy of ignoring the interactions in a complex structure.[107]

In the intent to replace mind functions with software, in the hope of creating 'machines that can think,' following Sorin's argument, cybernetics created schizophrenic

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remarks, the conflation of information with choice, and subsequently with memory brought back semantics "from the back door." Mirowski, *Machine Dreams*, 72.

[103] Simondon, *L'Individuation*, 31.

[104] Andrei Sorin, *Software and Mind: The Mechanistic Myth and Its Consequences* (Toronto: Andsor Books, 2013), 73.

[105] Simondon, "La Mentalité Technique," 296.

[106] Speculating on the shifts introduced by cybernetics, Simondon observes that "the first hermetism was pharaonic; the second, coming from the tool through mechanics, has been close to labor [*a été près du travail*]; how will the third situate itself? – perhaps in a dialectical relation with the preceding two." Simondon, "Naissance de La Technologie (1970)," 171–72.

[107] Sorin, *Software and Mind*, 179.

machines[108] – a tendency that has been historically documented by Philip Mirowski. In his brilliant account of the development of mathematical economics, Mirowski shows that the history of modern economics is in essence a history of machines and madness. It is the history of machines that push the limits of thought beyond the human sensorium to come to term with the infinity of the universe and the randomness at the heart of reason.[109] The conflation of a numeric notion of marginal utility with mind and money sealed this unlikely union between the mechanical conception of monetary (and hence, economic) value and its perception as a finite entity. My proposition is that money thus understood as, on the one hand, the concretization of a perfectly quantifiable abstract economic value and, on the other hand, as the embodiment of "a 'logic of desire,' a formalism 'mainly concerned with quasi-psychological or even logistical concepts like 'decisions,' 'information,' 'plans'"[110] amplified the perception of power *as* ecosystemic control through the *usage* of, and daily engagement with, money and economic calculation.

2.6 Turning Point: Toward a New Technical Paradigm?

Today the acceleration of economic activity has reached the point of liquefaction – pure flow. As chapter four discusses, liquidity has become the precept of financial trading. The more circulation, the more capital is produced. This has generated an all-encompassing acceleration that has transductively impacted all fields of life through a "horizontal movement of extension through generalization."[111] On the one hand,

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[108] This is the thesis famously articulated by Deleuze and Guattari in the two volumes of *Capitalism and Schizophrenia,* especially in the *Anti-Oedipus.* As the authors explain, "the theory of schizophrenia is formulated in terms of three concepts that constitute its trinary schema: dissociation (Kraepelin), autism (Bleuler), and space-time or being-in-the-world (Binswanger)." However, as Deleuze and Guattari argue, "before being a mental state of the schizophrenic who has made himself into an artificial person through autism, schizophrenia is the process of the production of desire and desiring-machines." For this reason, schizophrenia provides a fruitful entry point into the low-level connections of desiring-production that constitute reality. Deleuze and Guattari, *Anti-Oedipus*, 22–24.

[109] Mirowski shows that a lot of the scientists and economists that defined the contours of the new economic science in the second postwar period suffered at some point from episodes of mental instability – John Nash, Alain Lewis, Gerald Kramer, but also John von Neumann in the last years of his life, are some prominent examples. Interestingly, the above names were all related to game theory and the computation of public choice. "The very aspects of the Cold War that rendered the mathematical codification of rationality as the ultimate Thule of intellectual distinction … also dictated that the metallic tincture of madness would glint behind almost every formal argument in this period." Mirowski, *Machine Dreams*, 245.

[110] Morgenstern in ibid., 126. Oskar Morgenstern wrote *Theory of Games and Economic Behavior* with John von Neumann.

[111] Simondon, "Naissance de La Technologie (1970)," 171.

"technical *réseaux*" play an increasingly fundamental role in constituting, supporting, and modifying the planetary infrastructure;[112] on the other hand, we are witnessing the seeming demotion of politics in favor of a pervasive monetization and generalized algorithmic trading (of currencies, commodities, derivatives, personal and non-personal data, cognitive labor, personal relations, etc.) that indeed seem to make the process of individuation follow market dynamics. Whereas fiat currency could be considered a first instance of algorithmic technology, as Paolo Totaro and Domenico Ninno argue,[113] today algorithms perform the function of universal *numéraire.* While the production of value is increasingly bequeathed to ranking algorithms, rather than to labor, that operate an exploitation of cognitive capital beyond the scope and method of any major political-economic theory,[114] the social sphere is exposed to the contingency of price in financial markets, as demonstrated by the 2008 global recession and 2010 Flash Crash. Supposedly, we live in a quantified world. Transactions don't need to 'take place' – they deterritorialize in the market to reterritorialize again in the socius as numbers, as price.

To recap, in this chapter I have traced the genealogy of modern economic theories of value as related to the concept of energy in the natural sciences, and inscribed it in Simondon's schema of the mechanist phase of technological development. This period coincides with the invention of fiat money – the kind of money we still use today – whose novelty is the embeddedness of the function of store of value in its architecture. Following Amato and Fantacci, I have described fiat money as the most elementary capitalist technology, as the medium of storage and transmission of the value of economic exchanges. My argument is that fiat money has contributed to the

[112] Benjamin Bratton defines the "stack" as a kind of Simondonian technical *réseau*: "Planetary-scale computation takes different forms at different scales: energy grids and mineral sourcing; chthonic cloud infrastructure; urban software and public service privatization; massive universal addressing systems; interfaces drawn by the augmentation of the hand, of the eye, or dissolved into objects; users both overdetermined by self-quantification and exploded by the arrival of legions of nonhuman users (sensors, cars, robots). Instead of seeing the various species of contemporary computational technologies as so many different genres of machines, spinning out on their own, we should instead see them as forming the body of an accidental megastructure … This model is of a Stack that both does and does not exist as such: it is a machine that serves as a schema, as much as it is a schema of machines." Benjamin Bratton, "The Black Stack," *E-Flux* 3 (2014), http://www.e-flux.com/journal/the-black-stack/. The individuation of the stack as a technical ensemble affects the individuation of both human beings and nature, and vice versa.
[113] Paolo Totaro and Domenico Ninno, "The Concept of Algorithm as an Interpretative Key of Modern Rationality," *Theory, Culture & Society* 31, no. 4 (March 2014): 29–49.
[114] Matteo Pasquinelli, "Google's PageRank Algorithm: A Diagram of the Cognitive Capitalism and the Rentier of the Common Intellect," in *Deep Search: The Politics of Search Beyond Google*, ed. Konrad Becker and Felix Stalder (New Jersey: Transaction Publishers, 2009).

establishment of the capitalist axiomatic of signification, which corresponds to the taking-consistency of an understanding of economic value derived from the concept of energy in the natural sciences. As a technology, fiat money has served the purpose, from the seventeenth century onward, of storing and transmitting value thus conceptualized across markets and, by doing so, has amplified a certain understanding of the world more or less truthfully inspired by physics. I have then described the development of the capitalist ecosystem from the perspective of Simondon's schema of the mechanist development of technology, precisely from the seventeenth century to the mid-twentieth century. As Simondon notes, the cybernetic project introduced a break in the mechanism phase of technological development by establishing a novel schema that, while on the one hand furnished the metamodel for the neoliberal project, reinforcing the idea of teleological progress connected to the concept of Darwinian evolution that still underlies financial markets, on the other hand has the potential to give rise to a veritable invention in our mode of relating to 'Nature.'

Above I have described the two main novelties introduced by cybernetics and soon incorporated into neoclassical economics: the concept of information and the thermodynamic notion of entropy. Shannon and Weaver's theory of information reified information into a finite probabilistic entity and conflated it with the statistical definition of entropy. At the same time, the concept of entropy itself became subjected to a shift in meaning following Norbert Wiener's comment in *Human Use*. Due to Wiener, and especially John von Neumann, the understanding of entropy moved from being a mere natural law that determines the degree of randomness in a system, to a 'game of poker' to be played with Nature by annihilating its unpredictability and intrinsically deceptive character. From this point onward, the diagram of power morphed into a horizontal network aimed at the differential accumulation of energy, embodied by money, in order to destroy the Manichaean enemy by increasingly generating 'order' in a homeostatic way. Therefore, while, on the one hand, cybernetics (and the cyborg economics that derived from it) has reinforced some of the features of capitalist power (e.g. financialization, control), on the other hand, it has also radicalized the schizophrenic character of capitalism.

Given the unprecedented alliance between economic and technological forces today, it is possible to understand how today capitalist power 'makes more sense' than anything else – the system of signification it has established seems impregnable. Yet following Simondon, technology cannot ever be entirely axiomatized by economic forces. Although for Simondon cybernetics constitutes a further phase in the mechanist evolution of technics, he also lets transpire that it may inaugurate a new era of technological development. This is due to the instantiation of a "movement of thought"[115] that would contribute to the development of a technical mentality – a thought-network, that is, "the material and conceptual synthesis of particularity and concentration, individuality and collectivity."[116] As a matter of fact, cybernetics has furnished the cognitive schema for the invention of post-industrial technical objects – that is, technical objects such as information and telecommunication networks that eschew the foreclosing mechanist schema that the *logos* of the sciences has imposed upon technics.[117] Simondon describes post-industrial technical objects as the unity of two layers of reality – one stable and permanent, which adheres to the user, and the other modular, impersonal, mass-produced by industry and distributed by all the networks of exchange.[118] The "reticular structure"[119] that characterizes post-industrial technical objects makes them open and participatory. While Simondon was mainly referring to telecommunication networks such as phone cables and antennas, contemporary digital objects epitomize post-industrial technology. As I will explain in the unfolding of this thesis, not only do digital objects possess a seemingly stable layer, manifested by the sensible forms that appears at the interface, but they are also constituted by the fuzzy operationality of information that extends below the surface and opens digital objects to the 'participatory' reality of incomputable relations.

This openness of post-industrial objects is reflected in the technological changes that the capitalist ecosystem has undergone since the 1970s, as I described in the introduction. As Amato and Fantacci note, following the end of the Bretton Woods system in 1971 and the establishment of the early electronic exchanges, capitalist money becomes increasingly in conflict with itself, being at the same time a measure of debt and a means for its repayment; a form of supposedly 'safe' saving, and an investment

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[115] Simondon, "La Mentalité Technique," 302.
[116] Ibid., 307.
[117] Ibid., 303.
[118] Ibid., 311–12.
[119] Ibid., 311.

characterized by an irreducible risk – perhaps another instance of the schizophrenic character of the capitalist *modus operandi*.[120]

The next chapter will investigate in more depth how the shifting materiality and the value immanent to post-industrial technical objects have impacted the value and operations of money. As Simondon remarks, post-industrial technical objects constitute a turning point in the evolution of technology and may provide the means to establish a new ecosystem of power. In order to investigate if, and how, what I have defined in the introduction as digital money has the potential to challenge the present political-economic axiomatic through the material transposition of money to the digital plane, in the following chapter I turn to an analysis of the strange materiality, or concrete abstraction of the digital, drawing on Yuk Hui's theorization of digital objects that, in turn, is informed by Simondon's philosophy. As will be made clear in the next chapter, the post-industrial phase of technological evolution has affected the very technicity of money by inaugurating a new 'regime of functioning' that, while on the one hand may have strengthened capitalist power, on the other hand has the potential to divorce the technical value of money from the value that the *logos* of the 'dismal science' has imposed on it since the seventeenth century.

[120] Amato and Fantacci, *The End of Finance*, 89.

3. On the Mode(s) of Existence of Digital Money

Money itself isn't lost or made,
it's simply transferred from one perception to another –
Gordon Gekko, Wall Street[1]

3.1 The Cybernetic Paradigm and the Invention of Digital Money

In the previous chapter I started investigating how fiat money has been implicated in the development of the capitalist sense of power. It did so by weaving an axiomatic of signification around its usage and circulation that amplified a perception of value indebted to the mechanical view of the world initiated by Descartes. This is because, as I have explained through Philip Mirowski's work, economics has mapped its theorization of value on the physical concept of energy in physics. In the three hundred years since its introduction, fiat money – as a technology of value storage and transmission – has been instrumental in the individuation of capitalism as a mode of relation in the ensemble constituted by humanity and nature. I have also suggested that the ideas of teleological progress and transfer without losses implicit in the orthodox conceptualization of economic value have profoundly impacted the ways in which economic forces have approached the environment. Furthermore, I have introduced the cybernetic cognitive schema and suggested that the shifting conceptualizations of information and entropy that cybernetics introduces have affected economic theory and value. This turned money into a negentropic technology, whose goal was to bring order to the economy through negative feedback, and the economic agent into an information processor. At the end of the previous chapter, however, I showed how this novel conceptualization of the economy has progressively uncovered discrepancies and paradoxes in postwar economics. I have argued that this is because the technical value immanent to "post-industrial technical objects"[2] – the technical objects introduced by cybernetics, that have progressively led to what I have called 'digital money' – cannot be entirely axiomatized under the mechanist schema indebted to neoclassical economics.

[1] Oliver Stone, *Wall Street*, 1987.
[2] Gilbert Simondon, "La Mentalité Technique," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 311.

While chapter two has dealt with economic value – the *logos* that the physical sciences have imposed upon the technic of exchange concretized by money – in this chapter I will focus on the specificities of the technical value of cybernetics technology, in order to understand how its normative and genetic autonomy impacts the technic of economic exchange and challenges the capitalist axiomatic. As I explained in the previous chapters, for Simondon cybernetics introduces a paradigmatic shift in the evolution of technical objects and can be considered a veritable technical invention, which marks "the beginning of a lineage of technical objects."[3] A true invention disrupts the previous order and establishes a new one through the insertion of an "intrinsic and absolute"[4] normativity. This alone instantiates change in collective and individual values and exigencies, precisely by modifying the axiomatic of signification that underlies the individuation of a system.

Building on these premises, this chapter proposes that the invention of digital networked technology has disrupted the very ontological constitution of fiat money, thus troubling the capitalist axiomatic of signification and the sense of power it has established. To illustrate my argument, below I discuss the changes in the technicity of fiat money introduced with the passage from paper to digital, in order to foreground how the shift in the materiality of money has impacted its value. Secondly, I focus on the materiality of the digital informed by Simondon's realism of relations and Yuk Hui's work on digital objects, and analyze the process of reification that digital money has undergone since its inception and how that has impacted the capitalist axiomatic. Subsequently, I present the case of digital money in two of its material manifestations – over-the-counter (OTC) derivatives, as an instantiation of fiat currency, and Bitcoin – informed by Gilbert Simondon's enquiry in the mode of existence of technical objects and Yuk Hui's analysis of digital objects.[5] This provides a novel understanding of the materiality of the value of money that is neither reducible to commodity-substance nor to fiat-expression. Following Simondon's realism of relations, my goal is to foreground how the materiality of the forms through which exchange is actualized in the digital realm challenges the capitalist axiomatic of signification and the corresponding sense of

[3] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 43.
[4] Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 341.
[5] Yuk Hui, *On the Existence of Digital Objects* (Minneapolis: University of Minnesota Press, 2016).

power. In other words, I aim to uncover the 'technical value' of digital technology and explore how this troubles not only orthodox understandings of monetary value, but also the very power structure built around the architecture of fiat money – that is, as the previous chapter illustrated, capitalism. This is because, as I suggested in chapter two, technical value can never be axiomatized under economic considerations. In the following chapter I further pursue this trajectory in order to investigate how this has in turn affected the functioning of markets.

3.2 The Matter with Money: Technical Value from Paper to Digital

Chapter two mapped the relation between economic theories of value, conceptualizations of energy in the physical sciences and theories of money. The theory of commodity money, articulated by classical political economy but existing since antiquity, is linked to an idea of value as an external substance, which is indebted to Cartesian mechanics and finds its manifestation in the gold standard. However, the introduction of field theory and Hamiltonian mechanics shifted the understanding of economic value to the mind, understood as a vector in an independently constituted commodity space. This is the conceptualization of value supported by neoclassical economics and instantiated by marginal utility. From this point onward, economic value becomes an internal faculty of the human mind, which is expressed through exchange. Further, with the Chartalist theory of money, the expression of economic value by fiat becomes solely a prerogative of the State as the centralized sovereign mind governing economic, political, and social life.

These different understandings are reflected in the material support that has allowed for money to store and transfer value. As a matter of fact, the introduction of fiat money in the seventeenth century was accompanied by a change in the materiality of the money object – from gold (and other metals) to paper. As Brian Rotman notes, paper money introduces a closure from which a meta-subject emerges. With paper money, money becomes "depersonalised, freed from the attachment to a spatially particularised viewer or owner."[6] This closure also collapses "the illusion of anteriority [of things to signs] … at exactly the point when the printed bank note is recognised as an instrument for

[6] Brian Rotman, *Signifying Nothing: The Semiotics of Zero* (Stanford: Stanford University Press, 1993), 47.

creating money."[7] As a matter of fact, while "the value of [gold] money must be determined by the quantity of metal it contains; that is, it returns to what it was before, when princes had not yet stamped their effigy or seal upon pieces of metal,"[8] paper money introduced the notion of "a manipulated and 'manipulable' money"[9] – a money that can be manufactured at will. Thus, the passage to paper, as the material support that instantiates the technics of exchange, marks a shift in the technicity that money embodies. As Simondon puts it, "in order to understand technicity, it is insufficient to start from the constituted object; objects appear at a certain moment but technicity precedes them and exceeds them; technical objects result from an objectification of technicity."[10] From this standpoint, the 'value' of money precisely corresponds to the technicity objectified – reified – in the money object.

However, while Rotman concerns himself with signs, following Simondon's approach I want to shift the focus from signs, and even signals, to signification. Simondon explains the crucial difference between signals and signification as follows:

> Signals are spatial or temporal; a signification is spatio-temporal; it has two senses, the one in relation to a structure and the other in relation to a functional becoming…According to this manner of seeing individuation, a definite psychic operation would be a discovery of significations in an ensemble of signals, the signification prolonging the initial individuation of being, and having in its sense a relation not only to the ensemble of exterior objects but also to the being itself. As it contributes a solution to a plurality of signals, a signification has a bearing toward the exterior; but this exterior is not foreign to the being as a result of individuation; because prior to [the process of] individuation this being was not distinct from the ensemble of the being that is separated in the milieu and the individual.[11]

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[7] Ibid., 49 (emphasis in original).
[8] Foucault in ibid., 24.
[9] Braudel in ibid., 49.
[10] Simondon, *Du Mode*, 163.
[11] Simondon, *L'Individuation*, 257. Here I am interested in the spatiotemporalities produced by the digital according to the allagmatic operations of reification (a spatial and transductive taking-consistency) and recursion (a temporal modulation of energy and information).

As I explained in previous chapters, signification corresponds to the morphogenetic process upon which being individuates by giving a spatiotemporal direction to perception. Importantly, the axiomatic of signification is devoid of any linguistic and semiotic dimensions; rather, it allows meaning to emerge from the operations of spatiotemporal structuration of perceptions and cognition.[12] Following François Laruelle, we can reformulate the capacity of technics to give direction [*sens*] to perception as an instantiation of "the sense of power," which constitutes the "onto-theo-political" tendencies upon which a certain understanding of the world, and of power, takes consistency.[13] The passage to paper money as manifestation of the expression of a value by fiat – as a sign that is detached from any spatial situatedness, as Rotman explains, but that also allows for the manipulation of time through exchange – provoked a shift in the very conception and perception of power, also affecting the ontological formulation of money. As Ole Bjerg notes: "Commodity theory is based on a realist ontology insofar as the 'moneyness' of an object is a reflection of the real qualities of the object. In opposition to this, chartalist theory is a social constructivist theory of money."[14]

From this standpoint, while the theoretical foundations of economic value have remained almost unchanged for three hundred years, based as they are on a mechanist understanding of the world and of energy, my wager is that, with the passage from paper to digital, the strange materiality, or concrete abstraction, of post-industrial technical objects heralds a new "phase-shift"[15] in the evolution of the monetary

[12] Recalling Genosko's discussion of Guattari's a-signifying semiotics in the introduction, there is an important difference to be made between the Deleuzo-Guattarian conceptualization of signification and Simondon's. Whereas, as Genosko clarifies, for Deleuze and Guattari part-signs never get to "linguistic formation" but instead entail a "reticent, hesitant, working only with the parts and their intensities ... [in which] signification never culminates" according to Simondon, signification is not a 'linguistic formation' but is by definition a-signifying, since it provides the conditions for perception, cognition, and even linguistic formation to take consistency. Gary Genosko, "A-Signifying Semiotics," *The Public Journal of Semiotics* II, no. 1 (January 2008): 12. Furthermore, to Simondon signals can be understood as Guattari's part-signs, in that they only possess one dimension — either temporal or spatial — instead of being spatio-temporal key points that contribute to the weaving of the signifying axiomatic that orients individu(aliz)ation. Simondon's signification is not only material, like Guattari's asignifying semiotics, but it is also spatiotemporal. However, it does not correspond to a linguistic formation. To Genosko via Guattari "information precedes signification, the potentialities of which are in machinic systems, the site for the study of a-signifying semiotics" (ibid., 19). On the contrary, for Simondon information can only exist with signification, understood as the asignifying axiomatic from which language and meaning emerge.
[13] François Laruelle, *Au-delà du Principe de Pouvoir* (Paris: Payot, 1978), 15.
[14] Ole Bjerg, *Making Money: The Philosophy of Crisis Capitalism* (London: Verso, 2014), 113.
[15] In the third part of *Du Mode* Simondon discusses the phase-shift [*déphasage*] of the primitive magical unity that makes up the division between subject and object in the relation between human beings and the

technology, affecting both its ontology and its value. For these reasons, in order to understand the peculiar modes of existence of digital money, the value(s) it amplifies, and the sense of power it weaves through its circulation – three fundamental issues that cannot be thought apart from each other – a brief detour into the philosophy of digital objects is needed. In order to do so, I now turn to Yuk Hui's theorization of digital objects. This will allow me to uncover how the materiality of the digital is directly implicated in the paradoxical situation of the contemporary political economy. It will also provide the means to disentangle money from economic value in order to challenge traditional conceptions of monetary value and foreground the 'technical value' of digital money.

3.3 The Reification of Digital Money and the Relational Materiality of Forms of Exchange

Drawing on Heidegger's and Simondon's theories, Yuk Hui discusses the 'existence of digital objects' by mapping the development of markup languages and Web ontologies. In contrast to the new materialism of Jane Bennett's vibrant matter and Quentin Meillassoux's principle of factuality,[16] Hui's conceptualization of digital objects starts from an understanding of the materiality of form: "To talk about the materiality of form is not only to understand form in terms of its material support, but also to understand the individuation of form that presents in itself materially."[17] Thus Hui defines the materiality of the digital as the synthesis of the relations constituted by algorithmic structures. In doing so, Hui goes beyond the Aristotelian hylomorphic schema and instead accounts for the concrete materiality of processes of *in*-formation. For Hui, the materiality of the digital "is not a general principle, but rather a self-actualization, always on the move, in which we can trace a genealogy of the material condition of the individuation of forms."[18]

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world. "The genesis of a particular phase can be described in itself; but it cannot really be known with its sense and consequently grasped in its postulation of unity if it is replaced for the totality of genesis, as a phase in relation to the other phases." Simondon, *Du Mode*, 162–63. As Jean-Hugues Barthélémy explains, "phases only exist in relation to each other. Thus, they are marked by their *relativity*." Jean-Hugues Barthélémy, "Fifty Key Terms in the Works of Gilbert Simondon," in *Gilbert Simondon: Being and Technology*, ed. Arne De Boever et al., trans. Arne De Boever (Edinburgh: Edinburgh University Press, 2012), 221 (emphasis in original).

[16] Yuk Hui, "Form and Relation. Materialism on an Uncanny Stage," *Intellectica* 1, no. 61 (2014): 108–9.

[17] Ibid., 109.

[18] Ibid., 120.

> The existence of digital objects is constituted by the materialized milieu which gives it an identity, which does not come from the "matter" (considering a Youtube video), nor from the imposition of form, but by the relations *in it, created by it*, and that *surround it*. After all, we have to recognize that the materiality of form cannot be fully accounted for by the abstract notion of matter or the concrete material that the object is composed of.[19]

From this standpoint, traditional understandings of digital networked technology, that posit the materiality of the digital in either its manifestations on the screen, or in its physical supports (e.g. cables, antennas, fiber optics, hardware), are limited when it comes to accounting for the dematerialization of finance enabled by the developments of cybernetics and information theory in economics. These understandings, according to Hui and Simondon, are based on a hylomorphic false division between hardware and software, matter and form, that dates back to the Universal Turing Machine and that today is reflected in the structure of modern computers and the architecture of the Internet.[20]

In his exploration of the existence of digital objects, Hui starts from an account of data objects although he makes it clear that these cannot be thought apart from the relations that constitute them, internally and externally, and the logic that determines their interactions and transductions.[21] While data and algorithms cannot be thought apart from one another,[22] here I want to adopt Hui's schema to give an account of digital

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[19] Ibid., 119 (emphasis in original).
[20] Giuseppe Longo brilliantly describes the difference between clocks and Turing Machines on the basis of the distinction between software and hardware introduced by the latter: "in Turing machines, the (mathematical fiction) of hardware, the 'head and tape,' is distinct from the software, the 'programs,' as well as from the inputs, possibly numbers; however, they all coincide by coding the entire machine description by numbers … Most modern computers are still in the frame of TM's [Turing Machines], conceptually; more precisely, they include an operating system and a compiler or an interpreter, i.e. a physical realization of a Universal TM. Their difference w.r.to [with regard to] clocks should be clear: it is due to the key distinction between hardware and software, as well as that auto-encoding possibility. In clocks (and Babbage machines) all feasible computations follow a predetermined algorithm, carved for ever [*sic*] in the material structure." Giuseppe Longo, "The Difference between Clocks and Turing Machines" (Models of Cognition and Complexity Theory, Rome, 1994), 4, http://www.di.ens.fr/users/longo/files/PhilosophyAndCognition/clocksVSturingM.pdf.
[21] Hui, *On the Existence of Digital Objects*, 39.
[22] As Niklaus Wirth put it in his seminal *Algorithms + Data Structures = Programs*: "Programs, after all, are concrete formulations of abstract algorithms based on particular representations and structures of data.

money as data in order to map the process of progressive standardization and axiomatization that the digital financial architecture has undergone since its inception in parallel with the development of the World Wide Web (WWW). In this context, my aim is also to provide an initial demonstration of the fact that the potential for a new ecosystemic order is immanent to the strange materiality of digital money itself. My proposition is that this novel materiality troubles the traditional understanding of the value of fiat money and also challenges the sense of capitalist power. As a matter of fact, as any technology embodies a particular way of relating to the world, so a certain mode of existence of the monetary technology brings with itself a certain mode of relating to the exterior milieu.

While Hui acknowledges the ambiguity that the term digital object entails, he specifies that digital objects refer to data and metadata "which embody the objects with which we are interacting, and with which machines are simultaneously operating."[23] Hui explains that the genesis of digital objects consists in a double operation. On the one hand, this genesis entails the objectification of data, which corresponds to "the system of mapping or mimesis (for example, the production of digital images, digital video, etc., which are visually and repetitively distributed throughout the physical world)."[24] On the other hand, this genesis also implies a "dataification of objects" that "takes place by means of attaching tags to objects and coding them into the digital milieu (by means of this digital extension, the object then obtains an identity with a unique code and/or set of references)."[25] In the unfolding of this chapter I show that, in the case of digital money, there may be other instances by which digital objects come into being that directly stem from the algorithmic operations implicated in the creation of new value (in the specific case of digital money, this is exemplified by Bitcoin). In order to overcome the duality between objects and data in such cases, I prefer to use the term *reification* to indicate the taking-consistency, or concretization, of digital money. As I explained in chapter

… Decisions about structuring data cannot be made without knowledge of the algorithms applied to the data and that, vice versa, the structure and choice of algorithms often depend strongly on the structure of the underlying data. In short, the subjects of program composition and data structures are inseparably intertwined." Niklaus Wirth, *Algorithms + Data Structures = Programs* (Englewood Cliffs: Prentice Hall, 1976), xiii. However, as Yuk Hui remarks, it is helpful to start from a definition of digital objects in terms of their genesis: the metadata schemes and Web ontologies that provide the 'form' of digital objects.

[23] Hui, *On the Existence of Digital Objects*, 48.

[24] Ibid., 50.

[25] Ibid.

one, reification is a process in computer science that consists in making data structures and computational models explicit. Importantly, this process is distinct from the Marxist conceptualization of reification that indicates instead a form of alienation caused by capital relations epitomized by commodity fetishism.[26]

As Andrei Sorin argues, however, reification is one of the fundamental fallacies of the mechanist paradigm of technological evolution, which seeks to extract simple structures from complex phenomena, thereby severing the relations and interactions that make up the richness of an occurrence. For Sorin reification is an instantiation of "a mechanistic form of thinking: an illegitimate attempt to reduce a complex phenomenon to a simple one by taking something that is part of a whole, something that cannot possibly exist in isolation, and treating it as a separate thing."[27] However, as I noted in chapter one, in the contemporary digital ensemble reification is *functional* within the genesis of digital objects. In order to avoid the reductionist approach entailed by reification, and yet acknowledging its functional role in the organization of a system, following Simondon's allagmatic theory here I understand the reification of digital objects as a transductive process. In this way, I aim to provide an understanding of the objecthood of digital money without eliminating the relational processes that allow digital money to take consistency. Furthermore, understanding digital money according to its transductive properties provides the means to grasp it as an elementary technology:

[26] In contrast to Marxism, according to Simondon, there cannot be such a thing as a subsumption of human beings and technology to capital. In Simondon's universal cybernetics there is only place for humanity, nature, and technics. For Simondon alienation is due to the development of theoretical sciences in past centuries. As previously mentioned, Pascal Chabot observes that, for Simondon, the origin of alienation is to be found in a form of intellectualism "which possesses the knowledge and the idea of power [*puissance*] while lacking any concrete power [*pouvoir*], apart from that which it appropriates from others for its own ends." Pascal Chabot, *La Philosophie de Simondon* (Paris: Librairie Philosophique Vrin, 2003), 48. Importantly, the alienation of the human from technology is not only a socio-economic matter, due to the privatization of the labor process, but more profoundly, a physical-psychological one, which started precisely with the mechanist era of technological development, which has hindered "a more profound and essential relation, that of the continuity between the human individual and the technical individual." Simondon, *Du Mode*, 117–18. Thus, "the bankers … are also as alienated from the machine as the members of the new proletariat" (ibid., 118). Simondon reminds us that technical progress proceeds by leaps and bounds and not according to a continuous line (ibid., 40). The introduction of the idea of teleological process has caused a disequilibrium between the internal functioning of the machine and its external finality (i.e. the economy of production and consumption), which in turn has hindered the process of individuation in the human qua human, prompting an increasing level of alienation and foreclosure of the freedom of technics. Ibid., 119.

[27] Andrei Sorin, *Software and Mind: The Mechanistic Myth and Its Consequences* (Toronto: Andsor Books, 2013), 117.

"elements possess a transductive property that makes them the true bearers of technicity."[28]

What I have defined in the introduction as digital money – that is, the fluid ensemble composed by online deposits and transfers, stocks, securities, and also e-cash (although the latter case, as I will explain in the following sections, is rather different) – perfectly encapsulates the double movement identified by Yuk Hui in terms of the dataification of objects and the objectification of data. On the one hand, fiat money (e.g. banknotes) is turned into data and, on the other hand, the money-datum is made into an object by attaching tags to it and coding relations that extend their effect to the digital financial milieu. Below I will focus specifically on the first case. As banknotes are both objects and statements – signs that express the State's guarantee of their values to bearers – so the markup languages and Web ontologies I am going to discuss below express statements about the monetary relations and properties between parties. However, the strange materiality, or concrete abstraction, that constitutes such digital money objects makes them more than signs – they are spatiotemporal nexuses of signification. It also makes them less – and, for the same reason, *more* – than finite objects. This is because the transductive operations that constitute digital money are not completely axiomatizable; this turns digital objects into "open machines"[29] generating an excess that activates new individu(aliz)ation, as I will further explain below.

In regard to the second aspect, instead, contactless payment systems, such as Visa PayWave and Mastercard PayPass, exemplify the objectification of data. These cards have an embedded chip and antenna that, through radio-frequency identification (RFID) or near field communication (NFC), allow customers to make secure payments, while also however, monitoring purchasing habits and capturing relations of exchange.[30] This is also the principle upon which travel cards such as London's Oyster card and Sydney's Opal card work. In such examples, data acquire a renewed understanding in reference to money. The term 'data' comes from the Latin *datum* and indicates 'a given thing.' As Hui notes, in relation to the digital, one should pause to consider "how this

[28] Simondon, *Du Mode*, 73.
[29] Ibid., 11.
[30] Tinus Willemse, "Contactless Technology Overview," *MWR InfoSecurity*, August 8, 2013, https://www.mwrinfosecurity.com/our-thinking/contactless-technology-overview/.

materiality constitutes a new form of 'givenness.'"[31] Money as datum precisely invites us to consider how money is 'given,' and what constitutes this givenness. As I explained in the previous chapter drawing on Mirowski's work, the economic orthodoxy has always refused the precept that something can come from nothing – and this is what prevented neoclassical economics from embracing the discoveries introduced by relativity and quantum theory. Yet money as a digital datum allows one to consider contemporary practices in monetary policy, such as quantitative easing (that consists in the creation of new monetary flows in the economy through deliberations of central banks) and fractional reserve banking (by which banks operate with monetary reserves that are equivalent to a fraction of their holdings by central banks) from a new perspective. The desubstantialization and alleged dematerialization of money allows for the creation and transmission of a value that seemingly comes from nothing – an issue I will return to in chapter five.

Hui describes the concretization of digital objects by tracing the genealogy of Web ontologies and their schematization. As Hui puts it, "metadata schemes or Web ontologies are the forms that determine the appearance and the relations of the objects."[32] Digital objects thus constituted individualize through the discovery of an associated milieu – that is, the dynamic space in which the digital object "renegotiat[es] its relations with other objects, systems, and users."[33] Describing the architecture of the Web, Hui notes that the process of objectification of data has progressively moved on "from the *hyperlink-based* Web to become the *object-based* Web."[34] Furthermore, it is increasingly concerned with knowledge representation – that is, with attaching semantic meaning to data objects – in order to meet the requirements of the development of artificial intelligence (AI). This shift endows the machine with a more significant role, "not as an input-output device, but also as a partially 'thinking machine.'"[35]

These two concerns – object orientation and knowledge representation – are reflected in the contemporary architecture of the WWW. Starting with IBM's Generalized Markup Language (GML) to HyperText Markup Language (HTML) and up to the more recent

[31] Hui, *On the Existence of Digital Objects*, 49.
[32] Hui, "Form and Relation. Materialism on an Uncanny Stage," 119.
[33] Hui, *On the Existence of Digital Objects*, 57.
[34] Ibid., 50 (emphasis in original).
[35] Ibid.

eXtensible Markup Language (XML), Hui shows that the architecture of the WWW displays a “technical tendency” toward the separation of form and matter.[36] Furthermore, the recommendations and standards proposed for the realization of the Semantic Web aim to bring “structure to the meaningful content of Web pages.”[37] As I explained in the previous chapter, according to Sorin the mechanist fallacies of abstraction and reification apply equally to language and programming. Specifically, Sorin attributes the invention of structural programming, object-oriented programming, and relational database to the mechanist fallacies of abstraction and reification.[38] From this standpoint, the contemporary architecture of the Web exemplifies Sorin’s critique since it is based on a high-level of abstraction and treats computational relations, as much as ‘meaning,’ as discrete quantifiable objects and values. Paradoxically, then, digital networked technology seems to be still founded on a mechanist paradigm.

These tensions come to the fore in digital fiat money. Following Hui’s approach, in the following sections I present two paradigmatic cases of the concretization of digital fiat money in the financial sector. First, I focus on the infrastructure composed by markup formats and Web ontologies that enable algorithmic processes to operate in the financial environment. My proposition is that understanding the infrastructure that accommodates the dynamic, responsive architecture of the Web is essential for an understanding of the operations of postcybernetic control and for the formulation of a critique of neoliberal market dynamics. After an overview of the infrastructural components of the WWW, I will focus on two examples of the instantiation of digital fiat money – Financial products Markup Language (FpML), the proposed standard format for the organization and communication of financial data related to the trading of OTC derivatives, and Financial Industry Business Ontology (FIBO), the standard recommended for financial data terminology in the context of the Semantic Web. These contrast with the emblematic case of the genesis of a Bitcoin unit. While I will discuss Bitcoin in detail in the last two chapters, it is important to introduce it here in order to highlight the radical differences between these two modes of existence of digital money. As will be made clear in the below paragraphs, the value immanent to all modes of digital money – as the manifestation of the normative and genetic character of post-industrial technical

[36] Ibid., 59.
[37] Berners-Lee in ibid., 68.
[38] Sorin, *Software and Mind*, chap. 7.

objects – troubles the finite and consistent understanding of economic value indebted to neoclassical economics, as it gives rise to a fragmented and diverse landscape that in practice lacks semantic integration, thus threatening the 'sense' of capitalist power as a unified monolithic enterprise. Bitcoin takes this further, by undermining the understanding of the genesis of digital objects as the product of a process of reification. Rather, it entirely circumvents the dual movement between object and datum and instead emerges from the semi-autonomous algorithmic operations that constitute its network.

3.4 FpML, Capture, and the Extensible Surface of the Market

XML (eXtensible Markup Language) is the Internet-based protocol that defines the rules for presenting information on the Internet. Both XML and its precursor HTML differ from traditional markup formats since they use tags to describe chunks of data, thereby allowing for greater flexibility. In contrast to HTML, which specifies only how information should be displayed and it is relatively intuitive to understand,[39] XML can also describe information with its tags. That is, XML can accommodate metadata (i.e. 'data about data') in its syntax. However, precisely for this reason it is increasingly complex to use. The hybrid nature of XML, as both presentational and descriptive format, is the novelty that has made it so powerful. XML has already become the *lingua franca* of the Web, and has been adopted in particular in the scientific domain to facilitate the circulation of knowledge, in the music domain, and in "general common sense knowledge."[40] Any kind of data can be structured according to XML, including financial instruments, corporate descriptions, and market prices.

It is important to clarify that markup languages differ from programming and scripting languages in the levels of abstraction and broad functionality. Markup languages, such as HTML and XML, describe the structure of data – that is, they provide the means for algorithms to establish causal relations (e.g. read, parse, sort) among data according to

[39] As someone who belongs to the 'Myspace generation,' I had my first coding experiences with customizing my profile page with HTML.
[40] Fabian M. Suchanek et al., "The Hidden Web, XML and the Semantic Web: Scientific Data Management Perspectives," 2011, http://suchanek.name/work/publications/edbt2011tut.htm.

their own logic, and for this reason they are not considered programming languages.[41] Their name derives from the publishing practice of 'marking up' a manuscript with notations that allow one to distinguish the text from the typeface, style, or font size of a document.[42] In this sense, markup languages should be thought of as formats or schemas. In other words, they constitute the infrastructural background upon which algorithmic operations search and transform data, thereby enabling communication to occur across time and space. Indeed, markup languages provide the space-time substratum from which the communicative capacities of the Internet emerge. Following Simondon, XML can be considered as an ensemble of "*points-clés*"[43] – key points – that contributes to the constitution of the 'reticulation' upon which the individuation of an economic system unfolds. Importantly, as will be clear later on, such key points are "tropistic units"[44] that determine the 'direction' of individuation through the structuration of a spatiotemporal axiomatic of signification. They constitute the "singular points [that] command the relation human-world [*le rapport homme-monde*]."[45] Yet, as Simondon puts it, such singular points entail a certain reversibility "because the world influences the human and the human influences the world."[46]

As I mentioned above, any kind of data can be structured according to XML format, including financial instruments, corporate descriptions, and market prices. Financial products Markup Language (FpML) is the open-source XML standard for OTC

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[41] Programming languages, like C++ and Java, define the operative logic of a program, that is, they transform data from a given input to a certain output. Scripting languages are a subset of programming languages (e.g. JavaScript, and Python) that mediate between programs (e.g. between a database and a Web server) in order to generate new data. In reality, the differences between these definitions are very blurry.

[42] Traditionally, markup languages are divided into three categories, although the boundaries between them are becoming increasingly blurred. Presentation markup is used by word-processing systems and is hidden from the user to produce, for instance, the GUI paradigm WYSIWYG (what you see is what you get). Procedural markup is embedded in the text and provides instructions for programs to process that text; such markup is often edited by and visible to the author, as in the case of LaTeX and PostScript. Descriptive markup limits itself to labeling parts of a text with descriptive tags that provide specific instructions as to how they should be processed, with the goal of decoupling the inherent structure of the document from any particular treatment or rendition of it. For this reason, descriptive markup is often described as 'semantic.' James H. Coombs, Allen H. Renear, and Steven J. DeRose, "Markup Systems and the Future of Scholarly Text Processing," *Communications of the ACM (ACM)* 30, no. 11 (1987): 933–47.

[43] Discussing the 'primitive magical unity' in the third part of *Du Mode,* Simondon explains that "this structural figure is inherent to the world, not detached; it is the reticulation of the universe in privileged key points through which the exchange between the living and the milieu occurs." Simondon, *Du Mode*, 167.

[44] Simondon, *L'Individuation*, 30.

[45] Simondon, *Du Mode*, 165.

[46] Ibid.

derivatives trade.[47] As I explained in the introduction, in this thesis I consider as digital money every piece of software that instantiates monetary value. While, since the 1970s, interbank financial transactions are transmitted and recorded according to the standards provided by the Society for Worldwide Interbank Financial Telecommunication (SWIFT),[48] here I chose to analyze the case of FpML for several reasons: first of all, SWIFT is a centralized proprietary software owned by the cooperative of banks belonging to the SWIFTNet, therefore hard to research; secondly, given the open-source character of FpML and its extensible nature, it lends itself well to illustrating how algorithmic finance works through the architecture of the WWW, unbridled from proprietary constraints. In the following section, I will discuss another standard, FIBO, which is also concerned with interbanking communication but that is specifically focused on the issue of knowledge representation through Web ontologies.

FpML was introduced by JP Morgan and PricewaterhouseCoopers in 1999, as a new protocol for the Internet-based electronic dealing and sharing of information regarding financial derivatives, initially handling interest rate and foreign exchange products. In 2001 its development moved to the International Swaps and Derivatives Association (ISDA) and today it aims to be *the* standard language for the electronic processing of

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[47] The Commodity Futures Trading Commission, the US independent agency that regulates futures and option markets, defines OTC derivatives as follows: "Over-the-counter (OTC) derivatives are contracts executed outside of the regulated exchange environment whose value depends on (or derives from) the value of an underlying asset, reference rate or index. The classes of underlying assets from which a derivative instrument may derive its value include physical commodities (e.g., agricultural products, metals, or petroleum), financial instruments (e.g., debt and interest rate instruments or equity securities), indexes (e.g., based on interest rates or securities prices), foreign currencies, or spreads between the value of such assets." Commodity Futures Trading Commission, "Over-the-Counter Derivatives," *Commodity Futures Trading Commission*, 1998, http://www.cftc.gov/opa/press98/opamntn.htm. In other words, OTC derivatives differentiate themselves from other contracts because they can be privately traded, traditionally via a dealer network, without having to go through a centralized exchange such as the New York Stock Exchange. For a primer on OTC derivatives, see also: Randall Dodd, "The Structure of OTC Derivatives Markets," *The Financier* 9, no. 1–4 (2002): 1–5.

[48] SWIFT provides a messaging standard to carry out payments between banks and market structures. In other words, it is the automated clearinghouse that governs interbank relations across the members involved. "Messaging and Standards," *SWIFT*, August 24, 2015, https://www.swift.com/about-us/discover-swift/messaging-standards. Specifically, as a software developer explains, SWIFT works not according to atomic commit, as happens in traditional bank transactions, but instead through "several asynchronous steps that can be repeated or even reverted after any failure" and that involve the generation of a simple interbank message that "guarantees that the message is stored and will be delivered some time in the future." Rafał Dowgird, "How Does the Banking Transactions Work 'under the Hood' - Possibly in Detail," *Stack Overflow*, 2010, http://stackoverflow.com/questions/4512547/how-does-the-banking-transactions-work-under-the-hood-possibly-in-detail. For a description of an atomic transfer between databases in a traditional bank transaction, see: Hector Garcia-Molina, Jeffrey D. Ullman, and Jennifer Widom, *Database Systems: The Complete Book. Second Edition* (Upper Saddle River: Pearson, 2009), 298–99.

derivatives.[49] It is important to note that FpML is not an application or a network for electronic trading, but a standard intended “to streamline the process supporting trading activities in the financial derivatives domain through the creation, maintenance and promotion of an e-business language for describing these products and associated business interactions based on industry standards.”[50] Much like XML, FpML only defines the serialization format for the encoding and transferring of information – in this case, only in relation to swaps, derivatives, and structured products. For instance, the description of the element cash in FpML to indicate the underlying of a derivative will look like this:[51]

```
<?xml version="1.0" encoding="utf-16"?>
<xsd:element name="cash" type="Cash"
substitutionGroup="underlyingAsset">
     <xsd:annotation>
         <xsd:documentation xml:lang="en">Defines a simple underlying
asset type that is a cash payment. Used for specifying discounting
factors for future cash flows in the pricing and risk
model.</xsd:documentation>
     </xsd:annotation>
 </xsd:element>
```

FpML is an open standard, therefore freely available, the main goals of which are the automation of the information flow “across the entire derivatives partner and client network, independent of the underlying software or hardware infrastructure supporting the activities related to these transactions”[52] and the electronic integration of services across companies and processes, such as dealing and confirmation to the risk analysis of client portfolios. Importantly, the organization’s mission statement highlights the fact that “FpML is of value when the direct communication of derivative trade descriptions and environment information between two firms is desired.”[53] Therefore it is important not to confuse FpML with the technologies used to automate trading strategies that I will discuss in chapter four and six. Algorithmic trading relies instead on proprietary

[49] FpML 5, the most recent version of the standard, includes the products of Foreign Exchange (FX), including Swaps and Options, Credit Default Swaps, Equity products, Bond Options, and Commodities. For a detailed list, see: International Swaps and Derivatives Association, “Product Summary,” *FpML.org*, 2015, http://www.fpml.org/spec/index.html.
[50] “FpML® Information,” accessed May 13, 2015, http://www.fpml.org/about/factsheet.html.
[51] Information from: “Financial Products Markup Language (FpML®) XML Schema Documentation,” accessed July 21, 2016, http://schemas.liquid-technologies.com/FpML/5.0/.
[52] “FpML® Information.” For a synthetic description of the functions of FpML see: Brian Sentance, “FpML—The Building Blocks for Trade Automation?,” *WILMOTT Magazine*, March 2008.
[53] “FpML® Information.”

software that is often referred to as 'black box' for its secretive character – an issue I will turn to in chapter six.

There are many working groups developing the FpML standard – e.g. credit, commodity, equity, architecture, FIX integration, and "pricing and risk," which has the goal of creating a common framework for pricing/valuation, and market and credit risk reporting.[54] Because of the open-standard nature of FpML, working groups are open to specialists that want to contribute, thereby re-enacting the dynamics of free labor characteristic of the digital economy identified by Tiziana Terranova.[55] It also needs to be noted that there are plenty of other standards at work in the financial environment, such as RIXML for analyst research, XBRL for financial reporting, NewsML for news, and FIX (Financial Information eXchange) which is a direct competitor to FpML. This indicates that the tendency toward standardization is not a smooth ride, but presents technical, legal, and economic obstacles.[56]

As Hui notes, the individualization of digital objects "embraces three key concepts: *universality, interoperability,* and *extensibility*."[57] Extensibility is the main feature of FpML. It provides the means to 'wrap' institution-specific documents into FpML format, or conversely, to extend FpML itself by building institution-specific documents upon the existing types within FpML. Extensibility further allows for the extension of automation across financial tools and products and the customization of FpML for one's

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[54] "FpML® @ a Glance," accessed May 14, 2015, http://www.fpml.org/about/ataglance.html.

[55] As Terranova notes, free labor is not necessarily exploited labor. On the contrary, "free labour is a desire of labour immanent to late capitalism, and late capitalism is the field which both sustains free labour *and* exhausts it. … Late capitalism does not appropriate anything: it nurtures, exploits and exhausts its labour force and its cultural and affective production." Tiziana Terranova, *Network Culture: Politics for the Information Age* (Ann Arbor: Pluto Press, 2004), 94 (emphasis in original). From this standpoint, free labor can be understood as an instance of neoliberal priming, as Brian Massumi explains. Priming is a "form of conditioning, which modulates behavior by implanting presuppositions and activating tendencies in an open situation of encounter." Brian Massumi, *The Power at the End of the Economy* (Durham: Duke University Press, 2015), 37.

[56] For instance, up to 2008 FpML was mainly concerned with facilitating communication in post-trade operations, such as the electronic confirmation of trades, and diminishing trade-settlement time lags. In the aftermath of the recession, however, new regulations of the Commodity Futures Trading Commission demanded that swap execution facilities be able to provide pre-trade clearing certainty, therefore FpML had to extend its messaging protocol into the pre-trade work-flow too. So far this was the domain of the FIX (Financial Information eXchange) protocol that, in addition to providing a presentation and communication standard, also provides network and specification of transport mechanism. Peter Madigan, "Fix and FpML: A Friendly War," *Www.risk.net*, August 22, 2014, http://www.risk.net/risk-magazine/feature/2361155/fix-and-fpml-a-friendly-war.

[57] Hui, *On the Existence of Digital Objects*, 72 (emphasis in original).

own needs.[58] Standard protocols such as FpML, and its generic progenitor XML, have precisely the scope of increasing the consistency of the financial apparatus for it to be able to make information ‘comparable’ and ‘appropriable’ across different platforms in order to capture it and feed it back into the financial machine – a perfect instantiation of an apparatus of capture, as described by Deleuze and Guattari.[59] What Hui observes in the context of generalized digital objects applies to digital fiat money too – fiat digital money develops horizontally in “a process that gradually involves a greater number of objects, machines, and users to maintain its functionality and stability”;[60] vertically, digital money tends to become more concrete and individualized as it extends its web of relations, thereby reinforcing the axiomatic of signification upon which financial power operates. While the former case is exemplified by the multiplication of means of payment, that become increasingly personalized and attached to the body (from phone ‘cardless’ payments, to ‘paywave’ systems, up to chip implants, as I discussed in the introduction), the latter case is manifested in the increasing convergence and integration of functions and protocols. However, as will be discussed below, this second case is yet to reach full actualization.

As Hui continues, the three key features of digital objects mentioned above “are all, co-incidentally, synonyms for ‘objectivity’”[61] – in this case, the objectivity and universality of algorithmic finance. As a matter of fact, at first glance, one would consider FpML the smooth surface that links together traders (both on the buy side and on the sell side), dealers, and credit rating agencies. However, as I just mentioned, in spite of the tendency toward standardization the protocols used in the financial ecosystems are many. While, in a metaphysical sense one could talk of a generalized ‘pricing surface,’ which will be discussed in the next chapter, from a perspective that takes seriously the materiality of the forms of exchange made possible by digital protocols, there are many technical surfaces upon which the operations of the market are written, and many are the skills that need to be mobilized, to which the several working groups testify. In Hui’s words, the seeming objectivity of data schema “is in fact the constant process of

[58] As one insider notes: “FpML and OTC processing are both increasing in importance as financial markets become more and more automated, with cost and profitability (and operational risk!) incentives driving the front office to become more integrated with middle and back office.” Sentance, “FpML—The Building Blocks for Trade Automation?,” 29.
[59] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 441.
[60] Hui, *On the Existence of Digital Objects*, 72.
[61] Ibid.

evolution or individualization"[62] – that is, of the continuous interplay of processes of transduction and modulation that allow the digital object to stabilize itself and extend its milieu to accommodate more and more interactions.

3.5 FIBO, Semantics, and the Problem of Knowledge Representation in the Financial Ecosystem

While XML provides the 'scaffolding' for the architecture of the WWW, the Semantic Web is a 'readable' layer (that is, intelligible to both humans and machines) built on top of XML that allows for most kinds of operations on the Web. It is composed by several components – e.g. the Resource Description Framework (RDF), Web Ontology Language (OWL), tools for Gleaning Resource Descriptions from Dialects of Languages (GRDDL), the Simple Protocol And RDF Query Language (SPARQL). Although the Semantic Web is still in its infancy (considering the huge number of Internet pages existing online), since its inception it has been growing exponentially, to the point that in 2013 more than four million Web domains contained semantic Web markups – including the major players in the media ecosystem, such as Google, Apple, and Microsoft. Formulated by the World Wide Web Consortium (W3C), this set of standards has the goal of enabling cross-connections among data and "support[ing] trusted interactions over the network."[63] As Aaron Swartz observed in his posthumous *Unfinished Work,* however, the readability afforded by such standards has become an obstacle for programmers and a matter-of-fact barrier of access to non-programmers, ultimately obfuscating the architecture of the Web, but also allowing for data mining operations by bots and Web crawlers, and for the action of viruses and malware.[64] Somehow, then, the W3C's goal of cementing trust through common standards has led to the opposite result. It is through the Semantic Web that information is mined, transmitted, produced, and reproduced across different platforms – often, without the user's, or even the programmer's, consent. According to Alexander Galloway, the infrastructure of the Semantic Web constitutes an instance of protocological control – that is, the new mode of management, regulation, and biopolitical control concretized in

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[62] Ibid.
[63] "Semantic Web - W3C," accessed May 15, 2015, http://www.w3.org/standards/semanticweb/.
[64] Aaron Swartz, *Aaron Swartz's A Programmable Web - An Unfinished Work*, Synthesis Lectures on The Semantic Web: Theory and Technology (San Rafael: Morgan & Claypool, 2013), http://commons.wikimedia.org/wiki/File:Aaron_Swartz_s_A_Programmable_Web_An_Unfinished_Work.pdf.

the architecture of the Web. In particular, the Semantic Web constitutes "a new strain of protocol: protocol that cares about meaning."[65] It does so by adding semantic value to bits of information, thus allowing for the creation of machine-understandable information that is more easily parsed and connected.

It is important to note, however, the different understanding of materiality that Galloway advances in his exploration of protocological control. To Galloway, protocol forces have turned "*life,* hitherto considered an effuse, immaterial essence"[66] into matter that in turns allows for its commodification, or reification (for instance, through biotechnologies, biopower, etc.). Simondon and Hui provide instead an alternative approach to distinguish between the "signaletic material"[67] of electronic impulses and the material form of relational control that emerges through strings of zeros and ones. As I anticipated above, Simondon's metaphysics is that of an "energetic materiality in movement,"[68] whose rhythm is marked by the operation of information. In Simondon's philosophy, matter takes a form, as much as it gives a specific consistency to it. In the digital realm, *in*-formation corresponds to the intertwining of the processes of transduction and modulation of 'energetic matter' into specific digital objects:

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[65] Alexander R. Galloway, *Protocol: How Control Exists after Decentralization* (Cambridge: The MIT Press, 2006), 139.
[66] Ibid., 82 (emphasis in original).
[67] Gilles Deleuze discusses the signaletic material in *Cinema II.* To him, signaletic material "includes all kinds of modulation features, sensory (visual and sound), kinetic, intensive, affective, rhythmic, tonal, and even verbal (oral and written). … [It is] a material not formed linguistically even though it is not amorphous and is formed semiotically, aesthetically and pragmatically. It is a condition, anterior by right to what it conditions. It is not an enunciation, and these are not utterances. It is an *utterable.*" Gilles Deleuze, *Cinema II: The Time-Image*, trans. Hugh Tomlinson and Robert Galeta (Minneapolis: University of Minnesota Press, 1997), 29 (emphasis in original). For Deleuze, signaletic material seems to correspond to a 'pure expression' – that which makes expression possible. Hui avoids instead the conflation of form with the expression of matter, and acknowledges that form possesses an expression of its own force. As he clarifies, "thinking of forms as pure form (external to matter) or as pure expression (of matter) ignores the fact that forms demand a certain kind of force or power to secure and maintain privilege, especially when we consider how form resists the change of identity due to external forces." Hui, "Form and Relation. Materialism on an Uncanny Stage," 109.
[68] "Simondon demonstrates that the *hylomorphic* model leaves many things, active and affective, by the wayside. On the one hand, to the formed or formable matter we must add an entire energetic materiality in movement, carrying *singularities* or *haecceities* that are already like implicit forms that are topological, rather than geometrical, and that combine with processes of deformation: for example, the variable undulations and torsions of the fibers guiding the operation of splitting wood. On the other hand, to the essential properties of the matter deriving from the formal essence we must add *variable intensive affects,* now resulting from the operation, now on the contrary making it possible: for example, wood that is more or less porous, more or less elastic and resistant. At any rate, it is a question of surrendering to the wood, then following where it leads by connecting operations to a materiality, instead of imposing a form upon a matter: what one addresses is less a matter submitted to laws than a materiality possessing a *nomos*." Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 408 (emphasis in original).

> The machine is different from the tool in that it is a relay: it has two different entry points, that of energy and that of information. The fabricated product that it yields is the effect of the modulation of this energy through this information, the effect that is practiced on a workable material.[69]

Yuk Hui further clarifies this point by explaining that "in the reality of the Web, digital objects are at the same time forms and material relations supported by strings, characters, numbers (there are different realities, downwards, such as binary codes, signals, voltage differences, etc.)."[70] From this standpoint, it is possible to recast the issue of protocol as the diagram of control constituted by the relations occurring *within* and *between* digital objects, which redefines what is visible and what is not according to its own logic. Yet, by intervening in the process of information, as I will show below and in the following chapters, the 'technical effort' between the operator (the user-programmer) and the machine may result in the invention of very different objects from the same digital "workable material."[71]

To take a specific example of this approach to protocol, the Semantic Web relies on Resource Description Frameworks (RDF) and Web Ontology Language (OWL) to achieve the goal of semantic relationality. In the context of the Semantic Web, RDF is the "W3C standard for encoding *knowledge.*"[72] RDF constitutes the actual backbone of the sharing of knowledge online and the terrain for search engines. It provides a standardized way to make statements about Web resources and it has been specifically designed for the purpose of "making *machine-processable* statements … [that would allow] for representing these statements and exchanging them between machines."[73] RDF is based on the XML syntax but provides the means to describe relations between subject, predicate, and object. As Hui notes, "the transition from XML to a more logically defined RDF is a significant move toward an AI-motivated Web."[74] Similar to RDF, OWL is another standard language for ontology production. OWL is more sophisticated than RDF since it was "designed to represent rich and complex knowledge

[69] Simondon, "La Mentalité Technique," 303.
[70] Hui, "Form and Relation. Materialism on an Uncanny Stage," 119.
[71] Simondon, "La Mentalité Technique," 303.
[72] Joshua Tauberer, "What Is RDF," *XML.com*, July 26, 2006, http://www.xml.com/pub/a/2001/01/24/rdf.html (emphasis in original).
[73] Frank Manola and Eric Miller, "RDF Primer," *W3C Recommendation*, 2004, https://www.w3.org/TR/2004/REC-rdf-primer-20040210/#intro (emphasis in original).
[74] Hui, *On the Existence of Digital Objects*, 70–71.

about things, groups of things, and relations between things … to verify the consistency of that knowledge or to make implicit knowledge explicit."[75]

In recent years the Enterprise Data Management (EDM) Council has endeavored to provide a standard for semantic technologies in the financial sector – the Financial Industry Business Ontology (FIBO). FIBO is based on RDF/OWL standard and "provides a description of the structure and contractual obligations of financial instruments, legal entities and financial processes."[76] Founded in 2012, EDM is a "non-profit trade association founded by the financial industry"[77] that encompasses hundreds of exponents from the financial sector. Given its goal to provide common semantic standards across the financial industry, EDM can be considered as an instantiation of logistical media. As Ned Rossiter explains, "logistical technologies derive their power to govern as a result of standardization across industry sectors coupled with algorithmic architectures designed to orchestrate protocological equivalence and thus connection between software applications and workplace routines."[78] Semantic protocological standards such as FIBO – that enable the "harmonization of data across repositories as a common language (i.e. Rosetta stone) for risk analysis and business process automation"[79] – are "crucial to the emergence and dominance of finance capital and supply chain management as world-making forces."[80] However, as Louiqa Raschid notes, because FIBO is still in development,[81] the lack of communication between the several standards currently existing in the financial sector present challenges for the integration of the financial infrastructure: "There is no global end-to-end consistency across the supply chain, e.g., a payment [can] be made against an entity that has been removed from the supply chain."[82] Therefore, while online communication – and

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75 Pascal Hitzler et al., "OWL 2 Web Ontology Language Primer (Second Edition)," *W3C Recommendation*, December 11, 2012, https://www.w3.org/TR/owl2-primer/.
76 EDM Council, "Financial Industry Business Ontology™," accessed July 29, 2016, http://www.edmcouncil.org/financialbusiness.
77 EDM Council, "EDM Council - Enterprise Data Management," accessed August 3, 2016, http://www.edmcouncil.org/.
78 Ned Rossiter, "Coded Vanilla: Logistical Media and the Determination of Action," *South Atlantic Quarterly* 114, no. 1 (January 1, 2015): 135.
79 EDM Council, "Financial Industry Business Ontology™."
80 Rossiter, "Coded Vanilla," 135.
81 The initial proposal for FIBO has been published only in May 2015. W3C, "Initial Proposal - Financial Industry Business Ontology Community Group," May 4, 2015, https://www.w3.org/community/fibo/wiki/Initial_Proposal.
82 Louiqa Raschid, "BMGT 499B Next Generation Financial Cyberinfrastructure -- Data Science for Finance" (University of Maryland, April 2, 2013), http://www.umiacs.umd.edu/~louiqa/2014/BMGT499B/RESOURCES/Lecture1.pdf.

production and circulation of knowledge – is mined, mapped, and tracked semantically, there is no unified semantic technology that would allow for the exertion of an equal degree of control on financial data. The lack of open semantic standards for financial data science may in turn contribute to the black-boxed character of the financial sector, due to the obscuration of the knowledge of financial operations and communication among entities, as I will further discuss in chapter six.

Yet, in spite of the factual fragmentation of the financial digital landscape, 'global finance' – as a unitary system resulting from the recent expansion of financial technologies and dynamics on a planetary scale – exists in the reality of the experience of its systemic effects on the world economy, as the recent financial crisis demonstrates.[83] This may be due to the standards for financial communication that allow for the immediate transfer of 'digital money' across the globe (e.g. FpML, FIBO/OWL, SWIFT, FIX), turning financial power into an intensive topological surface, as I will further explain in the following chapter. Thus, if neoliberalism today has become environmental – a thesis advanced by Brian Massumi following the trajectory opened by Michel Foucault[84] – this may be due to the ubiquitous architecture that forms the relational layer of digital networked technology. However, while the financial ecosystem may have reached a planetary scale, this system is materially formed by multiplicities, gaps, cuts, and inconsistencies.

The case of Bitcoin that I will illustrate in the next section brings the disruptive potential of the energetic materiality of the digital further. As a matter of fact, Bitcoin undermines the foundations of the monetary and financial system in unprecedented ways. Bitcoin will be discussed at length in chapter seven. Here I introduce the case of a Bitcoin transaction as it provides an interesting comparison with digital fiat money. From a standpoint that understands money as a commodity endowed with intrinsic value, the 'energetic materiality in movement' of the digital refuses any direct correspondence between one kind of money and its material support. Both digital fiat money and cryptocurrency are made of the same 'stuff' – software – yet they work in entirely different ways. While during the gold standard, for instance, the precious metal

[83] See: Andrew Haldane, "Andrew G Haldane: Managing Global Finance as a System" (Maxwell Fry Annual Global Finance Lecture, Birmingham University, 2014), http://www.bis.org/review/r141030f.pdf.
[84] Brian Massumi, "National Enterprise Emergency: Steps Toward an Ecology of Powers," *Theory, Culture & Society* 26, no. 6 (November 1, 2009): 153–85.

offered a univocal correspondence between its value and money, the value of the digital and the technicity it instantiates opens up the monetary medium to unprecedented possibilities for its redesign and its operative logic.

3.6 Money No Object: The Case of a Bitcoin Transaction

In contrast to digital fiat money, cryptocurrencies are a peculiar hybrid of fiat currency and commodity money, born out of the 'reinterpretation' of previous discoveries in cryptography and computer science that eschew any previous theory of value. As I have begun to suggest, the process of transduction that occurs between mathematical formalization and digital implementation opens digital objects and algorithmic operations to what is the incomputable dimension of preindividual reality, thereby creating infinite occasions to produce novelty. It could therefore be said that the process initiated with cybernetics, rather than foreclosing emancipatory possibilities, has opened up a novel horizon for possible reversals of the sense of power that is immanent to the seemingly unilateral function of digital computation. As Laruelle remarks, sense constitutes the "beyond [*au-delà*] of the linguistic function"[85] – whether this function is spoken, written, visual, or mathematical. While the function is mechanic (the *logos*), sense is machinic. Sense is the transcendental condition internal to the function and therefore the very condition of its possibility to produce meaning. "Sense, in its authentic concept, is not the end or the aim, it is a 'fact' (the political effect produced by another active power or medium) toward a power to have an end [*pouvoir d'avoir une fin*] and of being constrained by a local task."[86] Sense is self-constituting, precisely like the Simondonian idea of signification, which corresponds to "the auto-constitution of a topology of being that resolves a prior incompatibility through the appearance of a new systematic."[87] Thus, sense only arises via a process of individuation, *as* the individuation of the relations that constitute perceptions, cognition, and thought. Furthermore, through the processes of amplification discussed in chapter one, sense thus conceptualized also inflects psycho-collective individuations. It is a vector, which carries within itself both the power to carry on the 'task' required by the event of

[85] Laruelle, *Au-delà du Principe de Pouvoir*, 240.
[86] Ibid.
[87] Simondon, *L'Individuation*, 256–57.

signification/individuation, and also the power (both in terms of *pouvoir*)[88] to actively resist it. From this standpoint, the invention of Bitcoin can be understood as a "minor hermeneutic"[89] operation of sense-making – an allagmatic operation that provides the means to structure a new mode of conceptualizing being. It is a concrete, individualized power (*pouvoir*).

Thus, following Simondon, Bitcoin can be considered a veritable technical invention that has the potential to set the foundations for "a new regime of functioning"[90] of the political economy, preluding a third 'hermetism' in the evolution of technology, as Simondon prognosticated.[91] As a matter of fact, Bitcoin did shake the foundations not only of the so-called economic discipline, but also and more importantly of the very conception of money and economy. The following chapters will deal in more depth with the invention of Bitcoin and its features. For the purposes of this chapter, it suffices to note that Bitcoin's disruptive power comes from being introduced as a form of "peer-to-peer electronic cash system."[92] The Bitcoin protocol is antithetical to the black boxes of financial institutions and IT corporations; Bitcoin is open and decentralized and, as I anticipated in the introduction, is founded on a concept of privacy and secrecy radically opposed to the contemporary financial ecosystem.[93] While I will discuss the operatory schema of Bitcoin in chapter seven, it is worth analyzing here the data structure of one Bitcoin, as this makes for an interesting term of comparison with the mode of existence of digital fiat money. Bitcoin immediately displays the allagmatic, transductive power of the digital, as the simple case of a Bitcoin transaction illustrates. As Andreas Antonopoulos observes, a Bitcoin transaction is the most important part of the Bitcoin ecosystem:

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[88] As I explained in chapter one, the understanding of power that is more or less explicit in both Laruelle's and Simondon's philosophy overcomes the dichotomy between *pouvoir* and *puissance* and instead conceives of power (as *pouvoir*) as a unilateral duplicity that is immanent to the action of control. Control is hereby reformulated in allagmatic terms as an act of information – a peculiar combination of the transductive and modulative processes that allow for the taking-consistency of an organization.
[89] Laruelle, *Au-delà du Principe de Pouvoir*, 5.
[90] Simondon, "La Mentalité Technique," 301.
[91] Gilbert Simondon, "Naissance de La Technologie (1970)," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 171–72.
[92] Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System" (Paper, 2008), https://bitcoin.org/bitcoin.pdf.
[93] As I mentioned in the introduction, it entails a secret, as Deleuze and Guattari put it, that works "by transparency, as impenetrable as water, in truth incomprehensible." Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 290.

> Everything else in bitcoin is designed to ensure that transactions can be created, propagated on the network, validated, and finally added to the global ledger of transactions, the blockchain. Transactions are data structures that encode the transfer of value between participants in the bitcoin system. Each transaction is a public entry in bitcoin's global double-entry book-keeping ledger, the blockchain.[94]

In the case of Bitcoin, the saying that 'money is no object' acquires a new meaning since, in the words of Satoshi Nakamoto, an electronic coin, one Bitcoin, is "a chain of digital signatures."[95] While in the case of OTC derivatives, the genesis of the object – an object that pre-existed its digital form – corresponded to its formal inscription into FpML, Bitcoin is native to the digital. Paraphrasing Simondon, each Bitcoin is not only an object *hic et nunc,*[96] but it also incorporates concretely its own genesis in the form of a Merkle tree. Merkle trees are data structures characterized by an upside-down tree shape that are used to summarize all the transactions in a block by way of cryptographic hashes. Each block in the blockchain contains a digest of all the transactions in order to efficiently verify the integrity of large data sets. The cryptographic algorithm used in a Bitcoin Merkle tree is SHA-256 applied twice;[97] this way, instead of storing transactions in each node, only their hashes are stored.[98]

> A transaction is a *data structure* that encodes a transfer of value from a source of funds, called an *input*, to a destination, called an *output*. One should think of them as bitcoin amounts – chunks of bitcoin – being locked with a specific secret that only the owner or person who owns the secret can unlock. The fundamental building block of a bitcoin transaction is an *unspent transaction output*, or UTXO. UTXOs are indivisible chunks of bitcoin currency locked to a specific owner, recorded on the blockchain, and recognized as currency units by the entire network. The

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[94] Andreas M. Antonopoulos, *Mastering Bitcoin* (Sebastopol: O'Reilly Media, 2014), 111.
[95] Nakamoto, "Bitcoin," 2.
[96] Simondon, *Du Mode*, 20.
[97] There are several cryptographic hash functions used to secure communication in distributed systems. The peculiarity of SHA-256 (Secure Hash Algorithm) is that, for each input, it produces a 256-bit-long string of numbers and letters. A hashing algorithm is a one-way function, which means that is easy to calculate but almost impossible to reverse-engineer. I will discuss this in more detail in chapter seven. See: Antonopoulos, *Mastering Bitcoin*, 63–64.
[98] Ibid., 111.

> bitcoin network tracks all available (unspent) UTXO currently numbering in the millions. Whenever a user receives a bitcoin, that amount is recorded within the blockchain as a UTXO.[99]

It also needs to be noted that Bitcoin is *functionally* different from fiat money. As I will further discuss in chapter seven, Bitcoin works as a *medium* for the inscription of a price but, contrarily to fiat money, is not subjected to price itself. As I explained in the previous chapter value and price are not the same but, since the moment in which money incorporated the function of value storage in its architecture, value and price have become increasingly conflated, to the point that today the two terms are used interchangeably. Since its appearance, Bitcoin reopened the debate between price and value. While the former corresponds to the fluctuating exchange rate that Bitcoin has acquired against main national fiat currencies (that is, the *price* that one is willing to pay in order to buy Bitcoin), the latter corresponds to the larger, unquantifiable, factors that determine Bitcoin adoption and acknowledgement as a means of payment. As Andreas Antonopoulos describes it, Bitcoin is like a cheque:

> On a paper cheque, that beneficiary can sometimes be the name of a bank account holder, but can also include corporations, institutions or even cash. Because paper cheques do not need to specify an account, but rather use an abstract name as the recipient of funds, that makes paper cheques very flexible as payment instruments. Bitcoin transactions use a similar abstraction, the bitcoin address, to make them very flexible.[100]

Although the institutional status of Bitcoin is radically different from a bank cheque, since it is not owned by any bank, it does serve the purpose of transferring a 'value' by inscribing a price on a concrete support. In the Bitcoin protocol, the operations of information and the 'energetic materiality' of the digital are co-constitutive of the Bitcoin-object in equal manner. From this perspective, a trans-*action* – that, in allagmatic terms, is both an operation and a structure – is always already a trans-*duction*

[99] Ibid., 114 (emphasis in original).
[100] Ibid., 71.

that, by allowing for the resolution of a disparation in a system through the discovery of new relational dimensions, extends to and modifies culture.[101]

While there exist APIs that provide XML for Bitcoin,[102] with Bitcoin the genetic process is upended. While the genesis of fiat digital money entails the necessity of the schematization of 'physical' money in FpML, in Bitcoin the formalization in XML is a way for apparatuses of capture to make the transaction, once again, compatible and appropriable,[103] but it is not necessary to the coming to existence of a Bitcoin unit itself. As mentioned above, Simondon defines invention as that which brings about a new technical lineage. This is manifested in the very 'thingness' of a Bitcoin. As I explained above through Yuk Hui's study of the genesis of digital objects, while fiat digital money is reified according to a double movement of objectification of data and dataification of objects, Bitcoin is not reified a priori but emerges from a series of algorithmic operations across the network of humans and machines that constitute the Bitcoin peer-to-peer network.[104] Thus, while FpML and semantic technologies constitute a further step in the continuous evolution of fiat money, the invention of cryptocurrency seems to introduce a break in the mechanist-capitalist paradigm.

In other words, Bitcoin is radically different from digital fiat money because it is a money that is native to the Internet – to the algorithmic relations that constitute the allagmatic architecture of the network. As Ole Bjerg observes: "Bitcoin is commodity money without gold, fiat money without state, credit money without debt."[105] Gold, state power, debt are all instantiations of the function of money as a store of value in the service of centralized power. Bitcoin's value instead is not 'stored' anywhere but

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[101] Simondon defines transduction as "a physical, biological, mental, social operation through which an activity propagates gradually within a domain, by founding this propagation on a structuration of the domain that is realized from one place to the next." Simondon, *L'Individuation*, 32.

[102] "Bitcoin Charts / Markets API," accessed July 16, 2016, https://bitcoincharts.com/about/markets-api/.

[103] Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 441.

[104] As Nick Land observes in the case of property relations: "Bitcoin is not a Marxist reification. Bitcoin reifies in the rare sense of 'ex nihilo, actually create a physical object.' Bitcoin reifies property. Property before bitcoin is an abstraction, a social relation treated provisionally as an object, but never attaining that status (Property is Impossible). Bitcoin quite literally makes property into something physical. Anything that can store a private key and keep it secret, and can use it to create and emit transactions, can own Bitcoin. The relation 'X owns Bitcoin' is spatially local and temporally persistent; in other words, it more closely resembles relations like 'X is made of wood' or 'X weighs 20 kilograms' than it does relations like 'X is a dollar billionaire.'" In other words, while Bitcoin eschews the mechanist process of reification, paradoxically it creates something more concrete than reified objects themselves. Nick Land, "Quote Note (#211)," *Outside in*, January 14, 2016, http://www.xenosystems.net/quote-note-211/.

[105] Ole Bjerg, "How Is Bitcoin Money?," *Theory, Culture & Society* 33, no. 1 (2016): 53.

concretely emerges from the systemic dynamics of the network, through participation and recognition of a shared worldview encoded in the blockchain – it is pure instantiation of the technical value of digital objects. While, as I will discuss in chapter seven, the value of Bitcoin has already been subsumed into the dominant system of power through its exchange with national fiat currencies – that is, through a process of capture aimed to make Bitcoin comparable to national fiat currencies and appropriable by financial power apparatuses – the technical value of Bitcoin persists in the contemporary eco-system of power and profoundly undermines it.

3.7 The Value of the Digital

To recap, in this chapter I have illustrated how the passage from paper money to the new materiality of forms introduced by cybernetic technology has radically impacted the technicity of money – that is, the normative and genetic value of fiat money. While paper money erased the anteriority of the world to the money object, cybernetics introduced a paradigmatic shift that made Cartesian mechanics limited to account for the possibilities offered by the new technologies. However, as Simondon notes in *La Mentalité Technique* the novelty introduced by cybernetics is "incomplete and in conflict with itself because not properly emerged [*mal dégagé*] in the frame of the affective categories, ultimately without unity and almost entirely to be constructed in the order of the will."[106] This is evidenced by the very architecture of the WWW and corresponding financial architecture built upon it, as the cases of FpML and FIBO show, which is still founded on what Andrei Sorin call the mechanist fallacies of reification and abstraction.

It should be noted that, in contrast to FpML and FIBO, for instance, the programming of high-frequency trading (HFT) algorithms follows entirely different dynamics. Donald MacKenzie explains that HFT algorithms operate at a very low level, by computing through hardware – that is, by sending binary digits "directly from the raw data feed to designated locations in a computer's memory."[107] As MacKenzie further elucidates, the programming of trading algorithms requires a heightened sensibility and an intimate

[106] Simondon, "La Mentalité Technique," 296.
[107] Donald MacKenzie, "Be Grateful for Drizzle," *London Review of Books*, September 11, 2014, http://www.lrb.co.uk/v36/n17/donald-mackenzie/be-grateful-for-drizzle.

relation between the programmer and the code (also called in programming slang “bit fucking” or “close-to-the-metal-programming”),[108] which ultimately creates the bottom-up, swarm-like logic and behavior of trading algorithms. In other words, high frequency trading precisely avoids the fallacy of reification:

> If you’re going to write really fast code, you have to understand the computer you are programming not as an abstract machine, but as a physical device through which electrical signals pass. Only then can you work out the most efficient way of channeling those signals.[109]

As I explained in this chapter, algorithmic finance necessarily relies on standard protocols for the recording and transfer of information, such as FpML and semantic data schemas that constitute the top-down automated approach to make sensible the information thus exchanged and produced. On the contrary, HFT algorithms are not restricted to the mechanical paradigm. However, precisely for this reason, they operate in the most complete obscurity. Similar to HFT algorithms, Bitcoin entirely eschews the mechanist fallacies, since it is not reified a priori but emerges from a series of algorithmic operations across the network of humans and machines that constitutes Bitcoin.

To recap, in the previous chapter I have argued that the technology of fiat money has contributed to the establishment of the capitalist axiomatic of signification and, since its invention in the seventeenth century, has progressively amplified the mechanist conception of economic value that it ‘stores’ to more and more realms of existence, impacting the perception of value in Western market societies and the sense of capitalist power. In this chapter, I have shown that the value immanent to the digital – as the strange materiality that constitutes contemporary monetary flows – cannot be entirely axiomatized under economic value. Instead, the value of the digital troubles the sense of capitalist power and the very ontological structuration of the money-object, as Bitcoin demonstrates. Simondon sees value as inherently technical, introduced by an invention that radically modifies the relation between humanity and nature. The definition of a technical, or machinic, value points toward a higher order of values that, in economic

[108] Ibid.
[109] Ibid.

terms, can be explained neither through the labor theory of value, nor as the output of the law of marginal utility. Instead it is closer to what Félix Guattari calls "constellations of Universes of value,"[110] that are constituted at the "machinic interface between the necessary actual and the possibilist virtual."[111] As Guattari puts it, "the sterile opposition between use value and exchange value [needs to] be relinquished in favour of an axiological complexion including all the machinic modalities of valorisation: the values of desire, aesthetic values, ecological, economic values…"[112]

The discussion of the mechanist development of fiat money that I started in the previous chapter provides the means to understand the categories of exchange value and use value as part of the capitalist mode of signification. In this chapter I have shown that, while digital fiat money is based on the same mechanist paradigm (in particular, in the domain of the 'affective categories' and the 'order of the will,' as Simondon would put it), the value immanent to digital, cybernetic technology, is profoundly undermining those notions. In other words, this chapter uncovered the tensions between technical value and economic value embedded in the elementary technology of digital money and showed that technical value ultimately troubles economic value. Therefore, the former can never be fully axiomatized by economic-financial power. Following this trajectory, the next chapter deals with the question of how the immanent value of digital money relates to price in contemporary algorithmic markets. I will discuss this issue by focusing on how the ontogenesis of digital money impacts the ontological structure of markets.

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110 Félix Guattari, *Chaosmosis: An Ethico-Aesthetic Paradigm*, trans. Paul Bains and Julian Pefanis, Reprint edition (Sydney: Power Institute, 2006), 55.
111 Ibid.
112 Ibid.

4. Liquidity and Contingency in Algorithmic Markets: On the Incomputability of Price and the Necessity of Crisis

Everywhere surfing *has already replaced the older* sports –
Gilles Deleuze[1]

4.1 Value, Price, and Computation

In the last two chapters, I discussed the taking-consistency of the capitalist ecosystem and its sense of power via an assessment of the technological development of fiat money up to its present digital form. Ultimately, I argued that the 'value' immanent to digital money – the normative and genetic power of digital objects – is profoundly undermining the assumptions upon which the orthodox understanding of economic value is founded, along with the capitalist signifying axiomatic. Continuing this trajectory, here I elaborate on the relation between price and the technical value of digital money through the application of Gilbert Simondon's philosophy to an investigation of market liquidity – one of the foundational concepts of financial trading. A market is said to be liquid if transactions between assets and money occur with the minimum price difference and in the shortest amount of time. However, as will be made clear, the traditional definition of liquidity is unable to encompass the complexities of contemporary market exchange. My proposition in this chapter is that liquidity is particularly relevant to the investigation of the relations between economic and technological forces, and as such it deserves thorough attention. As a matter of fact, while the collapse of the US housing market in 2007-08 and the Flash Crash of 2010 have received a lot of academic interest, less attention has been given to the measures implemented by central banks in the immediate aftermath of the crisis to revive trading and boost economic activity. These measures are exemplified by practices such as quantitative easing that, as the previous chapter illustrated, materially consists in the reification of new units of digital money in banks' databases. As Brian Holmes puts it, quantitative easing corresponds to "unlimited money," the speculative kind of money

[1] Gilles Deleuze, "Postscript on the Societies of Control," *October* 59 (1992): 6 (emphasis in original).

printed by banks and immediately financialized.[2] While the efficacy of such maneuvers remains questionable,[3] my goal in this chapter is to focus on the deeper issue that they exposed – that is, the centrality of market liquidity to financial activity and, by extension, to the dynamism of the socio-political sphere.

In proposing to focus on market liquidity, this chapter shifts the register from money to finance and from the 'thingness' of digital money to the event of price. However, as Massimo Amato and Luca Fantacci explain, liquidity can be more straightforwardly thought of as the contemporary mode of existence of fiat money, resulting from the conflation of the three functions of money – medium, measure, and storage – into a single form. The authors also argue that liquidity substantiates two constitutive elements of today's markets: money and "the transformability of credit into money,"[4] epitomized by financial instruments of securitization, such as derivatives contracts, that I introduced in the previous chapter. In doing so, liquidity blurs the differences between money and credit, current accounts and assets, debtors and creditors, thereby contributing to the structural lack of clarity in financial relations. However, in contrast to the predominant view of economics as a physical science outlined in chapter two, Amato and Fantacci observe that market liquidity is not a natural occurrence – "there is nothing natural and inevitable about the 'paradigm of liquidity.'"[5] Liquidity instead stems from specific historical contingencies and decisions – that is, the need for governments to make debt available in order to finance warfare, as I explained in chapter two.[6]

Starting from these premises, the goal of this chapter is to propose a reformulation of the concept of market liquidity in light of contemporary arguments concerning the ontology of finance vis-à-vis recent theories of computation that offer a novel

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[2] Brian Holmes, "Money Unlimited: Consequences of Quantitative Easing" (MoneyLab: Economies of Dissent, Amsterdam: Institute of Network Cultures, 2014), http://networkcultures.org/moneylab/2014/03/27/brian-holmes-consequences-of-quantitative-easing/.

[3] As we saw, quantitative easing (QE) consists in the introduction of new money by central banks into the money supply of a country in order to boost lending and promote economic activity. QE has been criticized for fostering financial instability, inflation (by reducing the value of money), and the unequal distribution of wealth. Furthermore, coupled with austerity, these measures are said to have reinvigorated the same financial power and dynamics that led to the crisis in the first place, for they answered the crisis with even *more* trading and *more* financialization instead of curbing the speculative attitude of financial institutions. See: Massimo Amato and Luca Fantacci, *The End of Finance* (Cambridge: Polity, 2011); Philip Mirowski, *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown* (London: Verso, 2014).

[4] Amato and Fantacci, *The End of Finance*, 17.

[5] Ibid., 44.

[6] Ibid., 186–88.

perspective on the ontology of algorithms. In doing so, this chapter aims to further the enquiry into the normative dimension immanent to post-industrial technical objects to which digital money pertains. Specifically, given the ubiquity and pervasiveness of algorithmic networks in finance, this chapter seeks to mediate between contemporary realist ontologies of the market and realist ontologies of computation that have emerged in the academic field in recent years in order to make sense of pricing mechanisms qua algorithms. In other words, this chapter aims to answer the following questions: how can we negotiate an ontology of finance premised on the primacy of the event of price and its immanent contingency, with a conception of liquidity understood as the process of transformation of (digital) assets into money and vice versa? And how does an ontology of computation, defined as a formal axiomatic immanently open to contingency, impact market liquidity and price? In order to approach these issues, I will start a conversation between contemporary philosophies of finance and recent arguments on the ontology of algorithms, guided by Gilbert Simondon's philosophy, in particular by his allagmatic theory. My wager is that there exist an "identity of relations,"[7] using Simondon's vocabulary, between the two realities of finance and computation. From this standpoint, the concept of liquidity offers a fruitful entry point – an interface – into the encounter between the market and the concrete abstraction of the computational processes that underlie – or better, axiomatize – global trading.[8]

4.2 Market Liquidity: Interfacing Financial, Technical, and Social Flows

In spite of its fundamental importance, liquidity is by necessity an indeterminate concept. The modern definition of liquidity comes from John Maynard Keynes' 1930 *A Treatise on Money* in which the term 'liquidity' allegedly appears for the first time.[9]

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[7] Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 533.

[8] The example of the MOnetary National Income Analogue Computer (MONIAC) illustrates well the difference between operatory analogy and structural analogy in Simondon's allagmatics. As Simondon explains, while the former is an "identity of relations, but not a relation of identity" the latter is a mere resemblance. Invented in 1949 by New Zealand economist William Phillips, the MONIAC aims to model economic dynamics on the basis of fluidic logic, thereby structuring economic liquidity on the bases of physical laws that, however, cannot fully account for the reality of market dynamics. "The Moniac," *The Reserve Bank Museum*, accessed July 22, 2016, http://www.rbnzmuseum.govt.nz/activities/moniac/introduction.aspx.

[9] Keynes uses the term 'liquid' throughout the two volumes of *A Treatise on Money* to indicate resources that are "in a form available for immediate consumption." John Maynard Keynes, *A Treatise on Money in Two Volumes. 1 The Pure Theory of Money*, The Collected Writings of John Maynard Keynes. Volume V (Cambridge: Cambridge University Press, 2013), 114. When discussing bank money, he observes that "a

Subsequently, Keynes reproposes it in *The General Theory of Employment, Interest and Money*, in which he outlines the theory of the 'liquidity trap.'[10] This corresponds to those instances in which the market does not respond to central banks' measures to revive trading because investors prefer to hold onto cash – a situation that has occurred in many countries following the collapse of the US housing market, which is considered responsible for the spiraling of the global recession. Yet as John Hicks notes, the terminology used by Keynes "is just a bit *too* liquid"[11] in the sense that it is not clearly explained. As Hicks points out "one thing is more liquid than another if it is '*more certainly* realizable at short notice without loss.'"[12] Put it simply, liquidity corresponds to the process of smooth transformation of assets (e.g. stocks) into money and vice versa. The market for a certain stock will be liquid if the bid/ask spread (that is, the difference between selling price and buying price) is low. However, as I will demonstrate in the unfolding of this chapter, this definition does not manage to convey the complexities of market operations and the multifaceted aspects of liquidity. There are two main reasons for this shortcoming: on the one hand, the notion of probability upon which pricing mechanisms are predicated does not account for the contingency immanent to the event of price; on the other hand, the structural role and distinctive character of the technological apparatus underlying the expansion of modern global finance has introduced a new kind of contingency that is directly related to the open axiomatic of computation.

As we saw, Gilles Deleuze presciently noted that the advent of the computer, coupled with a series of political and institutional changes, affected not only financial but also social flows and the very operations of power.[13] While the automation of trading,

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banker will always maintain some liquid resources in hand, partly in the form of cash and partly in the form of deposits with some other bank or banks" (ibid., 24). The term 'liquidity' appears instead in the second volume of *A Treatise* in relation to banks' reserves. John Maynard Keynes, *A Treatise on Money in Two Volumes. 2 The Applied Theory of Money*, The Collected Writings of John Maynard Keynes. Volume VI (Cambridge: Cambridge University Press, 2013), chaps. 25, 37.

[10] In *The General Theory* Keynes presciently observed that: "There is the possibility … that, after the rate of interest has fallen to a certain level, liquidity-preference may become virtually absolute in the sense that almost everyone prefers cash to holding a debt which yields so low a rate of interest. In this event the monetary authority would have lost effective control over the rate of interest. But whilst this limiting case might become practically important in future, I know of no example of it hitherto." John Maynard Keynes, *The General Theory of Employment, Interest and Money* (New York: Harvest/HBJ, 1964), 207.

[11] John R. Hicks, "Liquidity," *The Economic Journal* 72, no. 288 (1962): 789 (emphasis in original).

[12] Ibid., 790 (emphasis in original).

[13] I already anticipated Deleuze's observation in relation to the end of the Bretton Woods system that terminated the convertibility of money into gold. It is worth quoting here Deleuze at length since it illustrates well the paradigmatic change heralded by the new techno-economic apparatus: "Perhaps it is

inaugurated by the opening of the National Association of Securities Dealers Automated Quotations (NASDAQ) in 1972, was instrumental to the very constitution of modern global finance, my proposition is that contemporary financial technology, based on the theoretical tools provided by chaos theory and fuzzy logic, further impacts the very operations of liquidity and its effects on financial and social flows, challenging the ontological assumptions of 'flow' and 'fluidity' underpinning traditional conceptions of market trading.

In light of these premises, the in-betweenness of liquidity – its liminal nature between the material plane of assets and stocks (the so-called 'real economy'), the metaphysical realm of chance, and the computational abstraction of financial engineering – makes it a productive locus for the study of the entwinement of the social, financial, and technical operations that constitute the contemporary politico-economic juncture. While the impact of liquidity on social formations will be dealt with in more detail in the following chapter, here I specifically focus on the nexus between financial and algorithmic flows. My starting hypothesis is in fact that an understanding of financial liquidity qua computation may provide novel insights not only into the operations of contemporary finance but also into the ontological fabrics of markets – insights that emergent philosophies of finance cannot overlook.

In order to tackle this set of disparate issues, I will approach liquidity through its relation to the volatility, or contingency, of price. In the following section I review the ontological assumptions upon which the contemporary understanding of liquidity is based through an explanation of the Black-Scholes formula and Fischer Black's own thesis on noise and liquid markets. Subsequently, I discuss Elie Ayache's and Jon Roffe's metaphysics of the market – focusing on the contingency of price and the spatiotemporal dimension they attribute to the market – foregrounding the understanding of liquidity that these studies suggest but also pointing to some of their

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money that expresses the distinction between the two societies best, since discipline always referred back to minted money that locks gold in as numerical standard, while control relates to floating rates of exchange, modulated according to a rate established by a set of standard currencies. The old monetary mole is the animal of the spaces of enclosure, but the serpent is that of the societies of control. We have passed from one animal to the other, from the mole to the serpent, in the system under which we live, but also in our manner of living and in our relations with others. The disciplinary man was a discontinuous producer of energy, but the man of control is undulatory, in orbit, in continuous network. Everywhere *surfing* has replaced the older *sports*." Deleuze, "Postscript on the Societies of Control," 5–6 (emphasis in original).

limitations. After a review of contemporary technologies of quantitative market analysis, I then introduce the terms of Luciana Parisi's ontology of algorithms and demonstrate that algorithmic contingency endows financial markets with new spatiotemporal coordinates that impact the individuation of price. Further, with the support of Philip Mirowski's work on 'markomata,' I describe how algorithms further impact the metaphysical structure of global finance.

My emphasis on the spatiotemporal dimension of markets is informed by Gilbert Simondon's axiomatic method, according to which the problem of the individuation of complex, living systems – such as markets, if we account for the kinds of human and nonhuman agencies involved in their unfolding – implies "an axiomatic formation founded on chronology and topology, and not simply according to physical-chemical knowledge."[14] In the financial ecosystem, the 'chrono-topological coordinates' of such an axiomatic formation mark the ontological structure of contemporary algorithmic markets. This further corresponds to what in previous chapters I have called axiomatic of signification, which allows for the individuation of affectivity, perception, and cognition starting from tropistic and taxonomic units that provide individuation with a specific orientation. I have also explained that, in complex systems, these same dynamics constitute the 'sense' of power. In the following chapter I will investigate how this axiomatic structure further impacts the social power of algorithmic finance.

As I explained in chapter one, Simondon's approach is the most equipped to grasp the heterogeneous becoming of a complex system, such as the contemporary algo-financial ecosystem. This is due to the primacy that Simondon's method grants to the operations of individuation across relatively different degrees of existence (physical, technical, psycho-collective) and to the normative role it attributes to technics in the structuration of value systems. In particular, Simondon's axiomatic method is relevant because it allows for the inscription of the ontological coordinates of being, understood according to the aforementioned notions of chronology and topology, into a larger ontogenetic process, which Simondon defines as "the becoming of being, that by which being becomes, insofar as it is, as being."[15] For the purpose of this investigation, Simondon's approach will allow me to map the chrono-topological configuration of algorithmic

[14] Simondon, *L'Individuation*, 228.
[15] Ibid., 25.

markets in the context of the becoming of the larger technical ensemble of planetary-scale computation – the latter defined by Benjamin Bratton as "an accidental megastructure" composed by hardware, software, and wetware.[16] While in this chapter I will not deal with the larger socio-technical ensemble in detail, this renewed conception of liquidity will provide the means to grasp the specificities of contemporary systemic events such as financial crises, the consequences of which for the collective sphere will be discussed in the next chapter.

Here I also propose that financial liquidity – understood as the metastable field that derives from the encounter of economic, social, and technical forces – ought to be the real ontological focus of emergent philosophies of the market. My argument is that a reformulation of market liquidity qua computation allows for an understanding of liquidity as pure ontogenesis – the manifestation of the becoming of algorithmic markets. Yet this also testifies to the incomputability of price – and, by extension, of exchange – and may contribute to an explanation of the systemic crises that have unfolded since the automation of trading. In this chapter I suggest that these are not only "liquidity crises,"[17] as some commentators highlight but, more profoundly, "crises of individuation,"[18] as Simondon puts it. Such a reconceptualization of liquidity as the manifestation of the incomputability of price radically challenges the supposed 'fluidity' of market trading and rewires the concept of rationality underlying financial operations. Through this investigation my aim is to initiate further discussions that may enrich the contemporary philosophy of finance with insights into the ontology of computation, given the primary role that algorithmic technologies play in financial trading.

[16] Benjamin Bratton, "The Black Stack," *E-Flux* 3 (2014), http://www.e-flux.com/journal/the-black-stack/.

[17] Economists Massimo Amato and Luca Fantacci provide a compelling argument for the relation of liquidity crises, monetary architecture, and financial logic. To them: "The present situation is not simply a particularly intense and prolonged *liquidity crisis*, but also a *crisis of liquidity* as the principle governing the organization of the credit system in the form of the financial market." Amato and Fantacci, *The End of Finance*, 25 (emphasis in original).

[18] "The physical individual must be thought as a chrono-topological ensemble whose complex becoming is made of successive crises of individuation; the becoming of being consists in this non-coincidence of chronology and topology." Simondon, *L'Individuation*, 149.

4.3 Financial Flows and Volatility: Liquidity and Noise in Early Electronic Trading

Formulated in 1973, the Black-Scholes formula constitutes the first rigorous attempt to control the fundamental uncertainty associated with financial trading and facilitate the smooth exchange between stocks and monetary flows. Specifically, the Black-Scholes is a partial differential equation that provides a general model for the pricing of options – that is, derivatives contracts designed to hedge the risk associated with the ownership of an underlying asset, as they grant the right to buy/sell that underlying without the parties actually having to trade it. The formula describes the value of an option as a function of the current price of the underlying, its exercise price (which is fixed by the option contract), the time to expiration of the option, and implied volatility – where implied volatility means the variation in price of the underlying. The novelty of the Black-Scholes lies in the fact that it provided the means for the normalization of the risk associated with implied volatility through stochastic calculus. Because of its mechanic probabilistic nature, it contributed greatly to the diffusion of financial engineering and automated trading, which was developing in those years thanks to the rise of computational technologies that could perform ever increasingly complex calculations and, by doing so, paved the way for global derivatives markets. As Donald MacKenzie aptly puts it, the Black-Scholes soon became the 'engine' for financial trading all over the world, testifying to the performative nature of financial modeling.[19]

As Joseph Vogl observes,[20] the Black-Scholes is predicated on two fundamental assumptions of neoclassical economics: the efficient market hypothesis, according to which the market always contains perfect information, which consists in price differences, and the random walk, which formalizes the variations in stock prices according to Brownian motion that, in physics, indicates the random movement of particles suspended in a fluid. Counter-intuitively, this means that, because the market always already contains all information, and prices change unpredictably, the more the trading, the more the market should reflect all information available. This would in turn neutralize implied volatility and eventually create a risk-free market. Yet as Vogl notes,

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[19] MacKenzie, *An Engine, Not a Camera*.

[20] Joseph Vogl, "Taming Time: Media of Financialization," trans. Christopher Reid, *Grey Room* (January 1, 2012): 75–76.

by encouraging speculative trading, the Black-Scholes formula adds more uncertainty to markets instead of hedging it. The understanding of implied volatility in terms of random variations in stocks prices that, however, can be normalized through continuous trading is at the heart of Fischer Black's own thesis on noise and liquid markets. As Black puts it: "Noise trading is essential to the existence of liquid markets."[21] Consistent with the efficient market hypothesis, for Black, noise corresponds to the unavailability of complete information to the individual trader (whether a person or an institution) in the decision-making process (of trading, market modeling, allocation of resources, etc.). Importantly, Black argues, noise is exogenous, indeed opposed, to information trading and yet it enters the information conveyed by price precisely because the price of a stock reflects "both the information that information traders trade on and the noise that noise traders trade on."[22] This understanding of liquidity in terms of amount of information available in the market, as opposed to noise, implies that, while the market is *per se* efficient, the single trader will never gain access to complete information, thereby requiring constant speculative trading: "noise makes financial markets possible, but also makes them imperfect."[23]

Ironically, just one year after Black's paper, the first truly global financial crisis – the infamous Black Monday 1987 – unexpectedly hit the global economy. In the climate of general political and economic uncertainty that followed the early 1980s recession and the instability in the Middle East, on October 19, 1987, markets all over the world began to crash, starting in Hong Kong and taking over the major global markets in US, Europe, Australia and New Zealand, all in the span of twenty-four hours. While the causes that triggered the crash of 1987 are still uncertain, according to a report by the US Federal Reserve, there were several contributing factors, such as: the role of program trading, the impact of margin calls on market liquidity and market operations (that is, the manic selling of stocks for cash), and the lack of reliable information that led to overvaluation and distorted market psychology.[24] As Donald MacKenzie highlights, the endemic instability that led to the 1987 crisis cannot be directly traced

[21] Fischer Black, "Noise," *The Journal of Finance* 41, no. 3 (July 1986): 529.
[22] Ibid., 532.
[23] Ibid., 530.
[24] Mark Carlson, "A Brief History of the 1987 Stock Market Crash with a Discussion of the Federal Reserve Response," Finance and Economics Discussion Series (Washington: Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board, November 2006), http://www.federalreserve.gov/pubs/feds/2007/200713/200713pap.pdf.

back to any singular, certain cause – it was indeed a systemic crisis.[25] This event disproved not only the assumptions underlying the Black-Scholes formula but also Black's own argument on noise trading, showing that volatility cannot be tamed through speculations. In the section below I discuss contemporary philosophies of finance that, in the wake of black swan events such as Black Monday 1987, affirm the absolute contingency and primacy of price over stochastic financial models.

4.4 The Metaphysics of Liquidity: The Place of the Market and the Contingency of Price

To recap, according to the efficient market and the random walk hypotheses embedded in the Black-Scholes formula, increased speculation (and hence, noise) lowers implied volatility and facilitates market liquidity. In light of the allegedly unexplainable crises of 1987 and the more recent global financial recession, a number of philosophical contributions have advanced critiques of statistical models such as the Black-Scholes, precisely by challenging the probabilistic notion of implied volatility in relation to market price. Here I discuss Elie Ayache's critique of probability in derivatives markets and Jon Roffe's more general abstract market theory.[26] These studies belong to that speculative fringe of academia that seeks to overcome what Quentin Meillassoux calls "the correlationist two-step"[27] and go beyond the limitations of an epistemology that is still rooted in human bodies and minds. In doing so, they acknowledge that the forces and events that generate global finance draw their power precisely from having very little to no 'humanness' to them at all. In the following paragraphs I focus on two aspects of the market that these studies foreground, that are crucial to the outline of a metaphysics of liquidity: the contingency of the event of price vis-à-vis probabilistic financial models and the specific spatiotemporal structure that these works attribute to the market.

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[25] MacKenzie, *An Engine, Not a Camera*, 190–95.

[26] Elie Ayache, *The Blank Swan: The End of Probability* (Chichester: Wiley, 2010); Jon Roffe, *Abstract Market Theory* (Houndmills: Palgrave Macmillan, 2015).

[27] "By 'correlation' we mean the idea according to which we only ever have access to the correlation between thinking and being, and never to either term considered apart from the other. We will henceforth call *correlationism* any current of thought which maintains the unsurpassable character of the correlation so defined." Quentin Meillassoux, *After Finitude: An Essay on the Necessity of Contingency*, trans. Ray Brassier (London: Bloomsbury Academic, 2010), 5 (emphasis in original).

With his seminal *The Blank Swan,* Elie Ayache proposes to take the market seriously as an object of philosophical enquiry. Through a rigorous analysis of derivatives – otherwise called 'contingent claims' – Elie Ayache provides a definition of the market as "a *perfect medium of contingency*, not as an imperfect case of probability theory."[28] By means of a Deleuzo-Bergsonian critique of the categories of possibility and probability, Ayache challenges the notion of implied volatility embedded in the Black-Scholes formula and argues instead for the existence of a more fundamental absolute, real, contingency upon which trading is based. To Ayache, the statistical process of evaluation, such as the one provided by Black and Scholes, terminates where trading begins: "possibility as a whole is a backward narrative"[29] – in other words, it only occurs after the real has taken place. In regard to the spatiotemporality of the market, to Ayache, the market is a 'place'[30] – chronological time is not relevant to the event of price (setting aside *la durée* of the market, which manifests in the gaps between prices). Instead, the author suggests, the radical contingency of price erases time and replaces it with money.[31]

Radicalizing and extending Ayache's thesis, Jon Roffe proposes a general philosophy of the market built on two axioms: the methodological axiom of immanence – according to which we should "consider the market from the point of view of the market"[32] – and the axiom of inclusion, which postulates that everything that belongs to the market (that is, everything that can be priced) must be accounted for in the deployment of a philosophy of the market. Roffe observes that approaches to the financial market have so far subordinated the market either to the social (such as political economy and sociology), or to labor (Marxism), or to mathematics (mathematical finance), thus limiting their scope of enquiry. Drawing on Ayache's concern with spatiality, Roffe defines the market as an "absolute surface"[33] – a topological surface both discrete (because of

[28] Ayache, *The Blank Swan*, xvi (emphasis in original).
[29] Ibid., 16.
[30] "What if the future contingent event had a *place* instead of a time or a timing, a place we could inhabit independently of time?" Elie Ayache, "In the Middle of the Event," in *The Medium of Contingency*, ed. Robin Mackay (Falmouth: Urbanomic, 2011), 32 (emphasis in original).
[31] As Ayache puts it, money is "ultimately a more fundamental 'counting device' of randomness than the frequency count [therefore] money is more fundamental then time." Elie Ayache, "A Formal Deduction of the Market," in *Collapse: Casino Real*, ed. Robin Mackay (Falmouth: Urbanomic, 2014), 975.
[32] Roffe, *Abstract Market Theory*, 4.
[33] Drawing on Raymond Ruyer, Jon Roffe defines the market as an absolute surface in that it is intensive, material and displays the features of "auto-unification of dynamic multiplicity," which means that the surface and what populates it are one and the same; and equipotentiality, i.e. "an open ended and

prices) and continuous (as the monolithic entity of the market) with no depth, no values.[34] In the schema Roffe outlines, prices are intensive quantities – meaningless signs inscribed in the intensive surface of the market that bear no relations to anything beyond the market itself. In other words, prices are "quanta of the real"[35] – events in and of the market. In contrast to Ayache, Roffe recuperates the importance of time, but only in the relation between the market and the social, affirming that the time of the future is the guarantor of the radical contingency of price and of the market itself, precisely because radical contingency is a "power like time but capable of destroying it."[36] As I will make clear in the following section, my argument is instead that there is a temporality that is immanent to algorithmic markets and that irreversibly impacts not only the orientation of the social but also the actualization of price itself. Before getting to that, however, it is important to clarify the conceptualization of liquidity that these studies suggest.

For Ayache, the absolute contingency of volatility paves the way for a new metaphysics of liquidity, reframed as the "tradeability … exchangeability" of price – "a moving ground, a flowing medium where prices, either of the underlying or derivative, are equally moving and equally 'original.'"[37] Specifically, Ayache defines liquidity as "the 'past' of prices." Yet as he admits, "the past of prices seems to act contrary to the past of actual things"[38] for liquidity possesses "the capacity to reformulate and redistribute

contingent process of formation" that does not respond to geometrico-physical properties (ibid., 81). "The whole of the market, at once, and in all of its constitutive intensive quantities can be thought as *an intensive quantity itself*, a unique, perpetually metamorphosing Price. At this limit, there is no difference between price and implied volatility, since to think the market in this way is to no longer make reference to a given price or price-process against which other processes are co-ordinated: that is to say, to a fixed point of view. It is to think of the market as an absolute surface, united in its absolute multiplicity by auto-survey." Ibid., 84–85 (emphasis in original).

[34] In distinction to prices, Roffe defines values as coded flows (in Deleuze and Guattari's vocabulary) – absolute qualities with the capacity to orient, or direct, social life by ordering the future on the basis of past information. Yet under the techno-cultural system known as capitalism, Roffe explains, the market becomes the "surface of the social" (ibid., 98), resulting in the retroactive recording of prices as "the unconscious of the social" (ibid., 151) – i.e. as value systems. By proposing that "the market is the intensive surface of pricing" (ibid.). Roffe therefore suggests that the market has no values. However, "prices can take on value and meaning retrospectively, but are thereby no longer grasped as price" (ibid.). I will come back to Roffe's distinction between price and value in chapter seven when discussing Bitcoin.

[35] Roffe, *Abstract Market Theory*, 69.

[36] For Roffe the present is the time of the dynamism of capacities (i.e. the agencies of humans and social organizations possessed by such capacities); the past corresponds to the unconscious of the social; and the future instantiates instead "the empty form of time." Ibid., 145.

[37] Ayache, *The Blank Swan*, 56.

[38] Ibid., 58.

the possibilities that may have led to [prices]."[39] Or, to say it with Roffe, while "implied volatility is the name for the variability of all price from the point of view of a selected intensive locus,"[40] liquidity corresponds to what such an understanding of implied volatility exposes, that is, "the integral character of the market surface itself."[41] In other words, liquidity is the *intensity* of the surface itself – the virtual, or preindividual plane upon which price *becomes*.[42]

Ayache's and Roffe's studies offer remarkable, indeed groundbreaking, conceptualizations of the market, by affirming the necessity of the radical contingency of price for the 'liquid' functioning of the market itself. Yet by positing that the reality, and contingency, of the market is granted by the necessity of the time of the future, these studies seem to justify the free-market ideology of the Invisible Hand, leaving no room for political interventions in the present. Furthermore, they seem to overlook the automated – and, I will argue below, autonomous – mode of reasoning at the core of advanced systems of quantitative market analysis and modeling that underlies contemporary market making, which is inherently related to the socio-political and institutional milieu upon which the very activity of trading unfolds. As I explain in the following section, my proposition is that advanced technologies for quantitative analysis – such as genetic algorithms, neural networks, and machine learning systems, founded on the premises of chaos theory and fuzzy logic – have radically impacted both the ontogenetic operations and the ontological structuration of financial markets, with important consequences not only for price and financial markets, but also for the 'real economy.'

In order to overcome these limitations, I believe that a philosophy of contemporary finance would benefit from insights into the ontology of computation, the latter understood as the abstract architecture underlying market structures. Following Simondon's allagmatic method, my argument is that a reformulation of market liquidity also needs to account for another type of contingency; I am referring to algorithmic contingency, which not only complements epistemic and metaphysical contingency

[39] Ibid.
[40] Roffe, *Abstract Market Theory*, 83.
[41] Ibid.
[42] "What makes the price a price, its past, is what virtually it *will* be. The price *is* not. It is insofar as it *becomes*." Ayache, *The Blank Swan*, 58 (emphasis in original).

(Black's noise, and Roffe's and Ayache's absolute contingency of volatility, respectively) but also, I would argue, sublates them. This kind of contingency neither comes from lack of information, as Black argued, nor from the absolute contingency of price. More deeply, algorithmic contingency is immanent to computation as the dynamic, evolving architecture that contributes to the "axiomatic formation"[43] of market liquidity – that is, the "moving ground"[44] upon which the event of price unfolds. Before delving into that, in the next section I briefly present the above-mentioned technological advancements in quantitative market analysis, in order to clarify the novel operative logic that allows for the deployment of these instruments.

4.5 Intermezzo: On the Automation and Autonomization of Financial Reasoning

Joseph Vogl has advanced an understanding of financial markets as media systems, highlighting the paradoxes inherent to the Black-Scholes formula and the redundancy of noise and risk upon which liquid markets are predicated.[45] Here I want to radicalize this perspective and invite the reader to consider financial markets from the point of view of a theory of technology that takes seriously the ontology of computation – a perspective that accounts for the algorithmic, eminently quantitative, axiomatic that constitutes financial markets. Below I briefly review the main advanced technologies used in financial trading, before turning to a theoretical discussion of their ontological fabrics.

Not only do ubiquitous digital networks constitute the infrastructural layer and communication framework underlying global trading; today advanced statistical methods such as neural networks, machine learning systems, and genetic algorithms have become central to the development of automated trading strategies such as money management and market timing systems. The latter in particular involve strategies implemented to make decisions about buying or selling stocks by attempting to predict future market price movements, directly challenging Ayache's and Roffe's claims for

[43] Simondon, *L'Individuation*, 228.
[44] Ayache, *The Blank Swan*, 56.
[45] Through an analysis of the combination of "political decisions, business operations, theoretical implications, mathematical models, and information technologies" generated within and adopted by the financial sector from the 1970s onward, Vogl discusses the "becoming-media of finance." Vogl, "Taming Time," 73–74. While Vogl acknowledges that markets, as media systems, "are defined through heterogeneous hybrids of institutional, technological, theoretical, symbolic, and practical elements" (ibid., 81), to a certain extent, he still treats the algorithmic operations that synthesize such heterogeneous elements as black boxes.

the immanent contingency of price.[46] Today, through machine induction methods that allow a program to 'learn by example,' neural networks are able to generate optimal market timing solutions by inferring rules on how to proceed in the future from past datasets. Genetic algorithms instead are Monte Carlo search methods[47] explicitly based on the principles of natural selection and survival of the fittest in order to solve hard optimization problems. Thanks to their capacity to process billions of combinations in fractions of seconds, genetic algorithms are employed to evolve, combine, or select trading strategies, and for money management applications.

Such methods are based on theoretical principles such as fuzzy logic and chaos theory, that provide solutions to problems considered too complex for binary computation – such as climate science and coastline measurement, as in the case of chaos theory; and traffic control systems, that are necessarily based on indeterminate, or 'fuzzy,' definitions of the inputs. In the context of financial analysis, chaos theory allows one to account for the complexity of financial markets and the multiple kinds of feedbacks that occur in it; fuzzy logic instead provides the means to identify states of the market and support decision making for long-term investments. Importantly, in contrast to the binary logic of first-order cybernetics (based on one or zero, true or false, yes or no, etc.) these advanced modes of reasoning implement a systemic approach rooted in the autopoietic logic of second-order cybernetics that favors interactivity and correlation among disparate sets of data.[48] For instance, certain predictive models are based on the discovery of relational patterns between Google search results and stock prices.[49] In

[46] One early example of market timing strategy is the Seasonality Timing System, created by Norman Fosback in the early 1970s that, as the name suggests, is based on discovering seasonal patterns in equity prices in large datasets – note the 'algorithmic' premises of this method, based on the assumption of recursive dynamics in market trading, a theme I will further explore in the following chapter. Norman G. Fosback, *Stock Market Logic* (New Delhi: Vision Books Pvt, 2005).
[47] Monte Carlo is a brute-force random search optimization method that generates randomness to create initial solutions. Genetic algorithms (GAs) use randomness in their genetic operators (i.e. selection method, crossover, mutation) to generate individual solutions. I will discuss the Monte Carlo simulation method in chapter six.
[48] The term autopoiesis was originally coined by Francisco Varela and Humberto Maturana in regard to the realization of living systems. As they explain: "An autopoietic machine is a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components which: (i) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realization as such a network." Humberto R. Maturana and Francisco J. Varela, *Autopoiesis and Cognition: The Realization of the Living* (Dordrecht: D. Reidel Publishing Company, 1980), 78–79.
[49] Chester Curme et al., "Quantifying the Semantics of Search Behavior before Stock Market Moves," *PNAS* 111, no. 32 (August 12, 2014): 11600–605.

another example, the deep relationality of algorithmic market analysis has manifested in the so-called ‘hack crash’ of 2013. In this instance, following a hack, the Associated Press (AP) Twitter account announced that two explosions at the White House injured US President Barack Obama. In the few minutes before the hack was discovered and the AP account suspended, the Standard & Poor Index fell about 1 percent before rebounding, briefly erasing $136 billion in value.[50]

As their names suggest, such technologies rest on metaphors based on the human and organic world – such as the human brain, genetic evolution, vision, learning process. By doing so, they aim to “mak[e] subjective trading methods mechanical.”[51] The diffusion of such advanced statistical systems in contemporary finance challenges Ayache’s claim for the irreducibility of the trader in the market-making process.[52] Instead, quantitative investing heralds a new era in which data scientists and quants – or better, the skills thereof – have become the most sought-after positions by financial institutions. The state of the art in terms of market making is illustrated by the hedge fund Numerai that uses distributed artificial intelligence for capital allocation. In order to advance its research and strategies, Numerai crowdsources anonymous quants from all over the world and organizes monthly ‘data challenges’ based on encrypted financial data in order to develop prediction models using machine-learning methods. None of the

[50] Drawing on Gabriel Tarde and Tony Sampson, Tero Karppi and Kate Crawford analyze the contagious relationship between social media and markets precisely by focusing on the aforementioned case of the ‘hack crash.’ Karppi and Crawford focus on affective contagion; drawing on Gilbert Simondon, my wager is instead that there exist precise operational relations that contribute to the constitution of the axiomatic upon which the analogous individuation of both markets and socius emerges, as will be clear in the unfolding of this discussion. Tero Karppi and Kate Crawford, “Social Media, Financial Algorithms and the Hack Crash,” *Theory, Culture & Society* 33, no. 1 (January 2016): 73–92.

[51] Murray A. Ruggiero, *Cybernetic Trading Strategies: Developing a Profitable Trading System with State-of-the-Art Technologies* (New York: Wiley, 1997), 179.

[52] “The trader is where the gap between contingency and possibility opens again. The trader *is* the market, in other words, when we remember that the ‘market’ is precisely the shortcut from the contingent claim to the price.” Ayache, *The Blank Swan*, 358 (emphasis in original). Yet as a controversial research shows, because of the very nature of financial operations (i.e. based on pure information processing) a majority of jobs in finance are reportedly at high risk of automation (from 58 percent for financial advisors to a 94 percent for budget analysts), more than any other skilled industry. Carl Benedikt Frey and Michael A. Osborne, “The Future of Employment: How Susceptible Are Jobs to Computerisation?” (Oxford: Oxford University Engineering Sciences Department, September 17, 2013), http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf. The diffusion of high-frequency and automated trading strategies and the introduction of robo-advisers on Wall Street are clear examples of this trend. See: Nathaniel Popper, “The Robots Are Coming for Wall Street,” *The New York Times*, February 25, 2016, http://www.nytimes.com/2016/02/28/magazine/the-robots-are-coming-for-wall-street.html; Hugh Son and Margaret Collins, “The Rich Are Already Using Robo-Advisers, and That Scares Banks,” *Bloomberg.com*, February 5, 2016, http://www.bloomberg.com/news/articles/2016-02-05/the-rich-are-already-using-robo-advisers-and-that-scares-banks.

people are essential to the fund, but their code is. The current leader of the tournament board reportedly works in genomics and biostatistics.[53] This also testifies to the process of dividuation presciently described by Deleuze according to which, under the information paradigm, "individuals have become '*dividuals*,' and masses, samples, data, markets, or '*banks*.'"[54] As such, individual analysts and programmers are expendable, while the code they produce is what counts – quite literally.

Besides the specific functions of such methods, their ultimate goal is to increase liquidity by optimizing the buying and selling of stocks at the minimum price, supposedly making markets more efficient. Yet their use in financial trading is contentious: while some authors and quants praise the success of evolutionary trading strategies for their capacity to solve large optimization problems in a very short time, others warn of the black-boxed character of these algorithms. As a matter of fact, these technologies operate at a temporal scale and degree of complexity inaccessible to the human perceptual system, which prevents any attempt to audit them. For instance, Nevsky Capital, a once-successful $1.5 billion hedge fund, closed down in early 2016 blaming "black box algorithmic funds" for making markets increasingly complex and inaccessible.[55] The case of Knight Capital Group is emblematic in this regard: in 2012 the company famously lost $440 million due to a computer glitch that led its bots into a forty-five-minute long trading frenzy – in other words, it lost almost $10 million per minute.[56] These examples suggest that automated financial technologies ought to receive a rigorous consideration in the outline of a philosophy of the market. In the following section I attempt to do so through a discussion of Luciana Parisi's work on algorithmic ontology.

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[53] Robin Wigglesworth, "Artificial Intelligence-Focused Numerai Raises $1.5m," *Financial Times*, April 18, 2016, http://www.ft.com/intl/cms/s/0/b743fa8e-034a-11e6-af1d-c47326021344.html?ftcamp=engage%2Femail%2Femailthis_link%2Fft_articles_share%2Fshare_link_article_email%2Feditorial#axzz46CEjwy8G.
[54] Deleuze, "Postscript on the Societies of Control," 5 (emphasis in original).
[55] Robin Wigglesworth, "Fintech: Search for a Super-Algo," *Financial Times*, January 20, 2016, http://www.ft.com/intl/cms/s/0/5eb91614-bee5-11e5-846f-79b0e3d20eaf.html#axzz44sCMEouu.
[56] Yuk Hui discusses the case of Knight Capital as an instance of the temporality of "algorithmic catastrophe." Yuk Hui, "Algorithmic Catastrophe: The Revenge of Contingency," *Parrhesia* 23 (2015): 134–35. Hui argues that algorithmic catastrophes unfold in three temporal dimensions: acceleration, delay, and immanence. The event of Knight Capital is one instance of the delay caused by the speed of algorithmic automation, that impacts the capability of humans to intervene in automated (and, as Hui, argues, automatic) processes. See also: Nathaniel Popper, "Knight Capital Says Trading Glitch Cost It $440 Million," *The New York Times*, August 2, 2012, http://dealbook.nytimes.com/2012/08/02/knight-capital-says-trading-mishap-cost-it-440-million/.

4.6 Algorithmic Contingency and the Incomputability of Price

Because trading algorithms operate at a temporal scale and at a level of complexity below and beyond human cognitive capabilities, in order to grasp the import and impact of automated trading technologies on financial dynamics, it is necessary to turn to realist ontologies of computation, such as the one recently articulated by Luciana Parisi.[57] Parisi offers a veritable change of perspective on computation by inviting us to look at algorithms as something more than step-by-step sets of instructions. Pursuing the historical trajectory that starts with Kurt Gödel's incompleteness theorems in logic and mathematics and Alan Turing's treatment of incomputable functions, Parisi's ontology of algorithms dwells in today's advances in algorithmic information theory.[58] Drawing on Gregory Chaitin's formalization of the halting probability Ω[59] – that is, a real number that is perfectly definable but that cannot be computed by any smaller program – Parisi stresses the open formalism of the algorithmic axiomatic – the fact that certain things can be described finitely but cannot be decided and are therefore incomputable. For the purpose of this exploration of market liquidity qua algorithms, Parisi' thesis offers two fundamental contributions: her consideration of algorithmic objects as spatiotemporal actualities, and her affirmation of the necessity of the contingency immanent to computation for the processing of information.

Importantly, while Yuk Hui's work discussed in the previous chapter regarded digital objects, understood as the forms of relation that dynamically structure the ontological

[57] Luciana Parisi, *Contagious Architecture: Computation, Aesthetics, and Space* (Cambridge: The MIT Press, 2013).

[58] Kurt Gödel's 1931 theorems concerned formally undecidable propositions – that is, statements whose existence can be expressed but cannot be proved through the axiomatic method, thereby testifying to the internal inconsistency of mathematical formalism. Subsequently, Alan Turing's seminal 1936 paper on the *Entscheidungsproblem* shifted the debate onto the field of computation (that is, automated, mechanical, quantitative processes) by proving that there exist incomputable functions; in his discussion, he invented the Universal Turing Machine, the foundational concept for contemporary computing machines. Today, Gregory Chaitin pursues this path further by proving the existence of Ω, a real number that is perfectly definable but that cannot be computed by any finite program – in other words, it corresponds to the halting probability of a program.

[59] Chaitin defines Ω as: "an infinite sequence of bits in which there is no pattern, and there are no correlations. Its bits are mathematical facts that cannot be compressed into axioms that are more concise than they are." Gregory Chaitin, *Meta Math!: The Quest for Omega* (New York: Vintage Books, 2006), 65. Chaitin lends the scientific foundations for the constructive impetus to Parisi's project: because mathematic is fundamentally incomplete, due to the existence of a number that cannot be compressed (that is, comprehended) into a smaller axiom, Chaitin argues that reason is limited by definition and affirms the key role of the experimental method for the advancement of mathematics, in a way similar to the physical sciences. Gregory Chaitin, "The Limits of Reason," *Scientific American* 294, no. 3 (March 2006): 74–81.

being of data, Parisi is concerned with algorithmic objects: "an algorithmic object is more than a temporal appearance or the result of interactive stimuli. Instead, it is a symptom of the new spatiotemporal structures that are most clearly deployed by algorithmic architecture."[60] I believe that both readings emphasize complementary aspects of today's complex technological ecosystem, which can be grasped, according to Simondon's allagmatic theory, in terms of the structures and operations that together contribute to the individualization of the present 'technical ensemble.' Specifically, Parisi argues that algorithmic objects are novel spatiotemporal actualities "defined in terms of finite quantities (finite sets of instructions) and incomputable data."[61]

According to Parisi, it is the reality of incomputable data that makes computation possible. As the author states, incomputable data "reveal a strange contingency within form, or chance within programming"[62] that is inherent in the incompleteness of the axiomatic method. Such an immanent contingency marks the ontology of algorithmic objects. Thus they can neither be conflated with the dynamic continuum of the physical-material world nor with the ideal realm of pure mathematics. Instead, for Parisi, algorithms enjoy a mode of existence proper to their own being – that is, quantitative, open, and "imbued with incomputable or patternless objects."[63] Specifically, Parisi argues, "algorithms are actual objects that *produce* computational space and time."[64] This, according to the author, explains the ingression of novel spatiotemporalities in experience that are immanently infected with incomputable quantities, thus adding an "extraspace of nonunifying actualities"[65] within mathematical and physical entities.[66]

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[60] Parisi, *Contagious Architecture*, 9.
[61] Ibid., 259.
[62] Ibid., 94.
[63] As Parisi puts it: "algorithmic objects are actual entities: spatiotemporal structures imbued with incomputable or patternless objects. The latter are not, however, to be misunderstood as the indefinite background of self-evolving energy. On the contrary, patternless objects correspond to entropic bursts of energy within sets of instructions, thereby defining the odd existence of discrete yet infinite algorithms within the structure of our programming culture." Ibid., 8.
[64] Ibid., 259 (emphasis added). Algorithms produce a time complexity and space complexity, by which one means, respectively, the total number of steps required by a program to run to completion, and the computational extraspace, or 'memory,' required for a function to execute a program. As the name suggests, time and space complexity indicate the difficulty required for solving computational problems and are measured asymptotically, since the input size approaches infinity. For this reason, time complexity is traditionally measured in terms of its 'worst-case' complexity – that is, the maximum amount of time taken to run a function starting from an input of size n. For a technical discussion of time and space complexity see: Michael Sipser, *Introduction to the Theory of Computation. Third Edition* (Boston: Cengage Learning, 2013), chaps. 7, 8.
[65] Parisi, *Contagious Architecture*, 3.
[66] As Parisi puts it, computational processes are infected with "contingent infinities deploying the ingression of nonrecurrent and patternless data in recurrent networks." Ibid., 251.

This reformulation adds an extra plane – a "holey space," as Deleuze and Guattari would call it[67] – but not between the smooth space of topological control and the striated space of 'the matrix'; instead, Parisi suggests, it unfolds "underneath continual morphogenesis,"[68] thereby turning "the computational grid into a Swiss cheese of irregular holes, rough edges, and blind spots."[69]

This reformulation challenges the 'becoming topological of culture' that, as I explained in the introduction, indicates the shift according to which ubiquitous networked software has turned culture into a series of surfaces that behave topologically.[70] This becoming topological of culture would indeed suggest the triumph of liquidity and fluidity not only at the abstract level of information trading but also at a more material and sociological level.[71] However, *contra* this perspective, which Parisi dubs 'metacomputational' – according to which everything that is intelligible can be computed – Parisi proposes a mereotopological approach,[72] which instead takes seriously the functional role of contingency – the patternless data – immanent to algorithmic processes. This novel perspective on computation is extremely pertinent to this inquiry into the ontological fabrics of market liquidity, since quantitative market analysis is precisely founded on a metacomputational view, as the cases presented in the previous section demonstrated.

For instance, trading bots and artificial neural networks are said to provide more accurate trading strategies than computational models based on the efficient market hypothesis – that is, the postulate of the complete randomness of price.[73] By computing large amounts of time series in real time in order to determine optimal trading scenarios, financial neural networks are customarily conceived as a preemptive mode of artificial

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[67] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 413–15.
[68] Parisi, *Contagious Architecture*, 133.
[69] Ibid., 256.
[70] Celia Lury, Luciana Parisi, and Tiziana Terranova, "Introduction: The Becoming Topological of Culture," *Theory, Culture & Society* 29, no. 4/5 (2012): 3–35.
[71] Thomas Sutherland offers a compelling critique of the trope of liquidity and flow in sociology. Thomas Sutherland, "Liquid Networks and the Metaphysics of Flux: Ontologies of Flow in an Age of Speed and Mobility," *Theory, Culture & Society* 30, no. 5 (September 2013): 3–23.
[72] Drawing on Alfred N. Whitehead, Parisi defines mereotopology as "the study of the relation between parts, of that between parts and wholes, and of the boundaries between parts." Parisi, *Contagious Architecture*, xi. (2013, p. xi). See also: ibid., 123–35.
[73] Andrew Skabar and Ian Cloete, "Neural Networks, Financial Trading and the Efficient Markets Hypothesis" (Twenty-Fifth Australasian Computer Science Conference (ACSC2002), Melbourne, 2001), http://crpit.com/confpapers/CRPITV4Skabar.pdf.

intelligence that anticipates potential future scenarios and retroactively applies them to present strategies – what Parisi calls "postcybernetic control."[74] Yet against the seamless topological embrace of the metacomputational perspective – according to which 'smart technology' has ubiquitously taken over the background environment of biophysical matter, by transducing qualities into quantities and back into qualities again – Parisi argues that algorithmic objects "reveal that immanent programming is at work in the present … [by] deploy[ing] incomputable objects in the programming of spatiotemporalities."[75] The phenomenon of 'data snooping' is one instance of this kind of computational agency. Data snooping occurs when an AI trading system creates patterns among data whose correlation is however coincidental.[76] The failure to eliminate completely 'accidents' such as data snooping is but one manifestation of the autonomy of algorithmic reasoning – a mode of speculative reason that, as Parisi puts it, "cannot be accommodated by a cybernetic system of probabilities."[77] This realization directly undermines the tenets of evolutionary computational economics, which relies on generative and genetic algorithms for financial modeling, by arguing that algorithmic reasoning is irreducible to human thought precisely due to the quantitative dimension (that is, incomputable data) that constitutes it. However, rather than merely justifying accidents such as the above case, Parisi's thesis affirms that it is precisely the contingency immanent to algorithmic objects that enables the processing of information. My argument is that, in the context of financial trading, the event of price is the epitome of this process. In other words, price is the manifestation of the incomputability of trading – it testifies to the open axiomatic of the relations of exchange.

The conceptualization of algorithms as spatiotemporal actualities infected with the "discrete infinities"[78] of patternless data – the immanent futurity of algorithmic objects – reveals that algorithmic trading strategies such as the ones outlined in the previous section do not anticipate, or preempt, the future through increasingly complex

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[74] Parisi defines postcybernetic control as "the introduction of temporality (variations over time) and qualitative data into the calculation of probabilities, leading a system to achieve homeostasis and balance (negative feedback) or to transform excessive energy into information (positive feedback). Postcybernetic logic involves the transformation of energy into information by calculating potentialities (qualitative data changing over time) rather than probabilities (preset data)." Parisi, *Contagious Architecture*, 265.
[75] Ibid., 81.
[76] This may happen either because the same dataset has been fed to the program more than once, or when more generally the causality of such data has not been determined a priori. See: Skabar and Cloete, "Neural Networks, Financial Trading and the Efficient Markets Hypothesis."
[77] Parisi, *Contagious Architecture*, xvi.
[78] Ibid., 64.

computations. Instead, through the immanent programming of the present, they construct a future that would not have been possible otherwise. Parisi's characterization of algorithms resonates with Simondon's conceptualization of individuation that I explained in chapter one. For Simondon individuation corresponds to the temporary resolution of a metastability between orders of magnitude in *a relation of non-interaction* with each other. As a matter of fact, Simondon considers discontinuity a mode of relationality.[79] Following this trajectory, we can read the radical openness of computation as a mode of discontinuous relation that is functional to the individuation of the market-system. Furthermore, from the standpoint of Simondon's axiomatic method, the addition of computational time and space to the larger chrono-topological axiomatic, which orients the individuation of complex not-only-computational events such as financial transactions, makes of the event of price the instantiation of a future-present that is absolute, yet immanent to the automated trading strategies from which price, as a contingent event, actualizes itself. This means that it is the contingency immanent to algorithmic reasoning, always already approaching its halting probability, that allows for the 'smooth' functioning of liquid markets, not simply by anticipating future patterns but, more importantly, by unleashing spatiotemporal actualities in the programming of the present.

Therefore, contingency in finance does not only stem from the complexity generated by the activity of genetic and/or high-frequency algorithms, trading with each other in the search space of electronic exchanges, as chaos theory would have it. Instead, the immanence of incomputability in computation turns program trading strategies into "the calculation of complexity by complexity, chaos by chaos: an immanent doubling infinity or the infinity of the infinite."[80] In other words, in addition to the exogenous complexity of noise – due to the lack of complete information, but also to the activities of humans and nonhumans of all kinds, sharing agencies and operations of decision making – and to the endogenous metaphysical contingency of price, a rearticulation of liquidity in algorithmic markets also needs to account for the immanent, and irreducible, complexity within computational processes themselves.[81] Parisi's thesis provides the

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[79] Simondon, *L'Individuation*, 102.
[80] Parisi, *Contagious Architecture*, 19.
[81] "Although one tendency of postcybernetic control is to create a neoergonomic architecture of affective computation, another more subtle implication precisely corresponds to the failure of empirical functionalism to address the ontology of algorithmic entities and of incomputable objects without

means to grasp that it is precisely the open formalism of computational processes – which marks the limits of what can be computed and opens up to the reality of "the rumbling noise of incomputable quantities"[82] – that allows algorithms to work as the epitome of rational decision-making. This means that the rationality upon which liquid and efficient markets are predicated "is marked by the ingression of immanent speculation … : an infection with abstraction that irreversibly drives all forms of decision making beyond yes and no states."[83] Put differently, price *is* the instantiation of the rationality of liquid markets – but of a rationality that is immanently infected by, and inflected with, incomputability. While the previous chapter noted that the 'value' of digital objects already challenges economic value, this discussion further suggests that the technical value of the digital also troubles the traditional understanding of the rationality of price. In other words, being the material instantiation of the incomputability at the heart of exchange, price does not provide an adequate measure of financial value. What is needed is a different measure of worth, as will be clear in the following chapters.

After having clarified the radical novelty introduced by advanced algorithms into information processes, following Gilbert Simondon's axiomatic method it is now possible to sketch the spatiotemporal coordinates that characterize the ontological structuration of algorithmic markets, as the following section will discuss with further support from Philip Mirowski's recent work. According to Simondon's approach, the axiomatic of individuation is always already incomplete, thus testifying to the larger ontogenetic process within which being unfolds. Therefore, grasping the 'chrono-topology' of the market may further allow for a more nuanced understanding of the unfolding of collective dynamics, which extends beyond financial trading.

4.7 Markomata, the Complexities of Complexity, and the Rationality of Crisis

To sum up, Parisi's reformulation of the ontology of computation reveals the necessity of contingency to the structuration of smooth flows of exchange and communication.

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patterns. The more thought is embedded in computational apparatuses of cognition and perception, the more algorithmic objects unleash the incomputable data that cannot be synthesized, summed up, or simply instantiated in smaller programs (or in one totalizing form of thought)." Ibid., 80.

[82] Ibid., 19.

[83] Ibid., 153.

From this standpoint, the contingency of market price is the direct manifestation of the incomputability at the heart of the rational behavior of liquid markets. Furthermore, Parisi's definition of algorithms as novel spatiotemporal actualities re-adds a notion of time to the spatial conceptualization of liquidity proposed by Ayache and Roffe (that is, the 'moving ground' of price, the 'absolute surface'). In a way, this validates Ayache's point: the future contingent event does happen outside of time; but only outside of the time that pertains to the biophysical realm. In other words, algorithmic contingency, with which markets are imbued, does not destroy time – instead it adds to it. Therefore, it is not the time of the future that is guarantor of the contingency of the market, as Roffe argues; quite the contrary, it is the present, immanently infected by – and inflected with – the reality of incomputable quantities. In addition to this, as noted above, the immanence of contingency to computational processes also adds an extraspace of incomputable quantities immanent to the 'liquid' flows of data and monetary exchange. Thus, if recursive neural networks and linear decision trees have become the 'liquid architectures' of financial markets in light of the topological turn of culture, such architectures are always already incomplete – they instantiate "a fractal architecture of events (an incompatible infinite nexus of spatiotemporalities)."[84]

In the remaining of this section I want to discuss how the incomputability and complexity of algorithmic processes may further recode the ontological fabrics of financial markets, with the support of Philip Mirowski's recent work on "markomata."[85] As I explained in chapter two, in *Machine Dreams* Mirowski exposes the way in which cybernetics, wartime strategy, and computational technology recast the economic agent as an information processor, impacting the development of the economic orthodoxy and cementing its entwinement with the neoliberal doctrine.[86] Here Mirowski shows that John von Neumann's theory of automata furnished the blueprint for the development of evolutionary computational economics. This has triggered a further, more recent, tendency in contemporary microeconomics, whose focus has turned from the economic agent as information processor to a growing concern with "the formal specifications of

[84] Ibid., 80.
[85] Philip Mirowski, "Inherent Vice: Minsky, Markomata, and the Tendency of Markets to Undermine Themselves," *Journal of Institutional Economics* 6, no. 4 (2010): 415–43; Philip Mirowski, "Markets Come to Bits: Evolution, Computation and Markomata in Economic Science," *Journal of Economic Behavior & Organization*, Markets as Evolving Algorithms, 63, no. 2 (June 2007): 209–42.
[86] See also: Mirowski, *Never Let a Serious Crisis Go to Waste*.

markets as evolving computational algorithms."[87] This tendency is exemplified by recent work in system theory that, by studying markets and social networks according to the precepts of graph theory and game theory, is increasingly preoccupied not only with the behaviors of the agents but also with structures and the connectedness among structures.[88] Starting from these premises, in contrast with Ayache's and Roffe's theses, Mirowski defines a market as a formal automaton – a 'markomaton' – characterized by specific software:

> … which both calculates and acts upon inputs, comprised of an integrated set of algorithms that perform the following functions: Data dissemination and communications, plus rules of exclusion; order routing through time and space; order queuing and execution; price discovery and assignment; custody and delivery arrangement; clearing and settlement, including property rights assignment; record-keeping.[89]

Following from the previous discussion, such an understanding of markets *as* algorithms profoundly challenges the view of the market as a neutral locus or surface, as Ayache and Roffe suggest, and instead provides the means to define markets as both milieux and agents, whose operations not only impact financial transactions but also social dynamics – a topic, the latter, to which I will return in the following chapter. Moreover, in light of Parisi's discussion on the ontology of algorithms, markomata as both agents and milieux indeed become loci of the individuation of price imbued with incomputability. Paraphrasing Simondon's discussion of the living individual, one could dare to say that financial markets are "both agent and theatre of [the] individuation [of price]; [their] becoming is a permanent individuation or rather a series of outbursts [*une suite d'accès*] of individuation advancing from metastability to metastability."[90] This manifests both in relation to the time and space of market architectures.

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87 Mirowski, "Markets Come to Bits," 210.
88 See: David Easley and Jon Kleinberg, *Networks, Crowds, and Markets: Reasoning About a Highly Connected World* (New York: Cambridge University Press, 2010), 2–10.
89 Mirowski, "Markets Come to Bits," 211.
90 Simondon, *L'Individuation*, 29.

As an economic operator, each markomaton displays spatiotemporal coordinates unique to the functions it has been designed to execute and that are, in principle, limitless. Mirowski mentions several types of market that operate according to specific spatiotemporal features.[91] For instance, the Dutch or descending clock auction – an "interactive auction format, in which the seller gradually lowers the price from some high initial value until the first moment when some bidder accepts and pays the current price"[92] – allows for the "clearing of a market in a fixed specific time frame."[93] Conversely, the "computerized limit order book provides a public record in real time in the form of an accessible order book."[94] In contrast to the order book format, the sealed-bid auction, also called blind auction, is a type of market structure in which buyers submit 'sealed bids' to the seller.[95] A blind auction market can further be classified as 'first-price sealed-bid auction,' in which the highest bidder wins, and 'second-price sealed-bid auction' in which instead the highest bidder wins the auction and pays the price of the second highest bid (as it happens on eBay).[96] *Contra* these auction-type markets, in a posted-price market trade occurs according to a univocal advertised price. As Mirowski observes, "the posted-price market reduces personal interaction in the marketplace to a relative minimum … [but also] leaves open vast opportunities for arbitrage."[97]

In other words, each markomaton creates its own chrono-topological coordinates that, furthermore, can overlap when the same commodity is traded in different markets.[98] This reformulation challenges the aggregate law of supply and demand of orthodox neoclassical economics, since a commodity – whether a physical commodity or a derivative – can be traded through different markomata *within* the same spatiotemporal

[91] Mirowski, "Markets Come to Bits," 228.
[92] Easley and Kleinberg, *Networks, Crowds, and Markets*, 250.
[93] Mirowski, "Markets Come to Bits," 228.
[94] Ibid.
[95] Commodity Futures Trading Commission, "CFTC Glossary," *Commodity Futures Trading Commission*, accessed August 8, 2016, http://www.cftc.gov/ConsumerProtection/EducationCenter/CFTCGlossary/index.htm.
[96] Easley and Kleinberg, *Networks, Crowds, and Markets*, 250.
[97] Mirowski, "Markets Come to Bits," 228.
[98] The spatiotemporal discrepancies between these different types of market structure are also evident in the dynamics characterizing consumer markets and the arbitrage possibilities they allow for. For instance, while Amazon is a posted-price market, eBay is a second-price sealed bid auction. This allows eBay sellers to buy items on Amazon and resell them for a higher price on eBay, taking advantage of the blind auction model. See: Matt Levine, "EBay Arbitrage and Airline Competition," *Bloomberg View*, July 29, 2016, http://www.bloomberg.com/view/articles/2016-07-29/ebay-arbitrage-and-airline-competition; Jason Feifer, "Why It's Nearly Impossible to Stop This Amazon and eBay Scheme," *Entrepreneur*, July 27, 2016, https://www.entrepreneur.com/article/278622.

coordinates. Therefore, speaking of a single overarching market structure does not provide an adequate description of the financial landscape, as I already anticipated in chapter three. Instead there are multiple individualized markets, constituting a heterogeneous ensemble that affects physical, social, and psychic dynamics according to multiple spatiotemporalities. Furthermore, in relation to their networked nature, Mirowski explains that markomata are connected in "small world topologies because they are frequently restricted by their adaptation to particular local environments (i.e., humans) to only take as inputs information from other markomata similarly so adapted."[99] In other words, automated markets are not all connected to one another, precisely due to the constraints caused by human intervention. This dispels the "the myth of The Monolithic Market,"[100] leaving gaps of indeterminacy when it comes to price changes, income distribution, and firm sizes – an issue that may explain financial inequalities that further reflect in the social sphere. "The persistence of arbitrage inconsistencies is an endemic fact of life in the theory of markomata."[101]

Ultimately, Mirowski explains that markomata advance two orders of complexity: on the one hand, complexity derives from the incompleteness of markets conceived as Turing machines, that is the "universal terminus toward which all automata tend, … their internally defined 'halting conditions,'"[102] which validates Parisi's thesis on the ontology of computation. On the other hand, there is another order of complexity that corresponds to a local intractability of the class of problems that the machine is expected to solve. Mirowski argues that, while "full-blown halting problems"[103] rarely happen – although, as mentioned before, cases such as the 2010 Flash Crash are increasingly occurring – complexity manifests as "local increases in computational intractability in specific markets, which then reach a tipping point, precipitating a widespread crisis of computational complexity and liquidity."[104] The collapse of the US subprime mortgage market that triggered the Global Financial Crisis (GFC) of 2008 was an instance of this second order of complexity. This, for Mirowski, is the "inherent vice" of contemporary markets: "an endogenous development which by its very nature,

[99] Mirowski, "Markets Come to Bits," 232.
[100] Ibid., 237.
[101] Ibid., 232.
[102] Ibid., 228.
[103] Mirowski, "Inherent Vice," 436.
[104] Ibid.

cannot be tamed through conventional insurance or risk models."[105] Starting from these premises, Mirowski observes that this dual understanding of complexity rewires the meaning of market failures:

> When a markomata fails, it appears unable to halt. Prices appear to have no floor (or ceiling, in the case of hyperinflation), and the communication/coordination functions of the market break down. Hence there exists the phenomenon of 'circuit-breakers', which make eminent good sense in a computational economics (even as they are disparaged in neoclassical finance theory). Earlier generations of market engineers had apprehended the need for a manual override when there were 'bugs' in the system. And as any software engineer knows, one never entirely banishes all bugs from real-world programs. Markomata, therefore, never can become reified as the apotheosis of rationality.[106]

Thus algorithmic failures correspond to the inability of computational processes to functionally halt, whether the cause is the immanent complexity of algorithmic processes, as the case of Knight Capital described above pointed toward, or a local intractability.

While this line of enquiry certainly necessitates further investigation, whose consequences for the social sphere will be explored in chapter five, my forward-proposition in these concluding remarks is that the systemic crises that have unfolded since the automation of trading – such as Black Monday 1987 and the recent global financial recession – are not only crises of liquidity, as some economists argue,[107] but also *crises of computation* – or better, crises of the metacomputational view of the market according to which everything that can be described can be computed.[108] Furthermore, they testify to the "crises of individuation"[109] that, according to Simondon,

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[105] Ibid., 441.
[106] Mirowski, "Markets Come to Bits," 229.
[107] See: Amato and Fantacci, *The End of Finance*, 25.
[108] Philip Mirowski illustrates how the advancement of such a view has been part of the neoliberal project since its inception in Mont Pelerin in 1947. Philip Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (Cambridge: Cambridge University Press, 2002); Philip Mirowski and Dieter Plehwe, eds., *The Road from Mont Pelerin: The Making of the Neoliberal Thought Collective* (Cambridge: Harvard University Press, 2009).
[109] Simondon, *L'Individuation*, 149.

are necessary to the resolution of the ontogenetic problem within complex systems. Arguably, together with what Black identifies as lack of information, computational technology played a considerable role in the unfolding of the liquidity crises of 1987 and 2007-08 – not only by spreading risk through the networked channels of communication but also in the use of automated decision-making strategies, as some commentators note.[110] However, my hypothesis does not concern whether an algorithm caused the GFC (though a rogue algorithm was most certainly implicated in the Flash Crash of May 2010 and the collapse of Knight Capital in 2012). My proposition is instead that computational contingency – that is, algorithms always already approaching their own limits, the "limits of reason," as Gregory Chaitin puts it[111] – actualizes the absolute contingency of price and amplifies the magnitude of black swan events such as liquidity crises to the broader social reality.

In other words, the perspective that Parisi and Mirowski inaugurate is one according to which, if the machine halts, it is not because it does not work but because that is precisely what it is supposed to do. Similarly, Massimo Amato and Luca Fantacci insist that liquidity crises are endemic to contemporary finance precisely because that is the way finance works: "There is something, namely the crisis, that appears to be inevitable but at the same time unpredictable, and not because of any negligence but *because this is how the markets work*."[112] From this perspective, liquidity crises are the emblem of the rational behavior of markets — a rationality, however, at the core of which incomputability lies as the determining condition of every computation. This reformulation of financial markets as allagmatic architectures bursting with incomputability adds an extra dimension to the complexity of markets that a philosophy engaged with finance and technology cannot overlook.

In this context, Simondon's quasi-atomistic, or quantic, view of time and space reveals that individuation happens in the interstices between the structural elements of a heterogeneous and complex technical ensemble, such as global finance. Thus, following Simondon, the insertion of novel spatiotemporal actualities in the financial system –

[110] For instance, in 2007 automated mortgage underwriting reportedly encompassed 40 percent of all subprime loans in the US. Lynnley Browning, "The Subprime Loan Machine," *The New York Times*, March 23, 2007, http://www.nytimes.com/2007/03/23/business/23speed.html.
[111] Chaitin, "The Limits of Reason."
[112] Amato and Fantacci, *The End of Finance*, 16 (emphasis in original).

that is, the microtemporalities and topological inflections produced by the individuation of algorithmic objects, upon which quantitative market analysis is founded – orients, and *in*-forms, its ontological structure as well as the operations of its becoming. From this standpoint, liquidity becomes the instantiation of the pure ontogenesis of the market, marked by the intensive spatiotemporalities of algorithmic objects. This becomes particularly significant if we enlarge the scope of this enquiry to the ensemble of planetary computation of which markets, as well as collective formations, are part.

4.8 Contingency, Rationality, and the Becoming of Algorithmic Finance

In this chapter I have approached liquidity – the contemporary mode of existence of financialized fiat money – through the perspective of contingency. Drawing on Luciana Parisi's work, I have argued that the ingression of digital computation into market exchange has profoundly altered the ontological structure of the market. First of all, algorithmic objects add new chrono-topological coordinates to the axiomatic of individuation from which the event of price originates, causing price to become the instantiation of the incomputability of exchange. Furthermore, informed by Philip Mirowski, I have argued that algorithms are not only the 'agents' of the individuation of price but also the 'theatre.' This reformulation challenges the monolithic view of 'The Market' and instead demonstrates that finance is constituted by a heterogeneous ensemble of markomata that operate according to different space-times that at times overlap with each other, contributing to the increasing complexity of the financial ensemble. Ultimately, the complexity and contingency of algorithms becomes functional to trading, inverting the problem posed by market failures.

From this standpoint, the incomputability that lies at the core of so-called market rationality turns liquidity crises into the most rational response to the complexities of trading – an issue I will further develop in the following two chapters. Given the complexity, heterogeneity, and incomputability that underlies 'global finance,' liquidity can be better conceptualized as the pure expression of the ontogenesis of algorithmic markets – in other words, it indicates how the being of 'The Market' is preserved through the disparate becomings of its constitutive elements. Such a renewed understanding of rationality in algorithmic markets – as open axiomatic formations – does not imply that we should abandon any notion of calculation or computation to deal with market exchange. Quite the opposite, this reformulation may allow us to frame financial interventions according to different parameters and also, more radically, justifies formal interventions in the open axiomatic of liquid markets. As a matter of fact, in spite of the encroaching naturalization of market dynamics advanced by the neoliberal project, this understanding of algorithmic markets reveals that markets are inherently artificial techno-social ensembles. Thus they can be reworked down to their elementary components, such as money and financial tools, in view of the open axiomatic of digital computation.

From this standpoint, in light of Massimo Amato and Luca Fantacci's argument for the indissoluble relation between the contemporary liquidity paradigm and the monetary architecture of fiat money,[113] would a different monetary architecture – and, by extension, its corresponding data structure – axiomatize, albeit incompletely, monetary, social, and computational flows differently? For instance, could the blockchain, the underlying data structure of the Bitcoin protocol – as economic and organizational technology – offer a new metamodel for the financial architecture? These are pressing questions that I will endeavor to answer in chapter seven and eight. Before doing that, however, there is more conceptual work to be done, which entails addressing another, perhaps more urgent, question – precisely, that of the relation between data structures, algorithmic operations, and the contemporary logic of power. In other words, given the widespread, algorithmic nature of contemporary finance, how does that impact collective formations? How does the operative logic of algorithmic finance – the normative and genetic role of algorithmic operations – organize the social sphere? I will turn to these issues in the following chapter.

[113] "It is the institution of money *as liquidity,* of which its function as a store of value constitutes one of the fundamental pillars, that makes crises *of liquidity* possible." Ibid., 42 (emphasis in original).

5. Conquest and Greediness: The Socio-Technical Logic of Algo-Financial Power

What counts is not the barrier but the computer that ... effects a universal modulation –
Gilles Deleuze[1]

Le modèle triodique est l'analogue fonctionnel d'une structure sociale –
Gilbert Simondon[2]

5.1 Finance, Society, and Technology: An Allagmatic Approach to Power

This thesis aims to define a novel approach to value that would take seriously the normative and genetic role of algorithmic technology in the organization of markets and socius. Starting with chapter two, I have proposed that the architecture of fiat money – understood, following Amato and Fantacci, as an aggregate of the functions of medium of exchange, unit of account and, importantly, store of value – is directly implicated in the amplification of a certain perception of value that has favored the taking-consistency of the capitalist ecosystem according to the mechanist phase of technological development identified by Simondon. However, in chapter three I have shown that the forms of the relation that constitute digital money can give rise to very different kinds of money – for instance, OTC derivatives as expression of digital fiat money and Bitcoin – whose "energetic materiality in movement"[3] troubles the orthodox conceptualizations of monetary value, either as commodity or by fiat. Chapter four furthered this enquiry into the contemporary modes of existence of fiat money by shifting the focus on the flows that constitute financial markets – liquidity – and turning to the event of price. In chapter four I have argued that the processual reality and immanent contingency of computation impacts the metaphysics of algorithmic markets turning price into the material instantiation of the incomputability at the heart of exchange and making crises necessary to the functioning of the contemporary financial machine. Following this trajectory, the present chapter explores the power of social ordering of contemporary algorithmic finance. It does so by adopting an approach informed by Simondon's

[1] Gilles Deleuze, "Postscript on the Societies of Control," *October* 59 (1992): 7.
[2] Gilbert Simondon, *Communication et Information: Cours et Conférences*, ed. Nathalie Simondon and Jean-Yves Chateau (Chatou: Éditions de la Transparence, 2010), 171.
[3] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 408.

allagmatics that, as I explained in chapter one, entails a focus on the interplay between the operations and the structures that allow financial digital objects to take consistency. As I indicated in chapter one, the foundational operations of allagmatics – transduction and modulation – can be described according to the computational operations of reification and recursion that, together, contribute to the dynamic organization of socio-technical systems. This chapter proposes that transductive reification and modulative recursion underlie the logic of the contemporary mode of power – what I have called 'algo-financial power' – and, through the amplification to the social sphere, have very real effects on psycho-collective formations.

Specifically, in this chapter I focus on the operation of recursive sorting at work in derivatives trading and in the recording of transactions in personal bank accounts. Following Simondon's realism of relations, my proposition is that examining the social impact of contemporary finance through the abstract algorithmic operations that allow markets to function may offer a different perspective on algo-financial power. Further, this may provide the conceptual tools to relativize contemporary markets as a particular mode of exchange, rather than regarding them as an immutable reality – as the onto-theo-political truth of neoliberalism. The rationale behind this emphasis on algorithmic operations is that algo-financial power is a peculiar mode of power, which is coterminous with the network of abstract operations that constitute it, by which I mean the concrete but seemingly 'immaterial' relations that define the current logic of power.[4] Thus, while the material infrastructure of this mode of power is often black-boxed, as chapter six will discuss, the operational reality of algorithmic finance deserves thorough attention. Undoubtedly, contemporary power cannot do without the logistical infrastructure constituted by underground cables, powerful microwave antennas, massive data centers, etc. However, the concretization of algorithmic operations into code sets it apart from industrial capitalism, which instead drew its power from the biophysical and material infrastructure constituted by factories, workers, and means of transportation.

[4] Yuk Hui and Andreas Broeckmann address the issue of the peculiar kind of materiality of the novel communication technologies through an investigation of Jean-François Lyotard's 1980 exhibition *Les Immatériaux.* As they note, Lyotard's conception of immateriality was not a negation of materiality as such, but instead a questioning of man's "desire to become the master of matter." Their discussion suggests that Lyotard, like Simondon before him, aimed to go beyond the false division between form and matter at the foundation of the hylomorphic schema. Yuk Hui and Andreas Broeckmann, *30 Years After Les Immatériaux: Art, Science and Theory* (Lüneburg: meson press by Hybrid Publishing Lab, 2015), 10.

In order to start this enquiry, I open with a review of the literature in political economy aiming to uncover the power of the social ordering of financial logic, and show the shortcomings of some of these approaches – that is, the fact that they point to, but never make explicit, the relation between finance and its technical milieu. In order to overcome this impasse, informed by Simondon's allagmatic method, I discuss two technics of recursive sorting – the divide-and-conquer (D&C) paradigm and the greedy approach. Through Simondon's concept of amplification, I uncover how the same logic found in these algorithmic technics is reflected in the way in which structured financing works and how this contributed to the Global Financial Crisis (GFC). Furthermore, I show that this logic can be more generally detected in the way in which bank transactions are recorded. The argument of this chapter is that the computational recursive technics of D&C and greediness are two instances of the axiontology of financial neoliberalism – the at once operational and structural dimension of algo-financial power that gives to both the ontological structures and the value system underpinning the contemporary mode of power. However, the conclusion of this chapter also insists that the value of digital objects ushers in novel possibilities for the speculative engineering of alternative circuits of value creation and distribution through the manipulation and recombination of such recursive functions, as the following chapters will demonstrate.

5.2 Social Studies of Finance and the Financial Logic of the Social

Jon Roffe's philosophy of the market, which I outlined in the previous chapter, also entails a "minimal social theory."[5] Pursuing the trajectory started by Elie Ayache, Roffe affirms the contingency of the event of price vis-à-vis probabilistic models of the market and insists on the primacy of contingency over the structuration of value systems within capitalism.[6] To Roffe, the contingency of price impacts not only social relations but, more deeply, the 'memory of the social' and thus social formations as such. In other words, Roffe argues, through its inscription on the social surface, the contingency of price retroactively constitutes value systems, thereby problematizing the continuous nature of values. However, in the previous chapter, I have also demonstrated that price

[5] Jon Roffe, *Abstract Market Theory* (Houndmills: Palgrave Macmillan, 2015), 91.
[6] Ibid., 91–92.

cannot be held as a valid metric of value precisely because, through the insertion of computational contingency, it becomes an instantiation of the incomputability of relations of exchange.

In order to further this enquiry into the social power of contemporary finance, and find pragmatic and material ways to move beyond the impasse caused by such an understanding of price and value, here I want to shift the focus to contributions from the field of political economy that provide a less abstract approach to the logic of derivatives. In recent years, an increasing number of scholarly contributions from political economy and cultural studies have stressed the need to move beyond moralistic critiques of the economic orthodoxy that rest on an analytical framework that sees 'The Market' in opposition to the logic of the social and cultural sphere. In this regard, Melinda Cooper and Martijn Konings argue that the line of critique that has developed in parallel to the growth of modern finance since the 1970s – "one that portrays financial expansion in terms of the unstable growth of fictitious money and the subordination of social relations and institutions to the irrational logic of casino capitalism"[7] – barely scratches the surface of the foundations of political economy, as it is simply directed to the neoclassical conception of money and markets. Instead, the authors argue for a rigorous account of the ways in which "finance penetrates ever more deeply into the texture of human life and becomes fully imbricated with cultural and psychological dynamics."[8] In this regard, recently emerged fields of enquiry such as cultural economy and the social studies of finance encourage instead the pursuit of "a pragmatic, nonessentialist, and postrepresentational approach to social theory"[9] that would come to grips with the foundations of neoclassical economics – including the non-neutral role of money in the constitution of the contemporary financial architecture – and study financial practices and operations as immanently implicated in the unfolding of the social.

[7] Melinda Cooper and Martijn Konings, "Contingency and Foundation: Rethinking Money, Debt, and Finance after the Crisis," *South Atlantic Quarterly* 114, no. 2 (April 1, 2015): 240.
[8] Ibid., 242.
[9] Ibid., 242–43.

In line with this trajectory, Dick Bryan and Michael Rafferty investigate the social role of financial derivatives and their impact on class relations.[10] To them, financial derivatives intensify the competition in capital markets – "and thereby into all markets"[11] – with direct consequences for the labor market. Specifically, the authors uncover the dual nature of financial derivatives, as both capital and as a new form of commodity money, transforming the very nature of both. On the one hand, Bryan and Rafferty argue, derivatives create the conditions for a competitive commensuration among different forms of capital, which "asserts direct pressures on capital in production, and thereby in the labour process, because all capital, everywhere, needs to be (and is being) actively compared for its on-going profitability."[12] On the other hand, derivatives as money are "market-created money without formal nation-state guarantees ... that arise and terminate exclusively within the sphere of circulation."[13] In other words, derivatives are "not just functional to capital but are also to be seen as a new (commodity) money facilitating a more globally oriented scale of accumulation."[14] Importantly, derivatives constitute a new kind of commodity money based on "a system of computational links across a range of measures – privileging none, but reconciling all."[15] This is a kind of money made of pure computation, therefore variable in value – an issue that I have indirectly discussed in chapter three with the case of the reification of OTC derivatives according to FpML and FIBO. Thus derivatives "form a continuous, floating link between various financial asset forms."[16] As the authors argue, the unlimited computational nature of derivatives gives rise to a logic that proceeds according to a double movement of binding and blending: derivatives bind the future to the present and blend "different forms of capital into a single unit of measure. (They make it possible to convert things as economically nebulous as ideas and perceptions, weather and war into commodities that can be priced relative to each other and traded for profits)"[17] – thereby flattening the heterogeneity of things and relations onto the computational plane of the market. Not only are derivatives "part of the

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[10] Dick Bryan and Michael Rafferty, *Capitalism with Derivatives: A Political Economy of Financial Derivatives, Capital and Class* (Houndmills: Palgrave Macmillan, 2006).
[11] Ibid., 103.
[12] Ibid., 155.
[13] Ibid.
[14] Ibid., 106.
[15] Dick Bryan and Michael Rafferty, "A Time and a Place for Everything: Foundations of Commodity Money," in *Money and Calculation. Economic and Sociological Perspectives*, ed. Massimo Amato, Luigi Doria, and Luca Fantacci (Houndmills: Palgrave Macmillan, 2010), 117.
[16] Ibid.
[17] Bryan and Rafferty, *Capitalism with Derivatives*, 12.

commodification of everything and the incorporation of all social processes into the profit-making nexus"[18] but they also commodify risk and divorce it from the underlying object of risk.

Economists Massimo Amato and Luca Fantacci hold a similar position, which I anticipated in the previous two chapters. Radicalizing Bryan and Rafferty's argument, Amato and Fantacci trace the problem foregrounded by derivatives back to the paradigm of liquidity as the "architectural principle"[19] of the financial infrastructure of the past three hundred years. In particular, the authors critique the view that sees liquidity as "the other face of trust"[20] – according to which trust in the Invisible Hand of the market needs to be promoted at all costs – because this view doesn't account for the "*fundamental uncertainty* inherent in credit."[21] According to Amato and Fantacci, this perspective "*dissolves* the imponderability of risk, that is, every true operation of credit, and *resolves* it into a quantity of price, a commodity."[22] To the authors, liquidity embodies the *modus operandi* of financial capitalism precisely because it allows for the indefinite deferral of payments by monetizing the present value of future assets/investments in the present – that is, by making it liquid. By blurring the difference between money and credit, contemporary markets allow for the monetization in the present of future yields calculated according to the "bookkeeping artifice"[23] of fair value. Drawing on Marc Bloch, the authors maintain that the interchangeability between money and credit is at the foundation of the logic of capitalism:

> Delaying payments or reimbursements and causing such delays to overlap perpetually with one another: this was in short the great secret of the modern capitalist system, which could perhaps be most precisely defined as a system that would perish if all the accounts were settled at the same time. This system is fuelled by an optimism that constantly discounts the profits of the future, its eternal precariousness.[24]

[18] Bryan and Rafferty, "A Time and a Place for Everything: Foundations of Commodity Money," 108.
[19] Massimo Amato and Luca Fantacci, *The End of Finance* (Cambridge: Polity, 2011), 224.
[20] Ibid., 16.
[21] Ibid., 20 (emphasis in original).
[22] Ibid. (emphasis in original).
[23] Ibid., 248.
[24] Bloch in ibid., 59.

In other words, capitalism works by discounting (that is, monetizing) the future in the present, by making it liquid.

Jonathan Nitzan and Shimshon Bichler further radicalize this formulation by making explicit the relation between the logic of differential accumulation and the social power of finance in terms of "creordering" – a terms that "connotes the paradoxical fusion of being and becoming, state and process, stasis and dynamism."[25] What Amato and Fantacci call the bookkeeping artifice of fair value corresponds, in Nitzan and Bichler's formulation, to the calculation of a company's capitalization. *Contra* theories of value that emphasize either production (Marxian economics) or consumption (neoclassical orthodoxy), Nitzan and Bichler argue that capitalization – "the algorithm that generates and organizes price"[26] – effectively expresses the logic of contemporary power. Capitalization is traditionally calculated by discounting a company's prospective earnings (e.g. assets, investments, etc.) in order to reflect the supposed present value. Yet according to Nitzan and Bichler, capitalization is better grasped through a relation between a hype index and a risk coefficient – while the former corresponds to investors' irrationality and is responsible for over- and under-valuation, the latter indicates the degree of confidence of capitalists in their own predictions. In the reality of the capitalist market, Nitzan and Bichler state, capitalization becomes the operational logic for social ordering through pricing. In this context, creordering corresponds precisely to the differential logic of capital accumulation qua the power of capitalization. The capitalist market, the authors argue, becomes the very precondition of power through creordering[27] – "the accumulation of capital and the changing power of capitalists to transform society become two sides of the same *creorder*."[28]

In their own ways, these studies foreground aspects of the contemporary logic of finance that underlie a coherent theory of power. To sum up, the logic of derivatives proceeds according to a double movement of temporal binding and blending that, by erasing the differences between money, capital, and commodities (Bryan and Rafferty), enables the indefinite deferral of the settling of accounts through the monetization of

[25] Jonathan Nitzan and Shimshon Bichler, *Capital as Power: A Study of Order and Creorder* (London: Rutledge, 2009), 18.
[26] Ibid., 153.
[27] Ibid., 306.
[28] Ibid., 312 (emphasis in original).

credit in the present (Amato and Fantacci). This, in turn, corresponds to the power of creordering proper to capitalization (Nitzan and Bichler) that, by generating and organizing the 'value' of a company, also impacts social and collective dynamics. Yet again, what these theories point to – but perhaps don't make explicit in any detail – is the relation between the social power of finance and its technical milieu.[29] While the above authors admit that it is unlimited computation that allows for the very existence of the contemporary logic of derivatives and the amplification of the capitalist creorder to the social sphere, what is lacking in these accounts is an investigation of what computation actually is and how it operates. Without such a clarification, there is a risk that economic calculation and algorithmic computation become conflated and flattened onto the same plane. In order to divorce the 'algorithm of capitalization' from algorithmic logic, a rather different approach is required – one that starts from a focus on the technical operations of exchange that allow for the taking-consistency of the financial architecture. The approach I propose here is informed by Simondon's allagmatic method that, as I explained in chapter one, is precisely concerned with 'exchanges' of energy and information. Below I provide a short recap of allagmatics, focusing on the amplificatory aspect of the operations of transduction and modulation and foregrounding the technicity immanent to markets, before delving into an application of the allagmatic method to the contemporary financial architecture.

5.3 Algorithmic Operations and the Immanent Technicity of Finance

In order to overcome the limitations of the above approaches, my proposition is that Simondon's allagmatic method – the "theory of operations"[30] – may provide the means

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[29] As mentioned in previous chapters, economic and social reasoning are today conflated at the level of network design. For instance, Easley and Kleinberg's textbook – aptly called *Networks, Crowds, and Markets* – affirm that the "'connectedness' of modern society … is found in many incarnations: in the rapid growth of the Internet and the Web, in the ease with which global communication now takes place, and in the ability of news and information, as well as epidemics and financial crises to spread around the world with surprising speed and intensity. These are phenomena that involve networks, incentives, and the aggregate behavior of groups of people; they are based on the links that connect us and the ways in which each of our decisions can have subtle consequences for the outcomes of everyone else." Therefore, according to Easley and Kleinberg, they require a unified treatment. From this standpoint, discussing the logic of financial markets also needs to entail an account of the network structures and dynamics that allow for the functioning of these highly connected systems. David Easley and Jon Kleinberg, *Networks, Crowds, and Markets: Reasoning About a Highly Connected World* (New York: Cambridge University Press, 2010), xi.

[30] Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 529.

for “a pragmatic, nonessentialist, and postrepresentational approach to social theory.”[31] As I argued in chapter one, the autonomy and universality that Simondon endows operations with provides the means to explain the individuation of systems – such as ‘the social’ and ‘the economic’ – that are ontologically different but operatively analogous in a speculative yet pragmatic way. Through its focus on the identity of relations, allagmatics precisely explains the analogical becoming of processes and milieux that together concur to the constitution of a single spatiotemporal and perceptual axiomatic that orients the individuation of collective formations – that is, the axiomatic of signification that allows for the constitution of today’s sense of power or, in Brian Massumi’s words, the ontopower of neoliberalism.[32]

Simondon explains that structures and operations are ontological complements to each other, and they come together through an act – the transformative act of information understood as a genetic process[33] and not as a mere statistical relation between signals, as cybernetics had it – which endows individuation with an axiontology. The act of information “is axiontologic, because it grasps the reciprocity between the axiological dynamism and the ontological structures.”[34] In other words, information is the axiontological act that allows for the taking-consistency of a system through the interplay of operations and structures, providing at once a certain orientation of values and specific onto-epistemological schemas. This observation provides an initial pathway toward the goal of divorcing price from information, whose equivalence underlies the foundations of the economic orthodoxy, such as the efficient market hypothesis, as described in chapter four. It further provides the means to untangle the intertwining of computation and derivatives.

The interplay between operations and structures can be approached through the operations of transduction and modulation that, in turn, provide the means to analyze the fundamental computational operations of reification and recursion, as I explained in chapter one. Reification, like crystallization, allows increasingly complex forms to take consistency by way of relations with their associated milieux. The futurity immanent in

[31] Cooper and Konings, “Contingency and Foundation,” 242–43.
[32] Brian Massumi, *The Power at the End of the Economy* (Durham: Duke University Press, 2015).
[33] See: Simondon, *Communication et Information*, 159.
[34] Simondon, *L’Individuation*, 535.

the process of transduction,[35] Simondon explains, allows in principle for transduction to continue *ad infinitum*. Recursion, as an operation of modulation, is instead orthogonal to reification and, through a "structure of relays"[36] – allows for the dynamic control of the levels of energy and information within a system in order for it to reach temporal stability.[37] Put differently, transduction constitutes an instance of positive feedback that advances the process of morphogenesis toward the infinite, while modulation is a negative feedback that effectively allows for the "conservation of being through becoming."[38] Simondon observes that the metastability that derives from the activity of the reception of information in a system gives rise to an amplifying effect – the transposition of transduction and modulation from the local technical reality of the incidence of the operation of information in a metastable system, to psycho-collective and social realities.[39]

In other words, amplification is the operation by which the genetic and normative value of technics extends to different realms of existence in an analogical way. Analogy, from this standpoint, is understood as a certain identity of relations among different realities and, in Simondon's theory, constitutes a heuristic with which to grasp the unfolding of ontogenetic processes at different degrees of existence, as I discussed in chapter one.[40] While I describe reification and recursion as separate operations, in the reality of digital objects and algorithms the two cannot be thought apart from each other but, like transduction and modulation, together concur to the organization of a technical system

[35] "Transductive amplification is essentially positive; it presupposes neither isolation nor limit; it is the model of the positive operation, which feeds itself and propagates according to the instant result of its own exercise: it affirms itself because it is itself cause of its perpetual advancement; it is auto-position, and it is not self-limited." Simondon, *Communication et Information*, 173.
[36] Ibid., 167.
[37] In this context, it is interesting to note the nuances between Simondon's and Deleuze's conceptualizations of modulation. As we saw, Yuk Hui notes that the concept of modulation in Deleuze's philosophy reveals a certain *aporia.* Discussing Deleuze's early work, Hui notes that: "Modulation for Deleuze serves as a form of resistance, not only against moulding or cohesive forces, but also against a certain history of philosophy (e.g. the Aristotelian – Kantian tradition)." However, moving to later works, "such as the 'Postscript on Control Societies,' the concept of modulation becomes the paradigm of capitalistic production, or more precisely the operation of power in control societies." Yuk Hui, "Modulation after Control," *New Formations: A Journal of Culture/Theory/Politics* 84, no. 84 (2015): 77. To overcome this impasse, Hui resorts to Simondon's conceptualization of modulation, but not because Simondon "has a more authentic understanding of modulation than Deleuze"; rather, it is because "Simondon has a closer relation to the question of technology, and hence one can find in Simondon's thought a concrete modulation-control correlation; while at the same time, one can also find a modulation-individuation correlation" (ibid., 79). The tripartite correlation between modulation, control, and individuation in the context of financial markets is precisely the focus of this chapter.
[38] Simondon, *L'Individuation*, 25.
[39] Simondon, *Communication et Information*, 160–61.
[40] See: Simondon, *L'Individuation*, 532–36.

of exchange. Starting from these premises, Simondon claims that "the model of a triode is the functional analog to a social system."[41] Put differently, the "*real synthesis*"[42] between the processes of transduction and modulation in the organization of a system defines the social dimension of the operations of information in terms of the control exercised by the "earlier [technical] reality [*réalité ancienne*]" onto the "incipient reality [*réalité naissante*]" of social ontogenesis.[43] Furthermore, it needs to be noted that, according to Simondon's allagmatics, the relation between the transductive operationality of reification and the modulatory aspect of recursion is never entirely stable – on the contrary, it gives rise to a metastable organization, pulled between the futurity immanent in transduction and the past orientation of iterative repetitions. Simondon's allagmatic theory allows me to recast markets as dynamic architectures of exchange and move beyond substantialist approaches to finance and power in order to foreground how the local reality of computational processes impacts not only market dynamics but also the 'real economy.'

In chapter three and four I explained how the operation of reification provides the means to grasp the structuration of digital objects in terms of Web ontologies and data structures. I also showed that the ontological structures that constitute digital objects are never finite; instead, they correspond to an open axiomatic that always already maintains a margin of transductive indeterminacy.[44] In the following section I will focus on the operation of recursion – specifically, on recursive sorting – in order to explain the taking-consistency of the power of social ordering of algorithmic finance. While for Simondon local technical reality first impacts the psycho-collective sphere and only afterwards the social realm, here I reverse-engineer the process for the sake of familiarity with the objects of enquiry and discuss the technical processes that constitute the social logic of structured securities and personal banking; in the next chapter I will discuss how such processes also impact psycho-collective formations, thus structuring a specific 'sense' of power. My goal in this chapter is two-fold: on the one hand, I aim to show how the algorithmic paradigms of divide-and-conquer (D&C) and 'greedy' are

[41] Simondon, *Communication et Information*, 171.
[42] Ibid. (emphasis in original).
[43] Ibid.
[44] It needs to be noted that to Simondon indeterminism and determinism are only two limit cases of the process of individuation of a system. To him individuation is both determinate and indeterminate, instantiated through the operations of transduction and modulation. Simondon, *L'Individuation*, 149.

reflected in the logic applied to the structuring of financial securities and to the management of personal bank accounts, with very real effects on the social sphere, as the GFC and the practice of calculating overdrafts demonstrate. Further, I aim to foreground the genetic power of modulative amplification in terms of the operation that allows for the creation of value in algorithmic finance. This may help explain how the recursive quasi-causality of modulative amplification partakes in the (re)production of economic value in financial markets and institutions, thus providing a technical explanation for the logic of capitalization.

Importantly, by adopting such a strictly technical view, I do not aim to invoke a technological determinist position. On the contrary, as will be made clear in the unfolding of this chapter, my argument is that the abstract operations that furnish the logic for contemporary finance are evidence of the 'technicity' immanent to market exchange. As I explained in chapter one, technicity is one of the two fundamental modes of relation between human beings and the world (together with religiosity [*religiosité*]) that, according to Simondon, allow for the resolution of a problematic within a system. As Simondon explains:

> Technicity must never be considered as an isolated reality but as part of a system. It is a partial and transitory reality, resulting in a principle of genesis. As the outcome of an evolution, it is the depositary of an evolutionary power [*pouvoir évolutif*], precisely because it possesses the power [*pouvoir*] of being a mediation between the human and the world as solution of an originary problem [*premier problème*].[45]

Thus, as instantiations of the reality of technicity, before being encoded in computer programs, both the D&C and the greedy paradigms are first and foremost evidence of 'natural algorithms' – if by algorithm we understand any dynamic phenomenon that proceeds according to defined patterns.[46] Natural algorithms are essentially algorithms

[45] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 157.
[46] As Yuk Hui notes in his treatment of algorithmic catastrophe: "All catastrophes are algorithmic, even the natural ones, when we consider the universe to be governed by regular and automated laws of motion and principles of emergence." Yuk Hui, "Algorithmic Catastrophe: The Revenge of Contingency," *Parrhesia* 23 (2015): 122.

‘designed’ by evolution over the span of millions of years.[47] By foregrounding the technicity immanent to the abstract algorithmic operations that constitute financial markets, my goal is neither to affirm the ‘naturalness’ of contemporary finance (such a position would endorse the neoliberal project) nor to fall into the all too easy temptation of dismissing finance as the epitome of the evil of contemporary neoliberalism. Instead, following Simondon, my proposition is that, with the passage from technics to technology that I sketched in chapter one and two, and the concretization of digital objects, the technicity inherent to the D&C and the greedy approaches is embedded in the process of information that dynamically constitutes the financial architecture through the sorting of digital monetary objects and flows. In this way, the allagmatic power inherent to the operations of technicity produces an amplification of the organizational character of sorting algorithms to the social and psycho-collective spheres. A focus on the operatory schema and on the place and role of such sorting technics in financial markets will allow me to uncover the axiontology of algo-financial power – a power, I argue, whose values are intimately related to warring strategies and greediness. However, as the conclusion of this chapter will suggest, I also maintain that the open axiomatic of digital objects further allows for invention and for the speculative engineering of novel allagmatic architectures, as will be discussed in the last section of this thesis.

5.4 Divide-and-Conquer: Sorting the Social Through Financial Warfare

Recursion is a fundamental method in computer science by which a solution to a problem is achieved by breaking it down into sub-problems of the same kind as the original. Specifically, a recursive algorithm proceeds according to the ‘if – then – else’ logic until a desired solution is achieved and the program halts. However, as illustrated in the first chapter in relation to Niklaus Wirth’s seminal definition,[48] recursion is not so

[47] Bernard Chazelle offers important insights into natural algorithms. As he puts it: “Perhaps search engines don’t grow on trees, but leaves do, and a sophisticated algorithmic formalism, L-systems, is there to tell us how.” Bernard Chazelle, “Natural Algorithms and Influence Systems,” Research Highlights, CACM 2012 (Princeton University, 2012), 1, https://www.cs.princeton.edu/~chazelle/pubs/cacm12-natalg.pdf. See also: Bernard Chazelle, “Natural Algorithms,” in *SIAM*, 2009, https://people.mpi-inf.mpg.de/~mehlhorn/SeminarEvolvability/ChazelleNaturalAlgorithms.pdf.
[48] “The power of recursion evidently lies in the possibility of defining an infinite set of objects by a finite statement. In the same manner, an infinite number of computations can be described by a finite recursive program, even if this program contains no explicit repetitions.” Niklaus Wirth, *Algorithms + Data Structures = Programs* (Englewood Cliffs: Prentice Hall, 1976), 126.

much a mere instantiation of the iterative nature of certain programs; rather, it is the abstract operation that underlies the discretization of phenomena and the repetition of steps in time and space, whether computational or physical. There are several approaches to recursion that are widely used to provide solutions to sorting and searching problems. Here I specifically focus on the D&C technic, a paradigm of algorithmic design that uses recursion to solve large and complex sorting problems; I will then illustrate how D&C applies to and amplifies the reality of algorithmic finance. Later in the chapter I will discuss the greedy approach.

As the name suggests, D&C proceeds by first dividing a large problem into small sub-problems of the same type of the original. Secondly, D&C solves such sub-problems through multiple recursive calls of the same procedure. It then combines the solutions of the sub-problems to provide the optimal solution to the original problem. The D&C technic is a very common paradigm in computer programming and provides the foundation for efficient algorithms used in disparate fields, such as binary search, QuickSort and MergeSort, and the Fast Fourier Transform (FFT) algorithm.[49] In this section, I refer to the application of D&C to sorting problems, focusing on the resonances between D&C and the pooling-and-tranching ordering logic of derivatives that I will explain later on. My wager is that the logic that D&C adopts in sorting problems is reflected in the logic of derivatives markets and that, through the three-fold allagmatic amplification explained in chapter one (transductive, modulative, and organizing amplification), this paradigm underlies the axiontology of financial markets, impacting social life in very real ways. As a matter of fact, recursive sorting entails a process of dynamic selection modeled upon Darwinian evolution; as I will explain with the example of the US subprime mortgage crisis, in this context the 'fitness' required for 'survival' is recast according to, once again, an economic evaluation of worth.

The D&C paradigm dates back to the dawn of Western civilization, being widely applied to war strategy, social theory, and mathematics. For instance, the algorithm described by Euclid in 300 BC to compute the greatest common divisor of two numbers

[49] In *Wirelessness*, Adrian Mackenzie discusses the FFT in the context of wireless signal transmission – what he calls "air interface." Adrian Mackenzie, *Wirelessness. Radical Empiricism in Network Cultures* (Cambridge: The MIT Press, 2010), 66. Mackenzie describes the way in which FFT and its inverse, the IFFT, divide data and reorder them; he also foregrounds the overflowing and partial tendencies of this ordering logic, which is never straightforward but operates according to a "differential quotient." Ibid., 69–86.

is based on D&C, for it reduces such integers to increasingly smaller equivalent sub-problems and solves them recursively until a solution is achieved. It is also argued that Carl Friedrich Gauss predated the Cooley-Tukey FFT in the early nineteenth century.[50] However, D&C was first and foremost a warring strategy used in antiquity by many civilizations – from the Assyrian as early as 1300 BC to the Romans.[51] In war strategy, D&C involves dividing the enemy forces in order to weaken them and make easy for an army to conquer them.[52] Alternatively, it entails the exploitation of the internal divisions of a population by an external invader in order to easily defeat the former. This was the strategy famously used by Julius Caesar to subjugate the Gauls, for instance.[53] Today D&C is also often invoked in legal theory and the social sciences. Posner et al. note that "economists typically interpret divide and conquer in terms of a specific class of theoretical models whose main feature, roughly speaking, is that a single actor exploits coordination problems among a group by making discriminatory offers or discriminatory threats."[54] Aside from computer science, it is telling that the D&C paradigm also underlies certain applications of two famous game theoretical models – the Stag Hunt game and the Prisoner's Dilemma.[55] As Posner et al. explain, D&C allows third parties to take advantage of the tension between the mutual benefits of

[50] Cooley-Tukey is the most common Fast Fourier Transform algorithm. Cooley-Tukey FFT provides an efficient way to calculate the Discrete Fourier Transform (DFT), which provides "the frequency content of a signal and … facilitate[s] the computation of discrete convolution and correlation." The Cooley-Tukey breaks the DFT into smaller units and recombines them as required. M. Heideman, D. Johnson, and C. Burrus, "Gauss and the History of the Fast Fourier Transform," *IEEE ASSP Magazine* 1, no. 4 (October 1984): 14. See also: Thomas H. Cormen et al., *Introduction to Algorithms. Third Edition* (Cambridge: The MIT Press, 2009), 111.

[51] Eric A. Posner, Kathryn E. Spier, and Adrian Vermeule, "Divide and Conquer," Discussion Paper No. 639 (Cambridge: Harvard Law School, 2009), 1–2, http://www.law.harvard.edu/programs/olin_center/papers/pdf/Vermeule_639.pdf.

[52] As Machiavelli explains in *The Art of War*, "Among all his other actions, a captain ought with every art to contrive to divide the forces of his enemy, either by making him suspect his own men in whom he confides, or by giving him a cause that has him separate his own troops and, through this, become weaker." Niccolò Machiavelli, *The Art of War,* trans. Christopher Lynch (Chicago: Chicago University Press, 2003), 134.

[53] See: Christina S. Kraus, "Divide and Conquer: Caesar, De Bello Gallico 7," in *Ancient Historiography and Its Contexts: Studies in Honour of A. J. Woodman*, ed. Christina S. Kraus, John Marincola, and Christopher Pelling (Oxford: Oxford University Press, 2010), 40–59.

[54] Ibid., 1.

[55] In game theory, the Stag Hunt game is a prototype of the social contract that was inspired by Jean-Jacques Rousseau in *Discourse on Inequality* and describes a conflict between social cooperation and safety. It is used in international agreements. See: Brian Skyrms, *The Stag Hunt and the Evolution of Social Structure* (Cambridge: Cambridge University Press, 2003). In contrast to the Stag Hunt game, the Prisoner's Dilemma describes a situation that shows the paradox of why two 'rational' individuals may choose not to cooperate and became the blueprint for the Cold War international strategy. See: Philip Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (Cambridge: Cambridge University Press, 2002), chaps. 6, 7. The two games differ from each other because, while the Stag Hunt entails two pure Nash equilibria (both players can decide to cooperate or not cooperate), the Prisoner's Dilemma reaches Nash equilibrium only if both players choose to defect.

social cooperation and the private interests that these games exemplify, in cases such as "sabotage of communication channels, the payment of bribes, and the imposition of penalties."[56] While the D&C paradigm certainly predates computer science, we can regard it as an instance of the technicity immanent to contemporary algorithmic finance, whose genealogy, however, lies in strategies of conquest (of a territory, of a problem, of an enemy and also, in this specific case, of the social sphere). Importantly, before the formalization of D&C in computer programs, there was no single theoretical definition of this technics – a testimony of the complex and multifaceted character of the technicity immanent to this paradigm.

To illustrate the principle of the D&C approach in computer programming, Donald Knuth gives the example of a post office in sorting mail.[57] To facilitate the delivery of mail and maximize the efficiency of the post office, Knuth explains, a large collection of letters is sorted into separate bags according to geographical areas, and each bag can be further sorted into smaller bags to refine the geographical division, and so on until a desired scale is reached. The technic of sorting is also intimately related to the origins of the computer. As Donald Knuth observes, there is evidence that the first computer program ever written for the Electronic Numerical Integrator And Computer – the ENIAC – served the purpose of solving "the problem of sorting data in nondecreasing order."[58] John Maulchy – who, together with John Eckert, developed the ENIAC in the mid-1940s – advanced a technic of 'sorting and collating' as early as 1946 in the Moore School Lectures.[59] Yet it was John von Neumann who allegedly envisioned the first program for "sorting and meshing"[60] in his preliminary report on logic design for the EDVAC (Electronic Discrete VAriable Computer) in 1945. Von Neumann's sorting routine later became known as MergeSort. Based on the D&C paradigm, MergeSort is an efficient sorting algorithm composed by three steps: first, a list is split into halves (divide); secondly, each sub-list is sorted by recursively calling the MergeSort function on each sub-sequence until only one or zero elements remain (conquer); ultimately, the merge function further groups the elements back together in ascending or descending

[56] Posner, Spier, and Vermeule, "Divide and Conquer," 1.
[57] Donald E. Knuth, *The Art of Computer Programming: Volume 3: Sorting and Searching. Second Edition* (Reading: Addison-Wesley Professional, 1998), 175.
[58] Donald E. Knuth, "Von Neumann's First Computer Program," *ACM Computing Surveys* 2, no. 4 (December 1970): 247.
[59] Knuth, *The Art of Computer Programming*, 387.
[60] Knuth, "Von Neumann's First Computer Program," 253.

order (combine). MergeSort allows for both top-down and bottom-up implementations. In a very basic pseudocode, the operational logic of MergeSort looks something like this:

```
MergeSort (List(First..Last))
Begin
If List contains only one element Then
     Return Array
Else
     Middle = ((Last + First)/2) //"divide" the list by 2 and find the
middle point
     FirstHalfList = MergeSort(List(First..Middle)) //"conquer" by
recursively calling MergeSort for the first half of the List
     SecondHalfList = MergeSort(List(Middle+1..Last)) //"conquer"
second half of the list recursively
     ResultList = Merge(LeftHalfList, RightHalfList) //"combine" the
sorted lists
     Return ResultList
EndIf
End MergeSort
```

In what remains of this section, my proposition is that the D&C paradigm, of which MergeSort is but one instance,[61] is implicitly reflected in the way in which financial securities are 'pooled and tranched' together. While, as I will explain in chapter six, trading algorithms are effectively a black box – therefore my claim in this section is purely speculative – the logic according to which structured financing is organized on the basis of the risk of default of certain debt assets displays a logic that is strikingly similar to D&C.

Pooling and tranching are two key operations according to which private financial securities are structured. Pooling refers to the process of combining debt assets (e.g. loans, home mortgages, credit card debt etc.) into a single security, while tranching consists in slicing Mortgage-Back Securities (that is, the financial instruments constituted through the pooling operation, and secured by a mortgage or a collection of mortgages) according to the risk of default and other variables that can be customized according to the investors' requirements (such as the amount of return, specific priorities, etc.). Securities thus tranched are ordered according to rating systems ranging

[61] Together with MergeSort, QuickSort needs to be mentioned. Developed by Tony Hoare in 1959, QuickSort is an efficient sorting algorithm that provides a systematic method for ordering the elements of an array. As the name suggests, it is the fastest of the sorting algorithms. Quicksort (sometimes called partition-exchange sort) is an efficient sorting algorithm, serving as a systematic method for placing the elements of an array in order. Quicksort proceeds by comparison, meaning that it can sort items of any type for which a 'less-than' relation is defined. See: Cormen et al., *Introduction to Algorithms. Third Edition*, chap. 7.

from Seniors, to AAA, AA, A, BBB, BBB-, and finally equity, based on the level of default risk of the mortgages in consideration – with Senior and AAA being the safest investments, and anything below BBB- is considered "junk."[62] Pooling and tranching allow for the structuration of Mortgage-Backed Securities (MBS) and Collateralized Debt Obligations (CDOs) at increasing levels of complexity. While, as I just described, an MBS is a type of financial instrument constituted by loans (e.g. residential mortgages) purchased by financial institutions to be repackaged and traded, a CDO is a structured asset- (and today mortgage-) backed security issued by the same financial institutions in order to monetize their credits before their actual maturity. While the logic of pooling and tranching is obviously more complex than a mere D&C algorithm, there are uncanny similarities. Looking at the operations according to which such financial instruments are structured through a technical lens, one can note that they are operationally analogous to the D&C technic:

```
For a pool of mortgages
      "divide" the pool into smaller elements of the same type (e.g.
according to the risk of default, calculated, as I will discuss,
according to the Gaussian copula formula);
      "conquer" each portion by recursively calling the sorting
routine;
      "combine" the sorted list into tranches of a MBS ranked in
decreasing order;
End
```

The process is then repeated only taking the 'mezzanine' section of the MBS (that is, the tranches with a medium to high risk of default and corresponding high yield) in order to structure further CDOs. Given the riskier nature of CDOs, these instruments are insured against the risk of default through Credit Default Swaps (CDSs) – that is, credit derivatives that allow a financial institution (the purchaser of the CDO) to transfer the default risk to the seller of the swap (typically, a hedge fund or other short investors). In other words, a CDS works as an insurance policy against the risk of default of a particular CDO.[63] The financial instruments thus constituted are called synthetic CDOs, because in this case the underlying is not an actual mortgage security but consists in a bet for or against the chance that a CDS will default.[64] Using Bryan and Rafferty's

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[62] FCIC, *The Financial Crisis Inquiry Report* (New York: PublicAffairs, 2011), 71.
[63] Interestingly, CDSs were invented in 1994 by Blythe Masters, who today is one of the most active advocates of the adoption of so-called 'blockchain technology' in financial operations. I will return to this issue in chapter seven.
[64] For an exhaustive explanation, see: FCIC, *The Financial Crisis Inquiry Report*, chap. 8 "The CDO Machine."

vocabulary discussed in the first part of this chapter, the recursive function of sorting mortgages into structured securities *binds* the future (that is, the risk of future default) to the present by putting a price on the tranches of MBSs and CDOs thus produced, thereby also *blending* them with cash and other liquid assets. This way the 'value' of such structured debt assets also enters the capitalization of a corporation.

The normativity of the D&C paradigm is limited to the logic used to order and rate securities and cannot explain, for instance, the shortsightedness of the decision-making processes that led to the massive credit and risk expansion at the foundation of the collapse of the US subprime mortgage market. In order to further this enquiry into the axiontology of algo-financial power and provide an algorithmic explanation of the GFC, one needs to question the frame according to which such decisions were taken. In order to do so, in the next section I will discuss the greedy paradigm. Following this, I propose some reflections on the process of creation (that is, reification) of value through recursive amplification, and will further attempt to describe the steps of the 'algorithm' of contemporary financial power with a focus on the problematic posed by financial crises that I anticipated in the previous chapter.

5.5 Greedy Accounting: Algorithms and Home Banking

Similar to D&C, the greedy paradigm is a recursive approach to problem solving. However, unlike D&C, which is used to solve complex problems, greedy algorithms provide an optimal solution only to local problems. In other words, a greedy strategy is shortsighted, computing the optimal solution at each step of the iteration in the hope of producing a global optimum. For their short-term span and top-down approach, greedy algorithms only find applications in certain problems. Yet they provide reasonable solutions to many real life decision-making instances, such as the traveling salesman problem (which consists in visiting the maximum number of cities in the minimum amount of time), and change making. Similar to the D&C paradigm, a greedy approach predates its mathematical formalization and instead can be considered another manifestation of the technicity immanent to the abstract operations that allow for the resolution of a problematic. For instance, a greedy approach to the traveling salesman problem consists in visiting the nearest unvisited city to the current one. The change-making problem provides the steps for the determination of the minimum number of coins that needs to be selected when giving change.

A greedy technic encompasses five components: 1) a candidate set, from which a solution is created (e.g. the distances among cities, the value of the coins one possesses); 2) a recursive selection procedure, which chooses the best candidate to be added to the solution (e.g. the shortest distance at each step, the largest coin); 3) a feasibility function, used to check if the choice of a candidate contributes to the overall solution of the problem (e.g. would choosing this city allow me to cover the shortest distance? Would picking this coin exceed the total value owed for the change?); 4) an objective function, which assigns a value to a solution; 5) a solution check, used to verify that the choice made solves the problem.[65] For instance, provided that I have a certain amount of coins of different value in my wallet, the change-making problem could be solved in this way:

```
While (I have to make change and have more coins than I owe)
Begin
Take the largest coin in the set // selection procedure
      If (adding a coin makes the change exceed the amount owed)
//feasibility function
            don't take that coin
      else
            add coin to the change
      If (the total value of the coins equals the change owed) //
solution check
            the problem is solved
EndIf
End
```

It has been suggested that a greedy algorithm is also the strategy that banks adopt to reorder transactions in order to maximize overdraft fees.[66] In the US the practice of

[65] Richard E. Neapolitan and Kumarss Naimipour, *Foundations of Algorithms Using Java Pseudocode* (Sudbury: Jones and Bartlett Publishers, 2004), 138.
[66] Presh Talwalkar, "In What Order Does Your Bank Post Transactions? Why This Matters for Overdraft Fees," *Mind Your Decisions*, November 14, 2012, http://mindyourdecisions.com/blog/2012/11/14/in-what-order-does-your-bank-post-transactions-why-this-matters-for-overdraft-fees/. The homework of a computer science class, for instance, reports the following problem: "A customer of Wells Fargo Bank may make multiple withdrawals each day, but the bank determines the order in which they are posted to her account. a. (3 points) If the customer has overdraft protection, a fee of $39 is deducted from the account whenever a withdrawal reduces the balance below $0. Describe a bank-friendly greedy algorithm to order the daily withdrawals so as to maximize the number of overdraft fees charged. (Wells Fargo was sued for using such an algorithm). Explain why your algorithm is greedy. Do you think there is a better algorithm (i.e., one that could yield a larger number of overdrafts)? b. (3 points) If the customer declines overdraft protection, requests to withdraw funds are rejected when they would reduce the balance below $0. Describe a greedy algorithm for deciding which withdrawals to accept so as to maximize the amount withdrawn. Explain why your algorithm is greedy. Do you think there is a better algorithm (i.e., one that

reordering transactions highest-to-lowest has been at the center of a scandal when US bank Wells Fargo was sued for $203 million by its California customers for reordering transactions.[67] While the practice seems to have subsided since that event, according to a report by The Pew Charitable Trust, in 2015 nearly half of US banks still ordered transactions from the highest to the lowest in order to maximize transaction fees and hence profits.[68] In light of the above explanation, a greedy logic for overdraft re-ordering would encompass the following components: 1) a candidate set of transactions, and the corresponding values, to be processed; 2) a selection procedure (that is, a routine that would recursively sort the transactions in decreasing order); 3) a feasibility function that determines if that chosen transaction would result in the highest fee if processed next; 4) an objective function that assigns the value of the overdraft; 5) a solution check that verifies that the procedure leads to the largest overdraft fees. Although customers may not be aware of this practice,[69] algorithms affect their lives in very real ways.[70]

The logic of accounting of financial institutions reflects a greedy strategy by which banks reorder transactions highest-to-lowest in order to maximize fees and their short-term future profit; further, if the amount of overdraft is not immediately repaid, it enters the financial cycle. While the greedy strategy is considerably different from the D&C

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could yield a lower balance)?" CPSC S101, "Homework #5 Algorithms," 2011, http://zoo.cs.yale.edu/classes/cs101/current/s11h5.

[67] Joel Rosenblatt and Karen Gullo, "Wells Fargo Seeks Reversal of $203 Million Overdraft Damages," *Bloomberg.com*, May 16, 2012, http://www.bloomberg.com/news/articles/2012-05-15/wells-fargo-seeks-reversal-of-203-million-damages-in-appeal-1-.

[68] The Pew Charitable Trust, "Checks and Balances" (The Pew Charitable Trust, 2015), 12, http://www.pewtrusts.org/~/media/assets/2015/05/checks_and_balances_report_final.pdf. See also: Kathy Kristof, "Nearly Half of Banks Still 'Reorder' Checks, Boosting Overdraft Fees," *CBS Money Watch*, April 9, 2014, http://www.cbsnews.com/news/nearly-half-of-banks-still-reorder-checks-boosting-overdraft-fees/; Michael Corkery and Jessica Silver-Greenberg, "Overdraft Practices Continue to Gut Bank Accounts and Haunt Customers," *The New York Times*, February 28, 2016, http://www.nytimes.com/2016/02/29/business/dealbook/overdraft-practices-continue-to-gut-bank-accounts-and-haunt-customers.html; Halah Touryalai, "Yes, Banks are Reordering Your Transactions and Charging Overdraft Fees," *Forbes*, June 11, 2013, http://www.forbes.com/sites/halahtouryalai/2013/06/11/yes-banks-are-reordering-your-transactions-and-charging-overdraft-fees/.

[69] Financial institutions may not disclose such approaches. For instance, in my research among Australian banks I have not been able to source any information in this regard. However, the recording of transactions in my own bank account suggests that the practice of reordering transactions in decreasing order is used in Australia as well.

[70] For instance, a Redditor reports that his girlfriend was charged with $1,400 in fees for a series of transactions that, if processed chronologically, would have led to an overdraft of $100. riemannzetajones, "Dear Reddit, Wells Fargo Took Approx $1400 of My Girlfriend's Money in Fees over 1 Month. She Can't Afford This, Help! • /r/AskReddit," *Reddit*, 2010, https://www.reddit.com/r/AskReddit/comments/a50px/dear_reddit_wells_fargo_took_approx_1400_of_my/.

paradigm, they proceed according to a similar logic of recursive sorting. As a matter of fact, while banks record overdrafts not as losses but as future profits, financial institutions account for the present value of securities not as a credit but as a 'liquid asset.' In the context of financial accounting, Amato and Fantacci note that such calculative practices are possible because the contemporary logic of accounting accommodates, and in fact, encourages these maneuvers, being founded on what the authors call a "bookkeeping artifice"[71] – the fiction of fair value. This makes it possible to estimate the present value of future cash flows on the basis of abstract mathematical models that take no account of the context in which such models are deployed and, essentially, on affective predispositions toward the markets (what is also called market sentiment and confidence).[72] From this standpoint, accounting loses its 'accountability' since it loses its causal and decisional primacy in regard to finance, as Amato and Fantacci observe.[73] While, customarily, finance is supposed to make use of past data from accounting to make future decisions, today the relation between the two has undergone a perverse inversion, in the sense that it is predictive financial modeling that guides what enters the books through a process of evaluation that consists in attaching an economic value to something that hasn't matured any yield yet.

Both in the case of bank transactions and in the case of the accounting of derivatives instruments, recursive sorting provides the means for top-down decision making according to an asynchronous temporal scale. The practice of accounting hereby analyzed possesses the same features of the calculation of fair value: an asynchronous top-down reordering aimed at the maximization of future profits. In order to fully explain this logic, however, another passage needs to be explicated – that is, the process of the creation of value underlying recursive sorting. After discussing this, I will be able to draw some conclusions on the axiontology of algorithmic financial power, both in terms of the values it creates (and how), and of the power of social ordering of algorithmic logic.

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[71] Amato and Fantacci, *The End of Finance*, 248.
[72] The field of sentiment analysis to predict market movements is increasingly expanding also due to the new correlational capacities afforded by cross-platform analysis. For some examples, see: Huina Mao, Scott Counts, and Johan Bollen, "Predicting Financial Markets: Comparing Survey, News, Twitter and Search Engine Data," *arXiv:1112.1051v1 [Q-fin.ST]*, December 5, 2011, http://arxiv.org/pdf/1112.1051.pdf; "SNTMNT - Social Sentiment Analysis for Financial Markets.," accessed November 11, 2015, http://www.sntmnt.com/; Malcom Baker and Jeffrey Wurgler, "Investor Sentiment in the Stock Market," *Journal of Economic Perspectives* 21, no. 2 (Spring 2007): 129–51.
[73] Amato and Fantacci, *The End of Finance*, 67–75.

5.6 Value for Nothing: The Reification of Risk and the Social Algorithm of Derivatives

In this chapter I have analyzed the abstract technical operations that allow for the financial machine to function. I have first presented the operation of recursion as an instance of modulative amplification in Simondon's terms and discussed two technics of recursive problem solving that display uncanny similarities with financial logic: the D&C paradigm is reflected in the pooling and tranching technic according to which financial securities are rated and ranked, while the greedy approach is mirrored in the way in which transactions are ordered to maximize the short-term profit of banks. However, this model so far fails to explain the object of financial neoliberalism's decision-making strategies. In order to provide a more comprehensive picture of the algorithmic logic driving contemporary finance I need to discuss the process of the creation of value that such a recursive logic allows for.

As seen in the two cases provided, the D&C and greedy technics of recursive sorting generate new *value* at each and every iteration of the same procedure. In the case of financial derivatives, securities structured according to the D&C paradigm create new liquidity, which is immediately reified – that is, materialized according to algorithmic relations in data structured such as FpML or FIX, as I explained in chapter three. Similarly, in the reordering of bank transactions, each iteration of the sorting procedure creates new value in the guise of overdraft fees and corresponding digital objects that add to the bank's profits and enter the circuit of financial circulation if they are not paid back in due time. This process of value creation reflects Bryan and Rafferty's argument on the temporal binding of financial logic. Furthermore, it generates a new risk that didn't exist before, and that, for that reason, can (and *must*, according to financial logic) be subjected to further securitization in order to be neutralized. Even more so, this points to the fact that, in financial trading, risk and value are one and the same thing. The operation of temporal binding reifies the risk of future default in bits of code that are priced and traded. The higher the risk embedded in the future event, the greater the value of the transaction. This dynamic turns financial relations into a series of endless positive loops – as the volume of securities grows exponentially through the severing of the relation between creditor and debtor (and their consequent replacement with discrete monetary units), so too does the risk embedded in these instruments and their corresponding value.

With these observations in mind, it is now possible to explain the events that led to the GFC as a series of steps in an algorithm that incorporates the crisis in its functioning. Although, as stated in the previous chapter, there is no single, clear cause of the very recent, and arguably still on-going, global financial crisis, the ruthless practice of repackaging subprime residential loans into triple-A CDOs and then insuring them through CDSs (as described in the above section) is often considered one of the culprits of the collapse of the US subprime housing market in 2007 that led to the global recession.[74] According to the official report by the Financial Crisis Inquiry Commission (FCIC), the issuance of synthetic CDOs jumped from $15 billion in 2005 to $61 billion in 2006[75] – a remarkable increment that testifies to the climate of euphoria that pervaded the markets at the dawn of the twenty-first century. Parallel to the explosion of the issuance of CDOs, the creation of CDSs boomed too, to the point that in 2007 the market size of CDSs had a volume of 98 percent of the entire credit derivatives market, before the subprime mortgage crisis hit.[76]

The mathematical model behind this unfathomable credit expansion was David X. Li's Gaussian copula function that provided a simple, 'elegant' way to model the risk of default of CDSs according to a single correlation parameter.[77] This formula allowed for

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[74] Securities are rated on the basis of risk. The 'Big Three' global credit rating agencies are US-based Standard & Poor's, Moody's, and Fitch Ratings. These agencies had the task of rating securities on the basis of their risk. Yet, as the FCIC report states: "The three credit rating agencies were key enablers of the financial meltdown. The mortgage-related securities at the heart of the crisis could not have been marketed and sold without their seal of approval. Investors relied on them, often blindly. In some cases, they were obligated to use them, or regulatory capital standards were hinged on them." FCIC, *The Financial Crisis Inquiry Report*, xxv.
[75] Ibid., 191.
[76] Office of the Comptroller of the Currency, "OCC's Quarterly Report on Bank Derivatives Activities. Third Quarter 2007" (Washington: U.S. Department of the Treasury, 2007), http://www.occ.treas.gov/topics/capital-markets/financial-markets/trading/derivatives/dq307.pdf. It is also worth emphasizing that the rhetoric behind this unprecedented credit expansion was one of a process of the 'democratization of finance' by which banks made loans available to 'subprime' debtors for the sole scope of re-distributing the risk thus created as marketable securities. In other words, this expansion of credit was not due to an increase in the demand of loans by debtors; quite the opposite: it was created through instruments of securitization to meet the demand of investors all over the world. Amato and Fantacci, *The End of Finance*, 70.
[77] For a thorough account of the formula, see: Felix Salmon, "Recipe for Disaster: The Formula That Killed Wall Street," *WIRED*, February 23, 2009, http://archive.wired.com/techbiz/it/magazine/17-03/wp_quant?currentPage=all. As Salmon explains, the formula states that the probability of the default time expectancy of two members of a mortgage pool, A and B, equals the 'copula' of the behavior of A

the correlation between the default risk of heterogeneous assets on the basis not of historical data but merely according to the market data on the prices of CDSs themselves. The elegance and tractability of this formula heightened the confidence of investors and financial engineers, which allowed CDSs and CDOs to grow exponentially by feeding each other at the dawn of the new century. In a 'greedy' manner, in the climate of financial euphoria and continuing rising house prices that preceded the crisis, there was no apparent reason to question the assumptions embedded in Li's Gaussian copula. As the FCIC report states: "Financial institutions and credit rating agencies embraced mathematical models as reliable predictors of risks, replacing judgment in too many instances. Too often, risk management became risk justification."[78]

However, the moment in which the 'algorithm of derivatives' functionally, albeit temporarily, halted – that is, when the housing market declined and such loans could not be repaid – the fragile, liquid architecture of financial derivatives collapsed all at once. This caused a series of liquidity crises in the main markets that progressively extended and amplified the risk associated to the insolvency of investments to more and more aspects of the world, not only financial but also pertaining to the 'real economy' of social exchange. As Manuel Aalbers explains, there is a direct relation between financial dynamics and the US housing market:

> Housing is a central aspect of financialization. Through the rise of securitization and the vast expansion of secondary mortgage markets, not only in the US but also in other countries, the mortgage market becomes financialized. Increasingly, lenders become intermediaries who sell mortgages, but don't manage, service or fund them … But the financialization of homeownership is not limited to the development of secondary mortgage markets; it can also be witnessed in the financialization of (potential) homeowners. The financialization of home was never

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and B, calculated as the distribution function of their respective survival rate and the correlation parameter gamma. The formula assumed that the market could provide exact information about the price of default risk. As Salmon reports: "When you talk to market participants, they use words like *beautiful*, *simple*, and, most commonly, *tractable*. It could be applied anywhere, for anything, and was quickly adopted not only by banks packaging new bonds but also by traders and hedge funds dreaming up complex trades between those bonds." Ibid. (emphasis in original).

[78] FCIC, *The Financial Crisis Inquiry Report*, xix.

designed to enable homeownership; it was first and foremost designed to fuel the economy.[79]

Thus, the financialization of home is a central strategy by which algo-financial power 'sorts' the real economy (homeowners) according to credit scores, thereby 'conquering' it and putting it in the service of the financial economy. As Aalbers further remarks: "Predatory loans, whether securitized or not, by definition, do not present a *stable* income source and are therefore, in a very literal sense, prone to *accumulation-by-dispossession*."[80] Housing, and real estate more broadly speaking, therefore constitutes the territorial pole of the social logic of algo-financial power that, through accumulation-by-dispossession, produces a dis-integration of the collective realm – a 'dividuation' – that hinders the individualization of the social, rather than promoting it.

This means that the algorithm of contemporary financial power incorporates the halting moment of the crisis in its working. As I anticipated in the previous chapter, under financial neoliberalism the crisis is necessary to the functioning of contemporary algorithmic finance and, through allagmatic amplification, is instrumental in the perpetuation of the social power of finance. In other words, the crisis becomes a new occasion to exercise power, by further dividing-conquering-recombining individuals and collectives through financial operations and shortsighted decision making. Therefore, following Mirowski's differentiation between the two orders of complexity in markomata that I described in chapter four, the crisis is not an instance of a market failure. On the contrary, it is an instantiation of the rationality of algo-financial power and an occasion for the contemporary logic of power to increasingly divide-and-conquer the social through financial means. "'If you want to force a change,' Milton Friedman advised his Chicago Boys, 'set off a crisis.'"[81] Similarly, Philip Mirowski has demonstrated that neoliberalism thrives on the engineering of crises, through a double movement of deregulation and re-regulation[82] to the point that "neoliberalism has

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[79] Manuel B. Aalbers, "The Financialization of Home and the Mortgage Market Crisis," *Competition & Change* 12, no. 2 (June 2008): 160.
[80] Ibid., 162 (emphasis added). Predatory lending indicates the practice of convincing borrowers to accept deceptive or exploitative loans that a borrower doesn't need or cannot afford to repay – a practice that led to the subprime mortgage crisis.
[81] The Invisible Committee, *To Our Friends*, trans. Robert Hurley (South Pasadena: Semiotext, 2015), 22.
[82] Philip Mirowski, *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown* (London: Verso, 2014), 57.

become *more coherent* in the face of the crisis, not more diffuse."[83] It is interesting in this respect to note the profound difference in the operative logic of early cybernetic capitalism and contemporary financial dynamics. As I explained in chapter two, when economics turned into a 'cyborg science' through its encounter with cybernetics and operation research, it pursued the goal of homeostatic equilibrium (that is, negative feedback) in the regulation of markets.[84] However, this exposition has shown that instead, the social logic of contemporary financial power thrives on the positive feedbacks instantiated by financial crises – the "inherent vice,"[85] to say it with Mirowski, of algorithmic markets.

Therefore, not only does recursive amplification possess a normative character in the way it sorts social dynamics; it also has a genetic role through the production of new value in time via reification (that is, new risk, new 'digital money' – whether new OTC derivatives or overdraft fees). In light of these observations, my proposition is that the logic of synthetic finance can be recast as a process of reification (of value, of data types, of digital money) through recursive sorting. The circular quasi-causality of these positive feedback loops is amplified by the event of the crisis. As I have illustrated, the crisis is simply a function in the larger and complex D&C algorithm of contemporary finance – an algorithm that however contains an unpredictable variable, which corresponds to the margin of indeterminacy that lies in the transductive process of taking-consistency of digital individuals and, I would add, of the becoming of human individuals too. As I have argued in chapter four and will further explain in the unfolding of this thesis, the financial crisis also corresponds to a "crisis of individuation"[86] – that is, an occasion to solve the metastability of the complex system composed by financial, algorithmic, and social dynamics through invention. As this thesis will clarify, this is only possible through a 'technical effort' that sees humans working in alliance with machines.

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[83] Ibid., 50 (emphasis in original).
[84] Mirowski, *Machine Dreams*. However, in chapter two I also discussed that the concept of negative feedback was already present in economic thought at least since Adam Smith.
[85] Philip Mirowski, "Inherent Vice: Minsky, Markomata, and the Tendency of Markets to Undermine Themselves," *Journal of Institutional Economics* 6, no. 4 (2010): 415–43.
[86] Simondon, *L'Individuation*, 149.

5.7 Reification-Through-Recursion and the Axiontology of Algo-Financial Power

In this chapter I have argued that the social logic of algo-financial power can be explained according to the algorithmic operations of reification-through-recursion, founded on an orientation indebted to war strategies and greedy decision making. The abstract operations of reification and recursion also help recast the arguments presented at the beginning of this chapter in technical terms. Bryan and Rafferty's observation that derivatives proceed by binding and blending mirrors the D&C technic of the structuration of derivatives instruments. The process of recursive sorting binds tranches of securities to the risk of future default, thus allowing for its monetization in the present by blending it with other liquid assets or commodities. Furthermore, Amato and Fantacci's argument that the logic of capitalist finance advances through the indefinite deferral of payments is explicated by the relation between recursion and reification – that is, algorithmic finance works by reifying future value (risk) in terms of digital objects through recursive sorting and circulation. This process may also provide the foundations for understanding the creordering power of contemporary finance – that is, the normative and genetic power of the algorithm of capitalization that determines the value of a company on the basis of the prospective value of the securities it possesses.

Here we start to detect certain differences from the mechanist paradigm of the sense of power that I described in chapter two with the support of Simondon's schema of the birth of technology and Philip Mirowski's exegesis of theories of value in economics. In contrast to the eminently teleological power of the mechanist era, this is an algorithmic power that proceeds recursively, yet indefinitely, whose rhythm is marked by the halting moment of financial crises. While the ultimate goal remains that of differential accumulation, the hierarchical structure of the contemporary mode of power requires the positive feedback of the crisis in order to further creorder the social through division-conquest-recombination.

Furthermore, as I have noted in the above sections, both the D&C and the greedy approaches are instances of 'natural algorithms' that have, allegedly, allowed for the evolution of the living world over the course of history. As described above, both the D&C and the greedy paradigms perform operations of recursive sorting as a mode of dynamic selection – that is, the survival of the fittest, whose fitness however, is here measured in economic value. Hence the bail-outs of those banks that were 'too big to fail'[87] vis-à-vis the individual tragedies of homeowners who, with the burst of the financial bubble, lost jobs and houses without getting any support from institutional authorities, acquires a new significance. In this we can detect another dimension of the D&C paradigm – its genetic and increasingly naturalized role in the fragmentation of the social, in both subjective and territorial terms. This allows algo-financial power to manage the social in a more efficient and allegedly 'natural' manner – provided that the 'naturalness' of economic worth has been fully interiorized by the individual – through financial technics.

To recap, this exposition has foregrounded, albeit speculatively, the normative and genetic role of recursive algorithms in the logic of contemporary financial markets. I have argued that the divide-and-conquer paradigm has furnished the metamodel for the practice of pooling and tranching of derivatives and, through a process of modulative amplification, for the sorting of the social, as the GFC showed. The recursive logic of D&C creates new value and corresponding risk through the reification of new financial digital objects as data structures. Similarly, the sorting routine according to which financial transactions are reordered is done in view of the creation of further value (e.g. overdraft fees) to be put into circulation in the financial circuit if not repaid in due time. In other words, in contemporary finance recursion corresponds to the iterative process by which abstract value is created and accumulated. That is to say, the recursive reordering of transactions/debt assets allows for the process of reification of the imponderability of risk through the application of a certain 'value' (that is, the attribution of a price) to a computational event. Additionally, this value is subjected to more recursive reordering for further monetization – novel digital money. Through the amplification of these technics from financial markets to the 'real economy,' these methods extend the ordering logic of algo-financial power to social dynamics and formations, as the subprime mortgage crisis exemplified. Here I want to suggest that the relays produced by these different types of recursion – D&C and greedy – from the

[87] In response to the loan crisis of 2008, the US government passed the Troubled Asset Relief Program (TARP), to bail out large banks and insurance companies such as Fannie Mae and Freddie Mac. Furthermore, a report of the Financial Stability Board has recently listed a number of "systemically important financial institutions" to address the problem of 'too-big-to-fail.' Financial Stability Board, "Policy Measures to Address Systemically Important Financial Institutions" (Financial Stability Bureau, November 4, 2011), http://www.fsb.org/wp-content/uploads/r_111104bb.pdf?page_moved=1. See also: Mirowski, *Never Let a Serious Crisis Go to Waste*, 231–35.

technical reality of finance to the socius constitute the axiontology of algorithmic financial power, defining both the axiological dynamisms and the ontological structures of the allagmatic architecture of contemporary finance.

Through this technical approach my goal has been to offer a novel way to assess the logic of financialization – that is, the recursive character of a function that brings its future into the present, by preempting it and monetizing it – both of financial investments and of the 'real economy.' As I already stated, by taking such a strictly technical approach my aim has been to foreground the key role of the normative and genetic power that technical operations – the *in*-forming operations of technicity – have on the world. While I have argued that the axiontology of algo-financial power lies in warring technics and shortsighted, greedy, decision making, Simondon's method allows me to insist that the value immanent to the digital object ultimately lies in its openness, in the fact that it can be reprogrammed or recombined according to different forms of relation. As chapter seven will discuss, value lies in the algorithmic operations that compose digital objects and flows, and it is because of this kind of value that invention can occur. It needs to be noted, in fact, that recursion is never a simple repetition, due to the transductive action of the taking-consistency of new value, inherent in the allagmatic operations of exchange. To say it with Deleuze and Guattari, this "implies hit-and-miss changes in rhythm and mode rather than any omnipotence; and something always escapes."[88]

Before getting to the topic of invention, however, such a technical formulation of the creordering power of algorithmic finance raises a further, more immediate, question – the question of representability. In other words, how can one counter a power that lacks

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88 Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 217. In *A Thousand Plateaus* Gilles Deleuze and Félix Guattari discuss monetary flows in terms of payment-money and financing-money. To Deleuze and Guattari financing-money "has, not segments, but rather poles, singularities, and quanta" (ibid.). Deleuze and Guattari suggest that financing-money is "tied to desire and always subjacent to the solid line and its segments determining interest rates and supply and demand" (ibid.). In this chapter I have shown that, while desire certainly plays an important role in financial trading, as was shown by the lack of consideration for the limitations of Li's Gaussian copula for the rating of tranches, this cannot be thought of as removed from the technicity inherent to algorithmic markets. The conclusion that can be drawn from this analysis still agrees with Deleuze and Guattari's: "The task of making the segments correspond to the quanta, of adjusting the segments to the quanta, implies hit-and-miss changes in rhythm and mode rather than any omnipotence; and something always escapes" (ibid.). For a discussion of the relation between payment-money and financing-money, see also: Christian Kerslake, "Marxism and Money in Deleuze and Guattari's Capitalism and Schizophrenia: On the Conflict Between the Theories of Suzanne de Brunhoff and Bernard Schmitt," *Parrhesia*, no. 22 (2015): 38–78.

phenomenal consistency, and that operates beyond and below the threshold of human perception? In the following chapter, I will discuss how the creordering power of capitalization extends to the constitution of sense perceptions and cognitions, but I will also endeavor to answer the aesthetic question posed by algo-financial power by showing that, while representation is indeed impossible, algorithmic objects open up a new horizon of possibilities that may allow for the countering of algo-financial power in other manners.

6. Enter the Black Box: Aesthetic Speculations in the General Economy of Being

The market was by now a pure abstraction –
Michael Lewis, Flash Boys[1]

Wintermute was a simple cube of white light, that very simplicity suggesting extreme complexity. 'Don't look much, does it?' the Flatline said.
'But just you try and touch it.' –
William Gibson, Neuromancer[2]

6.1 Financial Power and the Problem of Representation

The previous chapter described the social logic of contemporary algo-financial power according to the technical operations of reification (of risk, of value) through recursive ordering and circulation. It further defined the axiontology of this mode of ordering as immanently intertwined with warring strategies and greedy decision making. Starting from these premises, the chapter raised the issue of the representability of this mode of power – a power that relies less and less on language and is instead increasingly integrated with "the numeric nature of computation."[3] As a matter of fact, as markets become increasingly evanescent – due to the flickering materiality of layers and layers of code blindly interacting with each other – it has become more difficult, if not impossible, to formulate an intelligible image of the financial ecosystem. This is arguably due to the sheer complexity of the algorithmic infrastructure upon which contemporary financial operations are executed, which has been at the center of much

[1] Michael Lewis, *Flash Boys* (New York: W. W. Norton & Company, 2014), 52.
[2] William Gibson, *Neuromancer* (London: Harper Voyager, 1995), 140.
[3] "After WWII the numerical nature of capital integrated itself with the numeric nature of computation: what has emerged is a Turing capitalism that is able to encode any form of knowledge and labour into data patterns and shows phenomena of autonomous cognition on a global scale (see the machine learning algorithms behind Google, Amazon, etc.). In fact this is not the 'the reign of the unthought,' this is a new crystalline conflict." Matteo Pasquinelli, "Capital Thinks Too: The Idea of the Common in the Age of Machine Intelligence," *Open! Platform for Art, Culture & the Public Domain*, December 11, 2015, 9, http://onlineopen.org/capital-thinks-too. In regard to the relation between money and labor in the contemporary ecosystem, Pasquinelli also notes that "language is no longer the most accurate model to describe the complexity of both money and labour. As much as work has been 'verbalized' in post-Fordism (as Virno remarked once), today's work is also *technified* and *abstractified* at the highest degree. As much as the sphere of language has introduced a wider field of abstraction into money and labour, information technologies have further expanded that trajectory of abstraction. Considering 'natural languages' as the model of post-Fordist labour and money (as Marazzi, Virno and many others once suggested) is a simplification in the age of algorithmic governance, computational capital and financial derivatives." Ibid., 10 (emphasis in original).

discussion since the eruption of the Global Financial Crisis (GFC) and the infamous Flash Crash of May 6, 2010, as the previous chapters noted. Yet, as Philip Mirowski observes, in spite of the thorough analyses of the present politico-economic juncture, financial neoliberalism has escaped any effective critique and survived the crisis it itself created.[4]

Starting from these premises, this chapter approaches the problem of the aesthetics of contemporary power. The unrepresentability of late capitalism is a topic that has been discussed at great length. Fredric Jameson famously argued for the necessity of a practice of cognitive mapping, which would enable a "situational representation"[5] by the individual in front of the unrepresentable totality of capitalism, thereby bridging phenomenological experience and economic structure. Since Jameson, there have been many attempts to theorize the aesthetics of contemporary power: from Susan Buck-Morss' reflections on the attempts to envision "the social whole"[6] through representational mapping of the economy, up to post-GFC arguments for a political aesthetics of the "technical sublime"[7] that would provide the means to navigate the enormous datasets and complex systems that constitute the neoliberal economy today. While these contributions argue for the necessity of a cognitive and representational foundation to the project of navigation of the neoliberal economy, this chapter embraces the unrepresentability of the power of algorithmic finance and proposes an alternative method to map its impact on psycho-collective formations. Furthermore, while the arguments reviewed above are predicated on a perspective that seems to suggest a Cartesian opposition between the economy, and the social and cognitive spheres, this chapter views financial dynamics as immanent in and co-constitutive of processes of individuation and subjectivation.

As chapter five observed, the logic of derivatives possesses a power of social ordering that manifests through the amplification of the operations of reification and recursion proper to automated trading to the social sphere. Informed by the ontologies of

[4] Philip Mirowski, *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown* (London: Verso, 2014).
[5] Fredric Jameson, *Postmodernism, Or, The Cultural Logic of Late Capitalism* (Durham: Duke University Press, 1991), 51.
[6] Susan Buck-Morss, "Envisioning Capital: Political Economy on Display," *Critical Inquiry* 21, no. 2 (Winter 1995): 466.
[7] Nick Srnicek, "Navigating Neoliberalism: Political Aesthetics in an Age of Crisis," *After Us*, September 2015, http://www.aft3r.us/navigating-neoliberalism/.

computation outlined in chapter four, this chapter proposes to look at algorithmic financial power as a primarily aesthetic mode of power, but one that operates directly in the realm of potentialities rather than in the statistical prediction of probabilities – in short, an aesthetics after finitude. Building on the findings of the previous chapters, my goal here is to demonstrate that algo-financial power organizes perceptions in a way that is not directly sensed but that, due to the ontogenetic character of algorithmic objects rather than the finite logic of the numbered number, directly contributes to the taking-consistency of the contemporary *sense* of power. As I explained in chapter one following Simondon and Laruelle, sense has to do with both directionality and perception. This turns financial markets into an "aesthetic battlefield"[8] between the organic plane and the machinic phylum of silicon chips and challenges the efficient-market hypothesis and the idea of the rational agent underlying contemporary financial modeling. Acknowledging the impossibility of providing a cognitive map of contemporary algo-financial power, this chapter proposes an aesthetics of technical engagement *in lieu* of the representational mapping argued for by the above-mentioned authors. In other words, this chapter advances a tactile aesthetics, or an aesthetics of the feel – what Stefano Harney and Fred Moten call hapticality, the "aesthetic sociality of the shipped, this logisticality."[9] In the unfolding of this chapter, I will recast hapticality in terms of Simondon's concept of transindividual technical relation, in order to broaden the scope of the concept to encompass not only human but also technical individuals.

In order to illustrate my point, this chapter opens with an overview of the genealogy of the contemporary algo-financial ecosystem. Secondly, it presents some examples of algorithmic trading strategies that contribute to the black box aesthetics of contemporary algo-finance. It further proceeds with a discussion of computational aesthetics paired with Simondon's notion of "techno-aesthetics"[10] found within his larger theory of individuation. In particular, I investigate how the "metacomputational aesthetics"[11] of the black box is amplified analogically through financial markets and

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[8] Luciana Parisi, *Contagious Architecture: Computation, Aesthetics, and Space* (Cambridge: The MIT Press, 2013), 80.
[9] Stefano Harney and Fred Moten, *The Undercommons. Fugitive Planning & Black Study* (New York: Minor Compositions, 2013), 96.
[10] Gilbert Simondon, "On Techno-Aesthetics," trans. Arne De Boever, *Parrhesia* 14 (2012): 1–8.
[11] M. Beatrice Fazi, "Incomputable Aesthetics: Open Axioms of Contingency," *Computational Culture*, no. 5 (January 15, 2016), http://computationalculture.net/article/incomputable-aesthetics-open-axioms-of-contingency.

persists in the socio-cultural realm as a "sense of dark foreboding,"[12] and further speculate on the inhuman aesthetics of algo-finance. In this context, I specifically discuss the 'algorithmic apocalypse' of the crisis, or crash, and contrast it with an aesthetics of experimentation and direct engagement with the machine – a haptic aesthetics of the feel that has the potential to establish a transindividual technical relation with a "real collective."[13]

My argument in this chapter is that the action of automated trading algorithms inaugurates a mode of control that relies on the 'creordering,' evaluation, and economic exploitation of perceptions according to algo-financial logic, in a way that is not directly sensed, but that instead constitutes the foundations of sense perceptions in the living. As explained in the previous chapter, Jonathan Nitzan and Shimshon Bichler understand creordering as "the paradoxical fusion of being and becoming, state and process, stasis and dynamism"[14] caused by the limitless force of capitalization, which not only allows for capitalists to retain their power, but also increases capitalist power through differential accumulation. While Nitzan and Bichler limit their claim to the 'gravitational force' of capitalization, I suggest that this logic may well extend beyond flows of capital to encompass desire, sense perceptions, and cognition. This is due, as I explained in chapter one, to the amplificatory character of the allagmatic operation of information in the stages that lead to the organization of a system through transductive reification and modulative recursion. In light of the social and affective capture by algorithmic platforms, François Laruelle's concept of an *économie générale des effets d'être* allows us to grasp the multiple processes involved in the production of the diversity of being, "both in its real and possible terms."[15] Summarizing Laruelle's thesis in a few paragraphs is beyond the scope of this chapter – and would be highly impractical, if not impossible, as Ray Brassier aptly remarks.[16] What is important to

[12] Matthew Fuller and Andrew Goffey, *Evil Media* (Cambridge: The MIT Press, 2012), 3.
[13] Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 340–44.
[14] Jonathan Nitzan and Shimshon Bichler, *Capital as Power: A Study of Order and Creorder* (London: Rutledge, 2009), 18.
[15] François Laruelle, "Économie Générale des Effets d'Ệtre." (Doctoral Thesis, Université Paris X Nanterre, 1975). The page numbers of Laruelle's thesis manuscript are not always available in the copy I sourced.
[16] Referring to *Économie Générale des Effets d'Ệtre*, and *Matière et Phénomène* (1976), Ray Brassier quips that they "remain unpublished or perhaps unpublishable, given their gargantuan heft (both are over six hundred pages long) and hair-raising conceptual severity." Brassier in François Laruelle, "What Can Non-Philosophy Do?," trans. Ray Brassier, *Angelaki* 8, no. 2 (2003): 169.

note, however, is that it provides a productive starting point for a conceptualization of markets as constituted by operations of individuation unfolding across different planes – physical, living, technical and, I may add, computational.

The concept of the general economy was taken up again by Laruelle in his subsequent text, *Au-delà du Principe de Pouvoir* that, as I explained in chapter one, is precisely concerned with going beyond the principle of the individuation of power and the onto-theo-politics that have crystallized the conception of power into its existing forms of domination. In order to do so, Laruelle identifies three syntheses of the Beyond of Power: an aesthetic synthesis of power, corresponding to the production of the processes of production and the reason why power becomes a principle; an analytic synthesis, that is, the reproduction of power and of its principle according to its internal rules; and lastly, an economic synthesis, which relates to the consummation of the power relations and closes the cycle of the general economy.[17] In truth, the previous chapters have implicitly illustrated these syntheses according to the three stages of the taking-consistency of the contemporary ecosystem: the aesthetic synthesis corresponds to the individualization of the 'sense' of contemporary power via the reification of the technics of exchange in fiat money that I have discussed in chapter two; the analytic synthesis can be understood according to the "internal rules [*règles internes*]"[18] of the logic of algorithmic money and finance that I have described in chapter three and four; lastly, the economic synthesis effectively corresponds to the social logic of algo-financial power and to the ways in which the relations it produces are 'consumed' by the social, as I outlined in chapter five through the example of the financialization of the home. By the same token, the potential for the reversal of the Principle of Power is already immanent to these phases, as was foregrounded by chapters three and four in particular.

According to Laruelle, power becomes a principle through an aesthetic synthesis. However, aesthetics is also the triggering force toward moving beyond such a principle. The implications of aesthetics in the current power formation, and its role in overthrowing it, will be further explored in the following sections with the support of Gilbert Simondon's philosophy. Before delving into that, I start with an overview of the

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[17] François Laruelle, *Au-delà du Principe de Pouvoir* (Paris: Payot, 1978), 35–36.
[18] Laruelle, "Économie Générale des Effets d'Ệtre," 36.

contemporary financial ecosystem, highlighting the functions that trading algorithms play in the individuation of the contemporary sense of power – that is, the axiomatic of signification upon which individuation unfolds across different modes of being.

6.2 The Genealogy of Black Box Trading: From Gambling to Warfare

While today global finance relies exclusively on electronic exchanges, according to statistics the percentage of actual algorithmic trading – which indicates "the use of programs and computers to generate and execute (large) orders in markets with electronic access"[19] – covers at least 30 percent of the entire US share trading volume. Algorithmic, or automated, trading traditionally consists in the use of electronic platforms by big investors such as investment banks, pension funds, and mutual funds in order to split their buy-orders and lower their impact on stock prices and risk. By contrast, its subset high-frequency trading (HFT), follows entirely different strategies that are essentially based on the speed by which algorithms access information in the market, along with 'noise-making,' which aims to confuse competitors.[20] HFT and algo-trading in general, have led to concerns being raised about the transparency of markets, the equal access to information, and last but not least, the ontology of algorithmic trading agents. Moreover, as chapter four illustrated, algorithmic trading radically challenges foundational concepts of financial trading such as liquidity – a topic I further discuss in the following sections.

Algorithmic trading is remarkably opaque. As I explained in chapter four, there are two sources for the complexity of algorithmic finance: the incomputability immanent to algorithmic logic and the exogenous factors that contribute to the local intractability of trading problems. In other words, because each player in the market does not know the extent and capacities of other players' algorithms, the increasing complexity means that

[19] Marco Avellaneda, "Algorithmic and High-Frequency Trading: An Overview," 2011, 4, https://www.math.nyu.edu/faculty/avellane/QuantCongressUSA2011AlgoTradingLAST.pdf.
[20] As previously mentioned, the work of Donald MacKenzie expounds the complex and at times contradictory socio-financial ecology made up of humans and machines. Donald MacKenzie, "Be Grateful for Drizzle," *London Review of Books*, September 11, 2014, http://www.lrb.co.uk/v36/n17/donald-mackenzie/be-grateful-for-drizzle; Donald MacKenzie, "How to Make Money in Microseconds," *London Review of Books*, May 19, 2011, http://www.lrb.co.uk/v33/n10/donald-mackenzie/how-to-make-money-in-microseconds.

no one knows why things happen.[21] While the main types of algorithms are known — these are: execution, volume participation, statistical arbitrage, and market-making algorithms[22] – there is no easily available precise information about the formal methods used by such algorithms to perform their functions in the market. These two orders of complexity turn trading algorithms into black boxes, as I will explain in the following section. That is to say, one knows *what* they do but doesn't know *how* they do it. This is an instance of what Philip Mirowski calls "agnotology"[23] – the deliberate manufacture of ignorance and doubt by neoliberal contingents for specific political-economic purposes. It is through this, Mirowski argues, that neoliberalism manages to answer market crises with more financialization. But is neoliberalism simply an epistemic problem? While it is undoubted that contemporary power also works affectively,[24] my argument here is that there exists a precise relation between the aesthetic and the affective. In order to understand this, one needs to turn to the concept of 'technicity' that, as I discussed in previous chapters, is a mode of relation between human and world – it is a "partial and transitory reality, both a result and a principle of genesis."[25] Here, with technicity, I indicate the relational interface that not only makes the invisible visible but also operationable.

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[21] I am referring here to events such as the Flash Crash. In spite of the years-long research into the event there are still doubts whether the crash was caused by an algorithm or by human intervention. For contrasting voices in the field see: Silla Brush, Tom Schoenberg, and Suzi Ring, "How a Mystery Trader with an Algorithm May Have Caused the Flash Crash," *Bloomberg.com*, April 22, 2015, http://www.bloomberg.com/news/articles/2015-04-22/mystery-trader-armed-with-algorithms-rewrites-flash-crash-story; Securities and Exchange Commission, "Findings Regarding the Market Events of May 6, 2010" (Securities and Exchange Commission, September 30, 2010), https://www.sec.gov/news/studies/2010/marketevents-report.pdf; Donald MacKenzie, "On 'Spoofing,'" *London Review of Books*, May 21, 2015, http://www.lrb.co.uk/v37/n10/donald-mackenzie/on-spoofing.

[22] As Donald MacKenzie explains, execution algorithms break large orders into smaller tranches and execute them at the optimal time in order to minimize errors; volume participation algorithms break up an institution's large order into small chunks calculated on the basis of that institution's traded volume in a given period; market-making algorithms have the task to buy stocks at a low price, and resell them at a higher price, making a profit on the spread between bid and ask price; statistical arbitrage algorithms aim to take advantage of statistical trading patterns among stocks belonging to different sectors but being somehow related. For instance, MacKenzie discusses the different ways in which oil prices affect gas corporations and airlines. Statistical arbitrage algorithms can take advantage of movements in oil prices to bet for or against certain seemingly unrelated companies. MacKenzie, "How to Make Money in Microseconds."

[23] Mirowski, *Never Let a Serious Crisis Go to Waste*, 226–30. The concept of agnotology is taken up by Frank Pasquale in *The Black Box Society* to describe the "knowledge problem" intrinsic to the neoliberal operatory mode. Frank Pasquale, *The Black Box Society: The Secret Algorithms That Control Money and Information* (Cambridge: Harvard University Press, 2015), 2.

[24] There are plenty of sources on the topic of power and affect. This is only a short and incomplete list: Melissa Gregg and Gregory J. Seigworth, eds., *The Affect Theory Reader* (Durham: Duke University Press Books, 2010); Emma Dowling, Rodrigo Nunes, and Ben Trott, "Immaterial and Affective Labour: Explored," *Ephemera* 7, no. 1 (2007): 1–7; Michael Hardt and Antonio Negri, *Multitude: War and Democracy in the Age of Empire*, Reprint edition (New York: Penguin Books, 2005).

[25] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 157.

For these reasons, a detour into the second postwar period is, once again, needed to uncover the origins of computational finance. These lie at the juncture of a peculiar set of relations that have contributed to the individuation of what Mirowski calls "cyborg economics"[26] born out of the encounter between cybernetics and the new political ideas that emerged as a reaction to the war period. Although the mutual imbrication of economics and computation can be dated back to the influence of Adam Smith on Charles Babbage's analytical engine, as I observed in the introduction,[27] here I want to emphasize one major event that marked a turning point in the development of economics, which had important consequences for the contemporary political-economic landscape – a sort of Deleuzo-Guattarian abstract machine. I am referring to the formulation, in 1946, of the Monte Carlo simulations method, the first electronic method of automated statistical sampling.[28]

Formulated by Stanislaw Ulam – a physicist passionate about solitaire and poker – the Monte Carlo simulation method is a class of computational algorithms that relies on repeatedly random samplings to obtain the distribution of an unknown probabilistic entity. Ulam's question was: "what are the chances that a Canfield solitaire laid out with 52 cards will come out successfully?"[29] In order to answer this question, Ulam posited that "if electronic circuits *could count*, they could do arithmetic … at almost incredible speed"[30] and therefore solve complex differential equations for the resolution of statistical problems. This was made possible by the first electronic computer – the Electronic Numerical Integrator And Computer, or ENIAC. The Monte Carlo method and the ENIAC were parallel discoveries both of which were originally conceived to solve problems in thermonuclear reaction for the development of nuclear weapons. Nicholas Metropolis, one of the members of the Manhattan Project research team – together with John von Neumann and Enrico Fermi – named this new method after the

[26] Philip Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (Cambridge: Cambridge University Press, 2002).
[27] See: Herbert A. Simon and Allen Newell, "Heuristic Problem Solving: The Next Advance in Operations Research," *Operations Research* 6, no. 1 (February 1, 1958): 2.
[28] Other mathematical concepts underlie Monte Carlo simulations, such as Brownian motion and Kolmogorov's probability theory. Monte Carlo can be considered the key implementation of these previous mathematical discoveries.
[29] Roger Eckhardt, "Stan Ulam, John von Neumann, and the Monte Carlo Method," *Los Alamos Science*, Special Issue (1987): 131.
[30] Nicholas Metropolis, "The Beginning of the Monte Carlo Method," *Los Alamos Science*, no. Special Issue (1987): 125 (emphasis added).

fact that Ulam's uncle liked to borrow money from relatives because he "just had to go to Monte Carlo" – alluding to his passion for gambling.[31]

With the development of parallel processing in software and hardware technology, the capabilities of the Monte Carlo method have increased exponentially. Today Monte Carlo simulations have become endemic not only to the sciences but, more importantly and perhaps not surprisingly, to the functioning of contemporary planetary computation – being used also in engineering, robotics, computational biology, statistics, design, and architecture. Furthermore, with Phelim Boyle's seminal contribution,[32] which proved that the Monte Carlo method could provide the same results as the Black-Scholes equation for the pricing of options, Monte Carlo simulations started to be applied in mathematical finance as well. In addition to this, with the increasing speed of technological development, Monte Carlo simulations have set the blueprint for evolutionary programming, multi-agent systems, and genetic algorithms that today constitute the foundations for much of the research in AI and neural networks.[33]

In their thorough coverage of the HFT ecosystem, Nick Srnicek and Alex Williams argue that the metaphor of "casino capitalism" is inadequate because it "entirely conceals the significant technical innovations generated by the financial sector in the last decade,"[34] turning the financial engine into an accelerated war machine. However, the above exposition shows instead that the genesis of modern finance is profoundly intertwined with the logic of gambling, as well as weapons of mass destruction and the conceptualization of evolution. In this we can read the genealogy of neoliberalism, which was developing in the first half of the twentieth century, in mutual presupposition with the techno-scientific developments of that age. Just one year after Ulam's invention, in 1947, a group of intellectuals gathered around the central figure of

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[31] Ibid., 127.

[32] Phelim P. Boyle, "Options: A Monte Carlo Approach," *Journal of Financial Economics* 4, no. 3 (May 1977): 323–38.

[33] Genetic algorithms and multi-agent systems are largely used in the financial ecosystem too. For more detailed information, see: René Carmona et al., "An Introduction to Particle Methods with Financial Applications," in *Numerical Methods in Finance*, ed. René A. Carmona et al., Springer Proceedings in Mathematics 12 (Berlin: Springer Berlin Heidelberg, 2012), 3–49; Pierre Del Moral, Gareth William Peters, and Christelle Vergé, "An Introduction to Particle Integration Methods: With Applications to Risk and Insurance," *arXiv:1210.3851 [Math, Q-Fin, Stat]*, October 14, 2012, http://arxiv.org/abs/1210.3851; Yuan Luo, Kecheng Liu, and Darryl N. Davis, "A Multi-Agent Decision Support System for Stock Trading," *IEEE Network* 16, no. 1 (January 2002): 20–27.

[34] Nick Srnicek and Alex Williams, "On Cunning Automata: Financial Acceleration at the Limits of the Dromological," in *Collapse: Casino Real*, ed. Robin Mackay (Falmouth: Urbanomic, 2014), 465.

Friedrich Hayek met in the Swiss resort of Mont Pelerin for the first time with the aim to found a new politico-economic movement that would overcome the limitations of the previous liberal doctrine. This is the movement that became known as neoliberalism.[35] For its groundbreaking features, Mirowski defines the neoliberal project as "a scale-free Theory of Everything."[36] This was in part due to Hayek's interest in cybernetics and complex systems – disciplines that are responsible for some of the most important discoveries of the twentieth century, and indeed for the contemporary socio-political, economic, and cultural order.[37]

Given the close links between the development of cybernetics and the rise of the neoliberal "ideology of no ideology,"[38] it is perhaps not surprising that the most salient features of the neoliberal doctrine anticipate the characteristics of contemporary object-oriented programming (OOP).[39] Following Mirowski,[40] these features can be summarized as follows:

- *General, multi-purpose program*. Since its origins, the aim of the Mont Pelerin Society (MPS) was to define a set of global, transdisciplinary principles – and indeed a

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[35] See: Philip Mirowski and Dieter Plehwe, eds., *The Road from Mont Pelerin: The Making of the Neoliberal Thought Collective* (Cambridge: Harvard University Press, 2009).

[36] Mirowski, *Never Let a Serious Crisis Go to Waste*, 59.

[37] Hayek himself outlined his own theory of the mind as early as 1952 in *The Sensory Order,* the main argument of which is precisely that of the necessity of constitutional constraints on government, since individuals, according to Hayek, are epistemically unable to intervene effectively in spontaneously emergent institutions. Friedrich A. Hayek, *The Sensory Order: An Inquiry into the Foundations of Theoretical Psychology* (Eastford: Martino Fine Books, 2014).

[38] Mirowski, *Never Let a Serious Crisis Go to Waste*, 28.

[39] It is interesting to compare neoliberalism's main features outlined above with the affordances created by object-oriented programming (OOP). These have been identified by Casey Alt in the project of foregrounding how "object orientation performs computational mediality." Casey Alt, "Objects of Our Affection: How Object Orientation Made Computers a Medium," in *Media Archeology: Approaches, Applications and Implementations*, ed. Erkki Huhtamo and Jussi Parikka (Berkeley: University of California Press, 2011), 279. Nonlinear organization, which is achieved through the activities of factoring and control, allows for the creation of multipurpose programs. In this context, factoring corresponds to the activity of reducing code redundancy by grouping repeated instructions into name procedures, while control consists in calling the correct procedures when needed in order to achieve a result. Furthermore, encapsulation provides the means to create discrete, modular computational entities that can be compiled autonomously and combined to create specific routines. In addition to this, messaging – "a sort of call by desire" (Rentsch in ibid., 293) – provides the means to achieve coordination through communication, whose interpretation is however left entirely to the receiver. It is a mode of control that operates through emergence: "This emerging and perpetually unfolding topological whole is what would be called the program in object orientation, and it is the summation of the multiple contingent object actions in response to various messages" (ibid.). Moreover, polymorphism allows a computational object to independently evaluate messages in a contingent and dynamic manner, in order to create a program that possesses the highest degree of adaptability to a context. Ultimately, the interface provides the means to present functionality to the end user while hiding – indeed, 'black-boxing' – the internal components and processes of the machine. As Alt puts it, "through the concept of interface, users are themselves subsumed within the fully embodied medium of object orientation." Ibid., 297.

[40] Mirowski, *Never Let a Serious Crisis Go to Waste*, 53–67.

new mode of thinking – that would extend to political, economic, social, and cultural life.

- *Adaptability and modularity*. Neoliberalism is not so much a monolithic theory as a set of *functions*, to be used according to different contexts.
- A *computational* view of the market, which blurs the difference between the natural and the artificial. This is evidenced by the theory of monetarism, promoted by another original MPS member, Milton Friedman, according to which controlling the money supply of a country can solve every socio-economic issue.[41] It is at the moment of the acceptance of this theory that the continuous, analog, concept of value is effectively, concretely superseded by the discrete, recursive entity of the monetary unit. That is, it may be at this moment that price begins to problematize value, as Jon Roffe puts it,[42] whose thesis I have discussed in previous chapters.
- *Control through emergence.* Such a computational view of the market demands constant control – a form of autopoietic, evolutionary control, indebted to second order cybernetics. As Mirowski suggests, this requirement of the neoliberal market provides an explanation for the main neoliberal reforms: privatization and financialization have been implemented not to augment and preserve individual freedoms, but to allow neoliberalism to constantly reinvent itself and survive the crises it itself creates.[43]
- *Ubiquity*. Neoliberal ideas and operations have become so ingrained in the fabric of society that they have extended to the sphere of the production of subjectivity, recoding moral and ethical dispositions. Already in 1979, Michel Foucault observed that "in neo-liberalism … *homo œconomicus* is an entrepreneur, an entrepreneur of himself"[44] devoted to the production of his own satisfaction through consumption. Following Foucault's trajectory, Mirowski explains that, under neoliberalism, individuals are "no longer a privileged ontological platform."[45] Indeed, as Deleuze put it, we have all become dividuals, in the sense that the individual body is substituted with and fragmented into a numerical code, which grants access to information and allows for

[41] See: Milton Friedman and Anna Jacobson Schwartz, *A Monetary History of the United States, 1867-1960* (Princeton: Princeton University Press, 1971). In *A Monetary History of the United States,* Friedman and Jacobson Schwartz explicitly "trace one thread, the stock of money," and argue that that thread may explain social and economic phenomena and events alike. Ibid., 3.
[42] Jon Roffe, *Abstract Market Theory* (Houndmills: Palgrave Macmillan, 2015), 152.
[43] Mirowski, *Never Let a Serious Crisis Go to Waste*, 64–65.
[44] Michel Foucault, *The Birth of Biopolitics: Lectures at the College De France, 1978-1979*, trans. Graham Burchell (Basingstoke: Palgrave Macmillan, 2008), 226 (emphasis in original).
[45] Mirowski, *Never Let a Serious Crisis Go to Waste*, 59.

manipulation by apparatuses of control.[46] This is also evident in the political sphere with the diffusion of monetarism since the late 1970s, when computational modes of management started to replace political organization and decision making, turning the social sphere into a market to be managed and profited from.

From this standpoint, it is clear that the development of digital technology is intimately related to transformations in modes of subjectivation that are not only inherently economical, but also neoliberal, to the point that these two characterizations have become indistinguishable from each other. As a matter of fact, digital networked platforms have allowed for the "living, mutating entity"[47] of neoliberalism to flourish, consolidating the tendency toward total financialization on the basis of a hybrid paradigm between strategic war-thinking and the speculative mode of thinking-feeling indebted to gambling. Mirowski defines the Internet as "a neoliberal playground" in which "[c]hat rooms, online gaming, virtual social networks, and electronic financialisation of household budgets have encouraged even the most intellectually challenged to experiment with the new neoliberal personhood."[48] At the same time, digital networked platforms have become the site of increasingly sophisticated micro-targeting strategies and consumer-data exchanges that capitalize upon every stroke of mouse, click, like, and any other *sensible* (both as in 'private' and as in 'which can be sensed') information that circulates online.[49] However, as I have argued previously, economic and technological forces cannot be entirely conflated and flattened onto the same plane. This is due to the transductive margin of indeterminacy immanent to 'post-industrial' technical objects, which grants them ultimate autonomy from economic concerns. The consequences of this tendency for the collective sphere, of which markets are an integral component, will be dealt with in the following sections.

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[46] Gilles Deleuze, "Postscript on the Societies of Control," *October* 59 (1992): 5–6.
[47] Mirowski, *Never Let a Serious Crisis Go to Waste*, 51.
[48] Ibid., 59.
[49] Interestingly, the practice of data brokerage follows strategies that increasingly mirror HFT. For more information, see: Natasha Singer, "Your Online Attention, Bought in an Instant by Advertisers," *The New York Times*, November 17, 2012, http://www.nytimes.com/2012/11/18/technology/your-online-attention-bought-in-an-instant-by-advertisers.html; Natasha Singer, "Acxiom, the Quiet Giant of Consumer Database Marketing," *The New York Times*, June 16, 2012, http://www.nytimes.com/2012/06/17/technology/acxiom-the-quiet-giant-of-consumer-database-marketing.html. Frank Pasquale also discusses data brokerage in the context of the reputation economy, especially in regard to credit scoring, health data, and consumers' habits. Pasquale observes that, in the United States, this practice also blends the difference between state and markets, when database-marketing companies, such as Acxiom, trade data and profiles with the US Defense Department. Pasquale, *The Black Box Society*, 19–58.

6.3 Black Box Aesthetics and the Rogue Strategies of Algorithmic Finance

As mentioned in the previous section, trading algorithms themselves are often referred to as black boxes, in the sense that they are proprietary software, of which one knows the input and the output, but the operations that allow for such transformations are obscured. Interestingly, the New York Stock Exchange's data center in Mahwah, New Jersey, also looks like a giant black box – which already gives a sense of the aesthetics involved in algo-trading. In this regard, one should also mention dark pools – that is, private exchanges, generally owned by investment banks, in which participants can buy or sell shares without those transactions being visible to the public.[50] From this standpoint, algorithmic finance is characterized by an aesthetics of opaqueness and inaccessibility. This is intrinsic to the technical genealogy of the neoliberal 'non ideology' that, as mentioned above, is intimately related to cybernetics and complexity theory.

As a matter of fact, the problem of the black box is one of the foundational issues of cybernetics and is extensively discussed by Ross Ashby.[51] As Ashby remarks, the theory of the black box arose in electrical engineering but also finds wide application in everyday occurrences. Ashby outlines a method to approach the problem of the black box based on direct observation, differential equations, topological mapping, and the application of historical series in the form of memory. While his explication goes beyond the scope of this chapter, it is important to note that he himself likens the problem of the black box to a navigational problem:

> We now see the experimenter much like the engineer in a ship, who sits before a set of levers and telegraphs by which he [*sic*] may act on the engines, and who can observe the results on a row of dials. The representation, though it may seem unnatural, is in fact, of course, capable of

[50] For more information, see: Donald MacKenzie, "Dark Markets," *London Review of Books*, June 4, 2015, http://www.lrb.co.uk/v37/n11/donald-mackenzie/dark-markets; Scott Patterson, *Dark Pools: The Rise of the Machine Traders and the Rigging of the U.S. Stock Market* (New York: Crown Business, 2013).
[51] W. Ross Ashby, *An Introduction to Cybernetics* (London: Chapman & Hall, 1957), 86–117.

representing the great majority of natural systems, *even if biological or economic*.[52]

As Ashby himself remarks, "the theory of the Black Box is simply the study of the relations between the experimenter and his environment, when special attention is given to the flow of information."[53] It is precisely by following the flow of information that I will attempt to open – albeit partially and speculatively, given the secretive character of algorithmic trading – the black box of algo-financial power. However, I will do so following not Shannon and Weaver's theory of information but Simondon's, who recasts information as a genetic and normative operation that allows for individuation to unfold across different realms of existence.

As I observed in previous chapters, algo-financial power is a vectoral, abstract, speculative mode of power; from this standpoint, a speculative move of equal magnitude and opposite direction is required in order to divorce thought from the naturalized form of neoliberal logic. Here I present some strategies that illustrate the operations of contemporary markets and that may contribute to an explanation of the taking-consistency of the black box of algorithmic finance. Two of these strategies are at least partially derived from further developments in the Monte Carlo simulations method – that is, evolutionary logic and ubiquitous correlation of random variables.[54] While these two tendencies are concerned with the mathematical optimization of trading strategies, a third case that I will discuss below is simply related to the speed of market-making algorithms – that is, algorithms whose role is to compete for the buying and selling of customers' orders. This strategy specifically concerns HFT algorithms and can be simply described according to the axiom "buy low, sell high."[55]

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[52] Ibid., 88 (emphasis added).
[53] Ibid., 110.
[54] See: Martin Haugh, "The Monte Carlo Framework, Examples from Finance and Generating Correlated Random Variables" (New York: Columbia, Fall 2004), http://www.columbia.edu/~mh2078/MCS04/MCS_framework_FEegs.pdf; "Monte Carlo Simulation of Correlated Asset Returns - MATLAB Portsim," *MathWorks*, 2016, http://au.mathworks.com/help/finance/portsim.html?requestedDomain=au.mathworks.com; Li Lin et al., "The Applications of Genetic Algorithms in Stock Market Data Mining Optimisation" (Sydney: Faculty of Information Technology, University of Technology and Capital Market CRC, 2009).
[55] This corresponds to the axiom of unequal exchange identified by Deleuze and Guattari in their outline of the capitalist axiomatic. See: Roffe, *Abstract Market Theory*, 109.

Although the black box of algorithmic trading is hardly penetrable, an extensive amount of research points to the widespread use of genetic algorithms (GAs) in financial mathematics.[56] GAs provide a heuristic methodology of search optimization based on metaphors with the natural science, such as inheritance, mutation, selection, and crossover. Essentially, GAs involve a simulation of organic evolution, in which a population of candidate solutions – creatures, phenotypes, individuals – is evolved for the optimization of a decisional problem, modeled upon data taken from the physical world. GAs base their decisions on the principle of the 'survival of the fittest,' mirroring the gene-centric game-theoretical evolutionary theory according to which each gene aims to maximize its own success either through cooperation or through selfishness, in accordance with the behavior of the majority of the population in the organism.[57]

This again reflects the neoliberal conceptualization of the market first proposed by Friedrich Hayek, which also emerged from the discussion of the social logic of algorithmic finance in the previous chapter. This is in fact a computational view that, as I mentioned above, blurs the difference between the natural and the artificial and measures the 'fitness' of each market player in monetary yield and not according to any actual biological-genetic feature. Under neoliberalism the market is conceived as a huge information system that contains perfect information, whose knowledge and operations are allegedly more efficient than any individual humans, and can therefore offer solutions to any crisis. This is because the market is viewed as a natural state of mankind, whose 'naturalness,' however, needs to be constantly constructed via political reforms aimed to preserve the 'freedom of exchange' – that is, the freedom for capital to 'naturally' flow across national boundaries. From this standpoint, if the market is 'Nature,' as the neoliberals would have it, GAs are the evolving organisms inhabiting it, with a life-like-ness and evolutionary logic that surpasses human existence. This view also underlies the mode of existence of markomata that I discussed in chapter four

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[56] For instance, Calypso Technology, one of the most renowned OTC derivatives risk-management platforms, uses the Galapagos distributed parallel genetic algorithm for its risk analysis and hedging applications. For more information, see: Adam Honeysett-Watts, "Calypso Acquires Galapagos," *Reuters*, February 26, 2009, http://www.reuters.com/article/2009/02/26/idUS193198+26-Feb-2009+BW20090226; Greg MacSweeney, "Calypso Acquires Galapagos Portfolio Platform," *Wall Street & Technology*, February 26, 2009, http://www.wallstreetandtech.com/trading-technology/calypso-acquires-galapagos-portfolio-pla/214600176.

[57] See: Richard Dawkins, *The Selfish Gene* (Oxford: Oxford University Press, 2006); Richard Dawkins, *The Extended Phenotype: The Long Reach of the Gene*, Revised edition (Oxford: Oxford Paperbacks, 1999).

following Mirowski's insights.[58] Such a conceptualization of markets as evolving entities promotes the figure of the "rational-agent-without-agency" described by Brett Scott: "a strange blend of extolling the virtue of the risk-taking individual whilst simultaneously asserting that they're irrelevant, mere puppets acting out the will of 'the market.'"[59]

The operative logic of trading algorithms is also linked to the ubiquitous role of smart and sentient algorithms in the contemporary media ecology, coupled with the potentialities of semantic search, and facilitated by the pseudo-rhizomatic form of contemporary networks – a non-hierarchical, seemingly spontaneous, emergent structure, which is precisely Hayek's idea of social order. Algorithms read news, know about climate conditions and geopolitical scenarios, monitor behaviors, etc. and in the span of few seconds or even milliseconds, construct models to price goods that we, in the physical world, use daily – for instance, energy, metals, etc.[60] David X. Li's Gaussian copula function that, as I describe in chapter five, was used to price and sort CDSs in the years prior to the global recession, is an instance of such practices of meta-correlation. As I explained in the previous chapter, the abstraction of the terms of the formula from the reality of market exchange was one of the culprits of the GFC. By proposing an 'elegant' – thus highly reductive – model for the correlation of default risk, the formula hid the complexities of trading until the problem of the default risk presented by subprime mortgages became intractable. On a different register, Google's trading algorithm seems to make decisions based on its search terms – a thesis confirmed by independent quants but not by Google itself.[61]

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[58] Philip Mirowski, "Inherent Vice: Minsky, Markomata, and the Tendency of Markets to Undermine Themselves," *Journal of Institutional Economics* 6, no. 4 (2010): 415–43; Philip Mirowski, "Markets Come to Bits: Evolution, Computation and Markomata in Economic Science," *Journal of Economic Behavior & Organization*, Markets as Evolving Algorithms, 63, no. 2 (June 2007): 209–42.

[59] Brett Scott, "Algorithmic Surrealism: A Slow-Motion Guide to High-Frequency Trading," *The Heretic's Guide to Global Finance*, June 17, 2015, http://suitpossum.blogspot.com.au/2015/06/high-frequency-trading-guide.html.

[60] As argued in chapter three, the case of the 'hack crash' is emblematic in this respect. For more information, see: Tero Karppi and Kate Crawford, "Social Media, Financial Algorithms and the Hack Crash," *Theory, Culture & Society* 33, no. 1 (January 2016): 73–92; Edmund Lee, "AP Twitter Account Hacked in Market-Moving Attack," *Bloomberg Business*, April 24, 2013, http://www.bloomberg.com/news/articles/2013-04-23/dow-jones-drops-recovers-after-false-report-on-ap-twitter-page; Heidi Moore and Dan Roberts, "AP Twitter Hack Causes Panic on Wall Street and Sends Dow Plunging," *The Guardian*, April 23, 2013, http://www.theguardian.com/business/2013/apr/23/ap-tweet-hack-wall-street-freefall.

[61] *Money & Speed: Inside the Black Box (Marije Meerman, VPRO)*, 2012, http://www.youtube.com/watch?v=aq1Ln1UCoEU&feature=youtube_gdata_player; Tobias Preis, Helen Susannah Moat, and H. Eugene Stanley, "Quantifying Trading Behavior in Financial Markets Using

The last strategy I want to discuss is that of accelerated market making and specifically concerns the capabilities of HFT algorithms. However, it also relates to the previous two strategies – genetic simulation and ubiquitous correlation – due to the ways in which it disrupts them. The rhetorical argument for HFT is that it makes markets more fluid by providing the conditions for cheap and quick trades, thereby also making them less volatile. Yet, it has been proved that high-frequency algorithms are market neutral. This is because they exploit differences in stock prices in a single sector, thereby achieving superior returns, without however contributing to the liquidity of that market. For instance, in March 2014, Virtu Financial, a HFT firm, reported that for the previous five years it made profit 1,277 out of 1,278 days, losing money just one day.[62] Virtu's strategy is founded on the law of large numbers in probability theory. As Virtu's CEO explains, by "seeking only to earn the spread on each transaction and not bet on the direction of markets, [Virtu] will make money close to 50 percent of the time."[63] In other words, Virtu does not produce any risk, hence value. Instead, as the volume of trades has increased dramatically, Virtu, and HFT in general, captures value without adding anything to the liquidity of markets. As a study by the US Securities and Exchange Commission (SEC) reports: "The fierce competition in speed implies the failed competition in price."[64]

In spite of the harsh critiques,[65] however, it needs to be noted that HFT constitutes a direct evolution of early electronic markets that, in principle, simply aimed at the automation of certain trading tasks performed by humans. As Virtu's founder notes, he realized the importance of electronic trading right when, in 1984, the NASDAQ introduced a system for the automatic execution of small orders against the best

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Google Trends," *Scientific Reports* 3 (April 25, 2013), http://www.nature.com/srep/2013/130425/srep01684/full/srep01684.html.

[62] "Virtu Financial Form S-1" (Washington: Securities and Exchange Commission, March 10, 2014), https://www.sec.gov/Archives/edgar/data/1592386/000104746914002070/a2218589zs-1.htm. See also: Matthew Leising, "Virtu Never Loses (Well, Almost Never)," *Bloomberg.com*, August 11, 2016, http://www.bloomberg.com/news/features/2016-08-11/virtu-never-loses-well-almost-never-in-quest-to-upend-markets.

[63] Leising, "Virtu Never Loses (Well, Almost Never)."

[64] Jiading Gai, Chen Yao, and Mao Ye, "The Externalities of High-Frequency Trading," March 15, 2012, 5, https://www.sec.gov/divisions/riskfin/seminar/ye031513.pdf. See also: MacKenzie, "How to Make Money in Microseconds."

[65] See: Lewis, *Flash Boys*.

quotations.[66] Thus high-frequency market making is not based on esoteric or complex trading strategies. On the contrary, its competitive advantage simply consists of the speed at which trades are performed.

Yet HFT algorithms are deemed responsible for disrupting the more traditional forms of trading, precisely in virtue of the speed at which they detect orders. For instance, in the context of meta-correlation strategies, a recent report by the SEC has identified "high levels of co-movement of message flows for stocks in the same channel"[67] – a co-movement that is, however, related not to real-world phenomena but simply follows alphabetic order. This is consistent with the strategy of 'quote stuffing.' Quote stuffing essentially involves a denial of service attack to one of the channels in which the data feeds of stocks are divided. Put differently, quote stuffing happens when a swarm of HFT algorithms incessantly enters and withdraws large orders in a channel, in order to flood those channels and cause competitors to lose speed. Thus by constantly making correlations, algorithms also generate new information – of which the new alphabetic patterns created by the co-movement of stocks due to quote stuffing, for instance, is a manifestation. This may in turn manipulate markets in ways not always accessible to us from outside the black box.

Together, these features of algorithmic trading – its genetic behavior, its ubiquitous, imperceptible sentience, and its otherworldly speed – make the neoliberal virtual machine a powerful apparatus of capture. The question therefore becomes: how is the imperceptible – the black-boxed – felt without being sensed? And how does this impact the evolution (and survival) of humanity in the face of evolutionary financial warfare? In the following section, I will suggest that it is precisely this inaccessibility that constitutes a new aesthetic feeling; however, as Laruelle remarks, it is also through an aesthetic synthesis (precisely, a "synthetic act of invention"[68]) that one can advance beyond the onto-theo-political 'truth' of neoliberal power.

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[66] Leising, "Virtu Never Loses (Well, Almost Never)."
[67] Gai, Yao, and Ye, "The Externalities of High-Frequency Trading," 1. Intuitively, co-movement indicates the tendency of two or more variables (in this case, stock prices) to move according to parallel patterns. Noting the absence of a commonly accepted definition of the term co-movement, a report by the European Commission formulates a definition of co-movement as "the common movement of returns that is shared by all returns at time t." Dirk Baur, "What Is Co-Movement?" (Varese: European Commission, 2003), 5.
[68] Simondon, *Du Mode*, 43.

6.4 Techno-Aesthetics and the Onto-Aesthetics of Computation

As theorist and software engineer Yuk Hui puts it:

> Each epoch is characterized by certain technical aesthetics. The use of different media of production and operation introduces various forms of experience that renew our perception of the world … Media aesthetics and its potential are closely related to, and conditioned by, the logic of technologies, which is concretised by new materialities.[69]

Gilbert Simondon's philosophy offers fruitful conceptual tools to uncover the relation between the technical (in this case, digital networked algorithms) and the aesthetic (that which relates to sense perceptions) – in other words, a techno-aesthetics. To Simondon "it is perhaps not true that every aesthetic object has technical value, but every technical object has, from a certain perspective, an aesthetic tenor."[70] As Yves Michaud observes, Simondon's aesthetic theory radically challenges any previous approach to aesthetics, since it concerns: "aesthetic impression (rather than the aesthetic object), techno-aesthetics (rather than natural aesthetics) and aesthetic attractors (rather than masterpieces)."[71] Further, according to Simondon, not only does aesthetics relate to sense perceptions but it is a mode of thought in its own right. Aesthetic thought precisely serves the purpose of "preserving the unity of thought … because it is the one to grasp being in its unity."[72] Importantly, aesthetics is in close relation – a "continuous transition"[73] – with the technical object. Even more so, "the techno-aesthetic feeling seems to be a category that is more primitive than the aesthetic feeling alone, or than the technical aspect considered from the angle of functionality alone (which is an impoverishing perspective)."[74] In other words, Simondon's reformulation points toward the radical immanence of the aesthetic to the technical, the role of which is to orient

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[69] Yuk Hui, "Induction, Deduction and Transduction: On the Aesthetics and Logic of Digital Objects," *Networking Knowledge: Journal of the MeCCSA Postgraduate Network* 8, no. 3 (June 3, 2015): 2, http://ojs.meccsa.org.uk/index.php/netknow/article/view/376.
[70] Simondon, "On Techno-Aesthetics," 2.
[71] Yves Michaud, "The Aesthetics of Gilbert Simondon: Anticipation of the Contemporary Aesthetic Experience," in *Gilbert Simondon: Being and Technology*, ed. Arne De Boever et al., trans. Justin Clemens (Edinburgh: Edinburgh University Press, 2012), 131.
[72] Simondon, *Du Mode*, 191.
[73] Ibid., 184.
[74] Simondon, "On Techno-Aesthetics," 6.

humanity in the world through the creation and organization of sense perceptions afforded by technical objects.

According to this techno-aesthetic view, aesthetics is not only related to the given sensible world, but in fact also constitutes it via the insertion of 'key points' or seeds (as in the case of the process of crystallization),[75] that orient the individuation of the living.[76] As will be clear in the remainder of this chapter, in the present algorithmic environment, this may indeed inaugurate a mode of control that directly relies on the 'creordering,' evaluation, and economic exploitation of the senses according to algo-financial logic. In other words, *contra* Félix Guattari's argument for the positive political potential of an ethico-aesthetic paradigm to be attained in the post-media era,[77] this chapter advances the hypothesis that the diagram of algo-financial power has already entered an aesthetic paradigm, precisely due to the open, evolving axiomatic of post-mass media technology. As Michael Lewis puts it in *Flash Boys*: "what had once been the world's most public, most democratic, financial market had become, in spirit, something like a private viewing of a stolen work of art."[78]

This conceptualization challenges and relativizes the traditional understanding of aesthetics indebted to eighteenth century German philosophy, which emerged as "an extension of the rationalist worldview"[79] initiated by Descartes' and Leibniz's metaphysics. According to this view, aesthetics is born *against* the infinite, as an attempt to tame the irrational realm of sensations. Yet, before the philosophical formulation of aesthetics as a finite, rational concept, aesthetics was ubiquitous, everywhere, unnoticed, corresponding to the continual flow of potential energy.[80]

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[75] Simondon, *L'Individuation*, 85–92.

[76] Simondon explains the process of crystallization as the development of an axiomatic structure according to a directionality, and an external and internal consistency: "In a conglomerate of crystals randomly assembled, each crystal has defined its faces, its dihedral angles, its edges according to a *direction* of the ensemble that can be explained through *exterior* circumstances, mechanical or chemical, but also according to rigorously fixed *internal relations*, beginning from a singular genesis." Analogically, we can explain the taking-consistency of the axiomatic of signification of complex systems along the same processes. Ibid., 86 (emphasis in original).

[77] Félix Guattari, *Chaosmosis: An Ethico-Aesthetic Paradigm*, trans. Paul Bains and Julian Pefanis, Reprint edition (Sydney: Power Institute, 2006).

[78] Lewis, *Flash Boys*, 69.

[79] Kai Hammermeister, *The German Aesthetic Tradition* (Cambridge: Cambridge University Press, 2002), 4. See also: Monroe C. Beardsley, *Aesthetics from Classical Greece to the Present* (Tuscaloosa: University Alabama Press, 1975), 141–63.

[80] I am greatly indebted to Justin Clemens' presentation at the *Aesthetics After Finitude Conference* for these insights.

Following a techno-aesthetic approach, the immanent relation between aesthetics and technicity today demands a shift in the philosophical conceptualization of aesthetics, precisely due to the peculiar ontology of algorithmic objects. Luciana Parisi and Beatrice Fazi note, in singular albeit related ways, how the ontology of computation is also immediately aesthetic – an "onto-aesthetic,"[81] as Fazi calls it. Through a thorough investigation of the ontology and operations of algorithmic objects in the field of digital architecture, Luciana Parisi argues that "logic is becoming an aesthetic operation."[82] For Parisi, computational aesthetics corresponds to the experience of discrete infinite datasets within finite algorithmic instructions that extend beyond the finitude of the biophysical world and that, however, cannot be reduced to the ideal formalism of mathematics. Computational aesthetics is immanent to computational logic: "it exposes contingency in programming, and the reality of chance in the calculation of probabilities."[83]

For Parisi, algorithmic aesthetics corresponds to the "conceptual prehension of indeterminate infinities"[84] – a nonsensuous feeling of incomputable data at the limits of perception.[85] In opposition to aesthetic computing, which praises elegance and harmony in mathematics vis-à-vis the complexity that a simple set of instructions can generate,[86] the ubiquity of computational processes – evidenced, for instance, by the Internet of Things – epitomizes the irreducibility of the complexity of enormous quantities of data interacting with each other. This, one could note, is certainly the case for the complexity of contemporary financial markets. More generally, algorithmic aesthetics corresponds to the speculative function of reason – of what Parisi dubs "soft thought."[87] In other

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[81] Fazi, "Incomputable Aesthetics."
[82] Parisi, *Contagious Architecture*, xiii.
[83] Ibid., xiv.
[84] Ibid., 70.
[85] Parisi defines this in terms of "nonsensuous thought," drawing on Whitehead's notion of "nonsensuous prehensions." That is to say "conceptual feelings that travel through the physical chain of causal efficacy but remain irreducible to sensorimotor stimuli. … On the contrary, [nonsensuous thought] deploys the lived abstraction of interstices between one actuality and another" (ibid., 236). This is close to Simondon's conceptualization of the axiomatic of signification, an ensemble of singular points that structure perceptions in a way that is not sensed but that is nevertheless real, and therefore enter the realm of experience of the living individual.
[86] Aesthetic computing is exemplified by John Conway's Game of Life, an implementation of cellular automata evolving according to certain rules defining birth, death, and survival. See: "LifeWiki," ConwayLife.com, (March 7, 2016), http://www.conwaylife.com/wiki/Main_Page.
[87] Drawing on Alfred N. Whitehead, Parisi defines soft thought not as "a tool for thinking (i.e., for planning, calculating, and rationalizing) space-time. Instead, soft thought is a way of producing computational space-time." As such, soft thought corresponds to the "mental pole of an algorithmic actual object." Parisi, *Contagious Architecture*, 169.

words, for Parisi algorithmic onto-aesthetics correspond to the individuation of spatiotemporal actualities that are eminently quantitative, because determined by the persistence of incompressible data – sheer complexity – into computational processes. These incompressible data can neither be reduced to the biophysical plane nor to the ideal mathematical, but instead introduce a new order of reality, which is a mode of "speculative reason."[88]

In a closely related way, Beatrice Fazi investigates computational aesthetics as the relation between experience and abstraction, whereby aesthetics "concern[s] the construction of experience, or indeed … an investigation into the possibility thereof," where experience refers to "self-determination vis-à-vis indeterminacy."[89] Fazi, like Parisi, eschews a phenomenological approach and instead focuses her enquiry on the ontology of computation. Drawing on Kurt Gödel and Alan Turing, Fazi affirms the incompleteness of the axiomatic method for the metacomputation of the sensible and the intelligible. The metacomputational paradigm understands the world as a closed system – indeed, a black box – that can be explained and controlled through 'Universal Computation' and *mathesis universalis* as onto-epistemological postulates.[90] For Fazi, in the metacomputational view, the transcendental ontology of ideal forms results in a classicist aesthetics grounded on the equivalence of beauty and truth — an aesthetics that relies on an "idealisation of a closed formulation of what can be intelligible."[91] Fazi calls "computational idealism" the aesthetic theory grounded on the postulates of Universal Computation.[92] To this, Fazi opposes an onto-aesthetics of computation

[88] Alfred North Whitehead, *The Function of Reason* (Boston: Beacon Press, 1958). Alfred N. Whitehead defines speculative reason as "the urge of disinterested curiosity" (ibid., 38) that, in the history of evolution, has allowed for the "upward trend[s]" (ibid., 7) characterized by more complex forms of life. As the mode of thought opposed to practical reason, for Whitehead, speculative reason "is a tropism to the beckoning light" (ibid., 65) – it corresponds to the futurity immanent to reason.
[89] Fazi, "Incomputable Aesthetics."
[90] Ibid.
[91] Ibid.
[92] "It is argued here that Universal Computation lies at the basis of an aesthetic approach to computation that I call *computational idealism*. The term 'idealism' is to be taken in its metaphysical sense, and indicates the principle according to which abstract laws are more fundamental to reality than that which we are presented with through perception and sensation. What I am depicting as an idealism of computation is a technocultural view that would maintain that computational structures are *ideal forms*, insofar as they are immutable entities, independent from matter as well as from contingency. From this perspective, aesthetic significance corresponds to a mathematical conception of beauty, articulated as the ultimate value, or as a cipher of computational being per se. The latter, in turn, is truthful insofar as it presents, through algorithmic inference, a means to an ideal of eternal and abstract formality that is essentially indifferent to change. What I have termed 'computational idealism' would thus seem to hold that there is equivalence between beauty and truth via *logical proof*: computational structures are truthful

founded on the contingency immanent to the axiomatic method – that is, an open formalism that reveals an incomputable aesthetics. Fazi is careful to acknowledge that incomputable aesthetics, as the aesthetics proper of the ontology of computation, is not the only possible aesthetics. However, it is certainly relevant in order to orient further onto-aesthetic investigations, particularly from the perspectives of media and art. These new approaches to algorithms and computation are certainly pertinent to my inquiry into the aesthetics of algo-financial power. After all, nowhere but in the market is the metacomputational view more evident. In light of this discussion, it is possible to grasp the aesthetics of algo-financial power as directly related to the production of the 'sense' of contemporary power – what Matthew Fuller and Andrew Goffey have described as "a pervasive sense of dark foreboding"[93] that persists in the socio-cultural realm, an aesthetics of the black box that is both empirical and abstract.

6.5 Beyond Finitude: Postcybernetic Control and the Chrono-Topology of Algorithmic Markets

The above reformulation provides the means to trace the techno-logical metamorphosis of aesthetics – from the infinite flow of early aesthetics, to the discrete finite sense perceptions of eighteenth century aesthetics, up to the discrete infinities discussed by the likes of Parisi and Fazi. Whereas aesthetics has been traditionally linked to the sensual, these discrete infinities correspond to the key points – the aesthetic attractors – that together constitute the abstract architecture, the groundless ground, upon which sense perceptions emerge. As advanced in chapter four, Simondon discusses this in terms of the event of the discovery of a chrono-topological axiomatic from which the individuation in the living unfolds.[94] For Simondon, individuation happens through dephasing, which is also a doubling as it gives rise to a "remarkable point" – that is, "a turning point that resolves, momentarily, into this or that singular event or discrete occasion of experience"[95] – and a milieu. These points and milieux mark the axiomatic of signification of the living – an abstract, open infrastructure that does not concern language or meaning, but instead corresponds to a morphogenesis of being. "Topology

as they are logically consistent; this consistency is beautiful because it adheres to the axiomatic character of computation." Ibid. (emphasis in original).

[93] Fuller and Goffey, *Evil Media*, 3.

[94] Simondon, *L'Individuation*, 223–28.

[95] Erin Manning, *Always More than One: Individuation's Dance* (Durham: Duke University Press, 2013), 18.

and chronology are not *a priori* forms of sensibility, but the very dimensionality of individuating being."[96]

Following this lead, it is important to note that trading algorithms introduce new chrono-topological coordinates, or key points, that add to the open axiomatic of individuation. In terms of temporality, algorithms trade below the speed of human perception in registering a stimulus. While the human threshold is about 140 milliseconds, it takes about 8 milliseconds to send a message from Chicago to New York and back via microwave signal. Furthermore, the fastest trades on the NASDAQ happen in microseconds, that is 1/1,000,000 of a second.[97] Spatially, trading algorithms shift the focus, and economic value, on the properties of materials and onto distances before considered trivial.[98] For instance, colocation services in the Mahwah data center can cost trading companies up to $10,000 a month.[99] The fact that these algorithms operate below the threshold of human perception does not mean that they don't exist, as I explained in chapter four. Instead, these novel chrono-topological coordinates add new remarkable points, new occasions of experience, from which perceptions, sensibility, and affectivity are constituted by way of an operation of taking-consistency – of *in-*formation, as it were – both internal and external to the individual.[100] In other words, the techno-aesthetic feel persists in experience without being necessarily sensed, precisely by entering the potential dimension of preindividual ontogenesis.

This resonates with Félix Guattari's discussion of energetic-spatio-temporal (EST) coordinates. As Guattari puts it in *Schizoanalytic Cartographies*:

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[96] Simondon, *L'Individuation*, 227 (emphasis in original).
[97] MacKenzie, "How to Make Money in Microseconds."
[98] For instance, Donald MacKenzie makes the point that "the spinal cord of US capitalism" is the geodesics – that is, "the shortest and fastest route on the surface of the earth between two places" – between Aurora, Illinois, and Chicago. Today this trajectory is crowded with microwave antenna dishes used for HFT. On another note, the size of the rain also matters when it comes to the transmission of HFT orders via laser. MacKenzie explains that the size of raindrops in London makes it difficult for laser transmission, while it facilitates communication through millimeter waves. MacKenzie, "Be Grateful for Drizzle."
[99] John Lanchester, "Scalpers Inc.," *London Review of Books*, June 5, 2014, http://www.lrb.co.uk/v36/n11/john-lanchester/scalpers-inc. Colocation consists in placing trading companies' servers in the stock exchange's data center to be as close as possible to the exchange's servers. The closer the server, the more expensive the rent of the space.
[100] As Elizabeth Grosz clarifies, in Simondon's philosophy, "the living being elaborates both perception and affect entwined, not as separate dimensions, but now brought together in a new dimension." Elizabeth Grosz, "Identity and Individuation: Some Feminist Reflections," in *Simondon: Being and Technology*, ed. Arne De Boever et al. (Edinburgh: Edinburgh University Press, 2012), 50.

> Everywhere, in every register, in the form of barriers, moulds, modules, punctual, circular, strange (fractal) attractors, catalyzers, enzymes, genetic coding, gestaltist perceptions, mnemotechnical props, poetic constraints, cognitive procedures, but also financial institutions, institutions of publicity, etc, filters are constituted as interfaces between: 1) the virulent virtualities of chaos, stochastic proliferations; and 2) actual potentialities that can be listed and consolidated.[101]

In the contemporary financial world, ubiquitous, interactive algorithms precisely constitute these "mutational filters"[102] that quantify and discretize qualitative relational dynamics (for instance, values, 'feels,' beliefs) in real time, and conversely, transduce these abstract quantities into key points that contribute to the ontogenesis of new perceptions of the physical world. Further, in the moment in which algorithms compete against each other to shave milliseconds off trades, the real-time-ness upon which financial engineering is predicated loses its traditional meaning, and temporal consequentiality gives way to a topological, intensive surface that extends to more and more aspects of the world. That is to say, trading algorithms impact not only the "intensive pricing surface of the market"[103] but, through pricing, affect and modify the sensible world in an emergent fashion. Or, to put it differently, they construct real-time models of the world from the bottom up, in which technology becomes an integral part of the human sensorium, while at the same time humans become an incidental element in the sensing of machines. However, as Parisi notes, one should not simply conflate algorithmic evolutionary dynamics with the emergent properties of matter. As will be made clear in the following paragraphs, one needs instead to consider the extraspace of entropic data – a space that doesn't corresponds to the dynamic continuum of the biophysical plane but instead "infects (or irreversibly reprograms) all levels of matter."[104]

As I explained in the previous chapter, the social logic of algo-financial power is rooted in warring strategies and short-term 'greedy' decision making that amplify the

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[101] Félix Guattari, *Schizoanalytic Cartographies*, trans. Andrew Goffey (New York: Bloomsbury Academic, 2013), 109.
[102] Ibid., 114.
[103] Roffe, *Abstract Market Theory*, 64.
[104] Parisi, *Contagious Architecture*, 9.

axiontology of algorithmic finance (understood as the dynamic interplay between ontological structures and genetic operations) to more and more aspects of the social. The above exposition supports this argument, showing that the genealogy of the Monte Carlo simulation method – a complementary technology of power – is rooted in a milieu involving gambling, mass destruction, constant surveillance, and ruthless capitalization to preserve economic freedom. While I do maintain that, following Simondon, technical value cannot be entirely axiomatized by economic considerations, it becomes clear how this configuration of technical operations and milieux has given rise to the contemporary sense of power. This may also help explain how black box aesthetics operates at different scales of reality and how it is capitalized upon by apparatuses of control – from abstract, but concrete, algorithmic environments, to physical spaces such as stock exchanges' data centers, to the "pervasive sense of dark foreboding"[105] that has engulfed the collective sphere, of which markets are now an integral component. When the *feel* of the market is automated, what is left to the human is the *sense* of displacement in front of the impenetrable black box.

The genetic role of 'post-industrial technology' in the individuation of complex, living systems has been also identified by Luciana Parisi in the field of urban design. For her, it is precisely the ontogenetic character of real-time algorithms that inaugurates a new mode of control – postcybernetic control – by concretizing new spatiotemporal actualities in accordance with algorithmic speculative reasoning. Or in her words: "the question of control is now as follows: how can that which relates to itself become? To put it crudely, postcybernetic control is now concerned with the programming of events."[106] This is partly because advanced algorithms have introduced an invariant function in computation, which operates by establishing axioms over axioms, thus subsuming all possible scenarios into a given set.[107] This has endowed software with the

[105] Fuller and Goffey, *Evil Media*, 3.
[106] Parisi, *Contagious Architecture*, 79.
[107] This is exemplified, for instance, by the fact that imperative programming (the kind of programming that mimics natural languages) admits the operation of a = a + 1. That is to say, that a variable 'a' can be equal to itself plus another unit. Most trading algorithms are written in some variations of C++, a general purpose programming language, which supports imperative-object oriented and generic programming features. This confers on them a more open character in a complex environment, as the above operator illustrates. This means that, on the one hand, these algorithms are able to account for differential changes; on the other hand, however, this also makes them more prone to errors and unintended behaviors. On the contrary, pure functional programming doesn't allow for that sort of operation. Trading firm Jane Street Capital famously writes its code in OCaml, a functional language built on a variation of Haskell. In doing so, Jane Street avoids incremental operators such as the above, thereby allegedly ensuring the correctness

capacity to account for qualitative relational changes among parameters and to be affected by external contingencies in real time, thereby turning the Euclidean matrix of computation into a topological surface of spatiotemporal relations.[108] This logic initiates a mode of preemptive control that functions by calculating potentialities, rather than possibilities, thus "flattening control and novelty (or event) onto a topological matrix of continual co-evolution."[109] This mode of control, which operates not only in urban design but also in relational databases, interactive models, and real-time simulations is immediately aesthetic, because it organizes perceptions according to its own functioning, in a way that is not humanly sensed; instead it "creates the perception of space as a relational field of emergence."[110] The form of aesthetic control that Parisi uncovers in the field of architecture can be true for market structures too. While parametrically designed buildings create alien urban spaces, algorithmic financial markets create geo- and socio-political scenarios that are always already foreign to us. From this standpoint, the question is not how to make sense of such a system, but how to make a *new* sense of this mode of power. In order to do so, one needs to foreground the technicity immanent to algorithmic finance and untangle it from the economic finality that has been imposed onto it, as I will endeavor to do in the following section.

6.6 Beyond Human: Algorithmic Apocalypse and the Values of Technics

As the above discussion made clear, the chrono-topological coordinates introduced by trading algorithms mark the vanishing point of the human, the *façade* beyond which the Anthropocene perspective ends and the true, obscene (as in: off-scene) 'Electrocenic' axiomatic weaves itself autonomously from human intervention.[111] However, one need

of the code. I obtained this information from private conversations with programmers and algorithmic traders.

[108] Celia Lury, Luciana Parisi, and Tiziana Terranova, "Introduction: The Becoming Topological of Culture," *Theory, Culture & Society* 29, no. 4/5 (2012): 3–35; Luciana Parisi, "Digital Design and Topological Control," *Theory, Culture & Society* 29, no. 4/5 (2012): 165–92.

[109] Parisi, "Digital Design and Topological Control," 171.

[110] Ibid., 167.

[111] Dan Mellamphy and Nandita Biswas Mellamphy, "Welcome to the Electrocene, an Algorithmic Agartha," *Culture Machine* 16 (2015): 14. It is worth reporting here their passage in full, as it illustrates well the relation between the human and the 'electrocenic' dimensions that also apply to algorithmic finance: "The 'anthropocene' masks the *vanishing-point* of the human; its *façade* – that under which the 'electrocene' advances in the manner of Descartes' *larvatus prodeo* – is the foregrounding of the human as the dominant agent of inscription … What we are suggesting here is that the anthropocenic worldview occludes what might at present be *an even more fundamental* (*underground* as well as *overarching*) 'electro-synarchic' agent of inscription with respect to which the human is only a *conduit* and *carrier* …: namely, a force of inscription that the human does not see (one that operates at the 'vanishing-point' of

not completely conflate the 'Electrocene' with neoliberal logic. In fact, the values of technicity "surpass utility"[112] and instead come to constitute the independent "regulatory normativity"[113] of technics. As Muriel Combes puts it:

> When all is said and done, it is technics and technics alone, considered from the point of view of its genesis, that contains an intrinsic normativity capable of regulating the social itself, and the role of culture is to make humans recognize this virtual normativity in order for it to become effective.[114]

The point is that *this* culture – a culture based on 'agnotological' practices – has not been able to make this normativity manifest as it might be; it is up to the 'inventors' of our times, in alliance with contemporary technology, to make this happen.

Simondon's study of technical objects insists on this point. Although he never witnessed the concretization of the cybernetic model into the Internet, he presciently advanced the hypothesis that the former may inaugurate a new era of technological development, due to the instantiation of a "movement of thought"[115] that would contribute to the development of a technical mentality – a thought-network, that is "the material and conceptual synthesis of particularity and concentration, individuality and collectivity."[116] As I explained in chapter two, for Simondon cybernetics furnished the model for the invention of post-industrial technical objects – that is, technical objects, such as information and telecommunication networks, that eschew the foreclosing industrial regime of functioning, and that are instead endowed with a reticular, distributed structure that makes them open and participable.[117] Contemporary

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human communication). The 'vanishing-point' of human communication, we propose (*pace* Baudrillard 1992, 2009: 15-24), is the point at which an*other* regime of communication arises – one that is altogether *obscene* (*ob-scena*, *i.e.* literally 'off-the-scene' (*cf.* Baudrillard, 1983: 150) and that cannot be represented within the theoretical frame-work advanced in the dominant conception of 'the anthropocene'. It is precisely *by way of the anthropocentricity of the human species* that the electrocene comes to encroach, entrench and establish itself, hidden in plain sight." Ibid., 14–15 (emphasis in original).

[112] Simondon, *Du Mode*, 222.

[113] Ibid., 227.

[114] *Gilbert Simondon and the Philosophy of the Transindividual*, trans. Thomas LaMarre (Cambridge: The MIT Press, 2013), 63.

[115] Gilbert Simondon, "La Mentalité Technique," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 302.

[116] Ibid., 307.

[117] Ibid., 311–12.

algorithms are the epitome of post-industrial technical individuals. Indeed, the process of transduction that occurs from mathematical formalization to digital concretization (that is, the fact that electronic circuits 'can count,' as in the implementation of the Monte Carlo method) opens algorithms to the incomputable dimension of a preindividual reality, thereby creating infinite occasions to produce novelty.

This is demonstrated by Parisi, for whom the evolutionary dynamics of advanced algorithms are not simple simulations. This is because algorithms undergo a process of ontogenesis, which implies the radical immanence of incomputability in their becoming – as Kurt Gödel, Alan Turing, and more recently Gregory Chaitin have demonstrated. In the context of financial markets, this means that trading algorithms incorporate contingency in the very fabrics of their being, as I discussed in chapter four. This instills a more open character to algorithms in complex environments, and may help explain black swan events such as the Flash Crash of May 6, 2010, and the thousands of mini-crashes that have been occurring in the markets since the turn of the new century. Further, it challenges the efficient market hypothesis upon which contemporary financial engineering is predicated, and the figure of the rational agent in market modeling. Moreover, it turns the market, and culture at large, into an unintended consequence of this open formalism. This is precisely the effect of the "surplus value of code," as Deleuze and Guattari call it, "an increase in valence, a veritable becoming"[118] – that is, the metastability immanent to algorithmic objects that constitutes the trigger of ontogenetic processes. In truth, this testifies to an economy of excess, rather than scarcity, that is immanent to the general economy of the modes of being.

This new mode of computation calls into question the rational logic of the numbered number, and instead turns culture into an 'aesthetic battlefield' between the organic plane and the machinic phylum of silicon chips "which together deploy not a transparent apparatus of communication but instead a fractal architecture of events."[119] As I explained in chapter four, computational contingency rationalizes crises of liquidity and makes them necessary to the functioning of the financial machine. Fischer Black already noted that noise is a fundamental element of equilibrium models, and not

[118] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 10.
[119] Parisi, *Contagious Architecture*, 80.

of the rational type.[120] Yet he did not foresee the 'apocalyptic' kind of equilibrium that computational noise – the contingency immanent to algorithmic operations – entails. Inspired by Yuk Hui's notion of "algorithmic catastrophe,"[121] here I want to reformulate the event of the crisis as an *algorithmic apocalypse*. In contrast to the doomsday scenarios that this term customarily evokes, here I employ the term 'apocalypse' according to its etymological meaning of 'unveiling' – the unveiling of algorithmic contingency into the fabrics of the world.

Through the notion of algorithmic catastrophe, Hui exposes the immanence of computational formalism to what he calls "second nature." Hui differentiates second nature from the traditional concept of nature, by highlighting the technicity immanent to the contemporary natural and naturalized patterns and phenomena that have become the key feature of the prevalent logic of power – that is, the blend of laws of nature, capitalism, market ideology, money, but also social relations, etc., that are embodied, precisely, in algo-financial operations. As Hui puts it: "The automatic of the second nature produces a new form of contingency, which does not oppose that of nature but rather contains it."[122] Financial markets are an apt instantiation of second nature, due to their inherently technical, discrete, and recursive character – which is indeed algorithmic, as I also illustrated in the previous chapter. From this standpoint, algorithmic apocalypses mark the vanishing point of the human and reveal the "*even more fundamental* (*underground* as well as *overarching*) 'electro-synarchic' agent of inscription with respect to which the human is only a *conduit* and *carrier*."[123] In other words, the algorithmic operations underlying the 'liquid' functioning of markets let computational contingency outside the channels of communication and weave it into the fabrics of everyday life. In spite of central banks' injections of liquidity into national economies through quantitative easing and other esoteric stratagems aimed to promote trading (such as negative interest rate policy), at some point the real hits back – as algorithmic apocalypse, as the absolute contingency of computational objects.

120 Fischer Black, "Noise," *The Journal of Finance* 41, no. 3 (July 1986): 530.
121 Yuk Hui, "Algorithmic Catastrophe: The Revenge of Contingency," *Parrhesia* 23 (2015): 122–43.
122 Ibid., 129. Hui illustrates this through the example of Fukushima in 2011. "The tsunami is not really the cause of the catastrophe, but rather part of the cause. That is to say, the contingency of natural law (which includes natural disaster or material failure) cannot alone explain the catastrophe, since nature (the sea) is integrated into the technological system as a cooling agent of the nuclear plant." Ibid., 130.
123 Mellamphy and Biswas Mellamphy, "Welcome to the Electrocene, an Algorithmic Agartha," 14 (emphasis in original).

In order to make sense of a system which "lacks spatio-temporal solidity"[124] – or, more precisely, which belongs to a spatio-temporal realm of which humans are increasingly a by-product – it is not so much a matter of 'resistance' to the logic involved, nor a matter of attempting more adequate forms of representation of this logic. Rather, it is perhaps a call to invent always anew potential space-times – new Worlds, new Universes, as Guattari would call them – that would harness the surplus value of algorithmic objects, precisely by grasping their 'techno-aesthetic feeling,' in order to orient individuation away from the contemporary sense of power. "A process of change of contexts … not of possibilities" as Elie Ayache puts it.[125]

6.7 Hapticality and *Trans*-gression: Toward the Invention of a *New* Sense of Power

In other words, one needs not to stop at the infinity of algorithmic occasions of experience vis-à-vis the finitude of human life. Instead, it is by crossing this threshold that one can counter the teleological acceleration of neoliberal power. The only way to do so – to make sense of it, as it were – is through a techno-aesthetic insertion that would break with the postcybernetic mode of control and give a new directionality to individuation. At this point a distinction needs to be made between the crash and the break. The crash – or the 'crisis' that I have described in the previous chapters – is a momentary collapse of the abstract infrastructure of power, an accident inbuilt in the operational logic of the machine that doesn't necessarily equate with a veritable change. Financial crashes are an instance of this, as they constitute necessary occasions for neoliberal contingents to respond to market crises with more financialization. Conversely, a break entails the opening up of a discontinuity for the insertion of novelty – a transgression. However, as I explained above, a crash also embodies the apocalyptic aesthetics of contemporary algo-finance – the moment of the revelation of computational contingency into the fabrics of everyday life. As such it can become a novel occasion of experience – it may allow for a break, for the establishment of a true discontinuous relation. Discontinuous relation is what allows for a veritable invention, as it entails the discovery of an "autocorrelation that makes the system viable."[126]

[124] Mirowski, *Never Let a Serious Crisis Go to Waste*, 34.
[125] Elie Ayache, *The Blank Swan: The End of Probability* (Chichester: Wiley, 2010), 6.
[126] Gilbert Simondon, *L'Invention Dans les Techniques: Cours et Conférences*, ed. Jean-Yves Chateau (Paris: Seuil, 2005), 103.

Simondon clarifies that the relation between human and technical object that enables such an invention does not follow the temporal regime of labor. Instead, it entails a "technical effort."[127] This is because the inventor is a "pure individual" – that is, a mediator between the collective and the inaccessible technical object, whose role is to allow for the invention to become a "germ of civilization" by breaking with social structures and instantiating new relations across the collective.[128] Technical effort involves a tactile attunement with the machine. This is what François Laruelle calls the 'power of the senses.' As I explained in chapter one, for Laruelle the sense of power can only be countered by a minor hermeneutic that corresponds to the production of a novel interpretation of the technologies of power. However, Laruelle specifies that sense, in this case, doesn't simply refer to phenomenological perception. Instead, it needs to be understood as "the degree zero of signification"[129] – that is, as an operation that is able to inflect the axiomatic of signification toward a new direction, impacting the way in which information unfolds through it.

Stefano Harney and Fred Moten refer to this in terms of hapticality – "a way of feeling through others, a feel for feeling others feeling you," an "insurgent feeling."[130] Simondon's relativistic approach to the individuation of physical, biological, and technical beings provides the means to open up Harney and Moten's notion of 'the others' to any kind of encounter, not necessarily or just human. Furthermore, Laruelle's theory recasts this capacity as directly implicated in the relations that constitute *a* power. Hapticality thus reformulated – as a peculiar kind of attunement to and novel interpretation of the movements of information as it passes through skins, porous membranes, perceptrons, sensors, and interfaces of all kinds – provides the means for a transindividual technical relation, which "inserts [the technical being] into an *élan* of universal communication."[131]

> The *value* of the *dialogue* of the individual with the technical object is to preserve human effort, and to create a transindividual domain, distinct from community, within which the notion of freedom takes a *sense*, and which

[127] Simondon, *L'Individuation*, 340.
[128] Ibid., 340–43.
[129] Laruelle, *Au-delà du Principe de Pouvoir*, 281.
[130] Harney and Moten, *The Undercommons*, 98.
[131] Simondon, *L'Individuation*, 340.

> transforms the notion of individual destiny but it doesn't crush it. [The technical being] is the correlative of the individual's autocreation.[132]

Transindividuation can thus be understood as a "form of feeling [that is] not collective, not given to decision, not adhering or reattaching to settlement, nation, state, territory or historical story." Therefore, it cannot be "repossessed by the group, which could not now feel as one, reunified in time and space."[133]

From this standpoint, how can one feel the imperceptible? How can one open – or better, *break* – the black box? Because of its attunement with the aesthetic plane, the privileged realm from which such a break can depart is that of the arts. As Simondon again puts it, the artist is an inventor, whose role is to exceed the finitude of the physical world and to imbue her works with virtual potential:

> Every inventor in the matter of art is futurist in a certain measure, which means that he [*sic*] exceeds the *hic et nunc* of needs and ends by enlisting in the created object sources of effects that live and multiply themselves in the work; the creator is sensitive to the virtual, to what demands, from the ground of time and in the tightly situated humbleness of a place, the progress of the future and amplitude of the world as a place of manifestation.[134]

The attunement of the artist-inventor to the new forms offered by the technical invention manifests today in many experimental fields that point toward the exigency to divorce aesthetics from the realm of representation and neoliberal value; to distance it from a phenomenological perspective; and open it up to the operations of thought in conjunction with the affordances of digital networked technologies, in order to uncover the techno-aesthetics behind the imperceptible operations of algorithmic media – an issue I will explore in more detail in the last chapter.

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[132] Ibid., 343 (emphasis added).
[133] Harney and Moten, *The Undercommons*, 98.
[134] Gilbert Simondon, *Imagination et Invention (1965-1966)* (Chatou: Éditions de la Transparence, 2008), 182 (emphasis in original).

Artists, inventors, software engineers are able to cut through the sensual, representational layer of experience in order to come into contact with imperceptible algorithmic operations. However, techno-aesthetics does not only become manifest in accidents but, importantly, entails the insertion of a break, a turning point, into the system composed by the human and the world for the formation of a new logic. This may be true for the economic too. Creation, attunement, invention always already pertain to the aesthetic domain, and do not need to be relegated to the visual arts. In the words of Milton Friedman, one of the original MPS members: "The construction of hypotheses is a creative act of inspiration, intuition, invention; its essence is the vision of something new in familiar material."[135] As neoliberalism 'invented' a new mode of power through its alliance with cybernetics, today we are witnessing bursts of inventions in the financial world too, stemmed from new modes of relations with algorithmic media. As the next couple of chapters will show, examples such as blockchain technologies and the parasitic hedge funds of the Robin Hood Cooperative counter market logic through a singularization and distribution of values away from the homogenizing effect of capital. Such examples thereby invent new ways of navigating the real away from neoliberal logic, with new modes of relation between human and machine – new operations of individuation – that would overcome the reterritorialization on capital and economic value, reverse the contemporary sense of power and generate new, irreversible, Universes.

In conclusion, in this chapter I have argued that the aesthetics of algo-financial power is not to be understood as an instance of the mapping of the aesthetic field onto the political economy – a thesis pursued by Fredric Jameson and more recent authors that call for the necessity of a representational mapping of the operations of contemporary power. The discussion of this chapter instead suggests that computation instantiates a shift through which aesthetics becomes immanent to the becoming of the general economy of being – that is, the production, or individuation, of the very forces of production of thought, subjectivity, political formations. From this standpoint, contemporary neoliberalism, especially in its financial operatory mode, can be conceived as an aesthetic mode of control after finitude. Its only boundary, in *this* 'universe,' is the incomputability at the heart of algorithmic processes. For this reason,

[135] Milton Friedman, "The Methodology of Positive Economics," in *Essays in Positive Economics* (Chicago: University of Chicago Press, 1953), 43.

this chapter calls for the invention of new worlds, new universes of value that may provide the operation of information with a different logic. As the articulation of algorithmic markets that I provided above via Hui's notion of second nature shows, the axiomatic formations underlying the becoming of the complex reality of global finance can be tweaked, twisted, and rebuilt. Paraphrasing Laboria Cuboniks: "if [second] nature is unjust, change [second] nature!"[136]

However, is it enough to say that art, through its contested relation to the financial-institutional world, offers viable alternatives to the current balance of power, or is the position of art vis-à-vis finance another testimony to the widespread, all-encompassing capture of algo-finance? Before answering this question, the next chapter turns to an exploration of the 'discontinuous invention' of Bitcoin in order to foreground what is the real value that is immanent to it. Only after doing so it will be possible to assess to what extent the contemporary sense of power has taken over the cultural realm, and what the possibilities are for the establishment of what Simondon calls a 'technical culture' that would encompass economic relations without however giving any primacy to them.

[136] Laboria Cuboniks, "Xenofeminism. A Politics for Alienation," 2015, http://laboriacuboniks.net/.

7. Algorithmic Governmentality, Governance-by-Design, and Collaborative Platforms: The Lesson of Bitcoin for the Speculative Engineering of a Commons-Based Blockchain

The most important designing is ontological –
Terry Winograd and Fernando Flores[1]

7.1 Invention, Money, and Organization

This thesis opened with the issue of digital money and, after exploring several instantiations of the digitalization of fiat currencies – in their ontogenetic, social, and aesthetics dimensions – it returns to digital money, albeit quite a different one. To recap, in chapter three I described a Bitcoin unit as one instance of digital money in order to show how the technical value of the digital troubles the traditional understanding of the economic value embodied in – and stored by – fiat money. In the unfolding of the thesis I have further argued that digital money – as the technical interface between social and economic exchange – is profoundly implicated in the taking-consistency of the 'sense' of a novel mode of power that can be identified according to a particular configuration of the technical operations of reification and recursion. Chapter five showed how this logic underlies financial markets and, through the transductive amplification of the crisis, extends to the ordering of the social. In chapter six I have also discussed how such algorithmic operations 'creorder' psychic-collective formations, inserting singular occasions of experience – imperceptible spatiotemporal key points – in the axiomatic of signification that allows for the perceptual engagement with the external milieu. I have then argued for an aesthetics of the feel – a haptic aesthetics – that would counter the lack of representability of the financial ecosystem with an act of synthetic invention. This is made possible by the openness of the internal structure of what Simondon calls 'post-industrial technical objects' that, as I have explained in chapter four, has impacted profoundly on the metaphysical structure of 'The Market.' Furthermore, this openness may allow for the emergence of new forms of relation from the 'gaps of non-interaction' between the fields of force that provide the groundless ground upon which individuation unfolds.

[1] Terry Winograd and Fernando Flores, *Understanding Computers and Cognition: A New Foundation for Design*, Reprint edition (Norwood: Ablex Publishing Corporation, 1990), 163.

In light of these premises, I now turn to the technical specificities of what is arguably one of the most significant 'veritable inventions,' using Simondon's vocabulary, in the financial sector for the last three hundred years – Bitcoin. Following on from the trajectory opened in chapter three, my goal in this chapter is to foreground the details of the 'technical value' immanent to the invention of Bitcoin. I will do so by focusing not so much on markets as on the larger issue of governance. As I have argued throughout the thesis, Simondon's allagmatic method provides the means to consider markets as instances of organizations. From an allagmatic perspective, markets are therefore implicitly related to issues of governance, or better self-governance, as I discussed in chapter one. As a 'universal cybernetics,' allagmatics is in fact directly related to issues of directionality, control, and power. Thus here I will approach Bitcoin through the problematics and novel possibilities it introduces in relation to governance and self-governing. By doing so, I aim to shift the register from the restricted topic of economic emancipation to the broader issue of collective organization. This is because, as I have explained previously, money is a social machine – an elementary technology – therefore it is directly implicated in the organization of collective formations. Further developing the themes of the previous chapters, my goal here is two-fold. On the one hand, I aim to dispel the techno-dystopian claims that see blockchain technology as the emblem of a new phase of anarcho-capitalism. Yet I aim to do so not on the grounds of technological determinism but, on the contrary, by acknowledging the radical socio-political indeterminacy immanent to the Bitcoin ecosystem. On the other hand, I aim to uncover what, I argue, is the real novelty of the Bitcoin stack: an incentive structure immanent to each and every node of the network coupled with a peer-to-peer (p2p) flat power topology and a recombination of the allagmatic operations of reification and recursion.

In order to approach these topics, I will proceed as follows. First, I present the current blockchain landscape, discriminating between permissioned and permissionless blockchains, and highlighting the role of the Bitcoin protocol as both a monetary technology and as a network that serves the functions of both database and exchange. Second, I introduce the terms of the debate on algorithmic governance under neoliberalism, discussing arguments concerning the 'black box society' of planetary computation and expanding this to include a consideration of blockchain technology. Third, I step back and discuss what I believe is the true the novelty of the original

Bitcoin architecture: that is, the coupling of a flat power structure with a system of incentives immanent to each and every node of the network; this constitutes the 'absolute normativity' of Bitcoin – a kind of normativity that the design of distributed platforms cannot overlook. Fourth, I elucidate the fundamental differences between price and value(s) through a brief metaphysical detour into the philosophy of finance and technology that I anticipated in previous chapters, in order to allow for the conceptual divorce of price from value and to foreground the radical difference between Bitcoin's value system and price mechanisms. Fifth, I reframe Bitcoin's incentive structure in terms of the open-ended 'enabling constraints' that have allowed for the emergence of the Bitcoin platform, in order to open up spaces for experimenting with novel reward and evaluation schemes. Ultimately, I point toward further challenges in the design of p2p governance structures, with a specific focus on blockchain-platforms that would reflect the cultural heterogeneity and diversity of values of a twenty-first-century already distributed world, a theme I will further explore in the last chapter.

7.2 Blockchain Beyond Bitcoin, Organizations Beyond Markets

In chapter three I discussed a single case of a Bitcoin transaction. I have shown that in truth there is no such a thing as 'one Bitcoin unit' since Bitcoin's value emerges from a series of algorithmic operations that eschew the process of reification characteristic of the production of digital fiat money. In this chapter I aim to broaden the scope of my analysis of cryptocurrency, opening with an overview of the Bitcoin ecosystem. As a matter of fact, eight years after its invention, Bitcoin is experiencing an inherent paradox. Following the conceptual divorce of the money-token from the underlying data structure (that is, the blockchain), the novelty of Bitcoin – the fact of being a "peer-to-peer electronic cash system"[2] – has been neutralized by institutional powers that turned it into a commodity to be accumulated and traded for a price, on par with other liquid assets such as stocks, bonds, and national fiat currencies. Meanwhile so-called 'blockchain technology' – that is, the Bitcoin data structure devoid of the function of value creation, as will be further clarified below – has been increasingly gaining traction across all sides of the political-economic spectrum, from orthodox financial institutions to commons-oriented experiments in governance and collaborative production.

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[2] Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System" (Paper, 2008), https://bitcoin.org/bitcoin.pdf.

Emerging out of the evolution of the Bitcoin protocol, blockchain technology refers to Turing-complete, trust-minimizing, cryptographic technologies that allow for the creation of universally programmable platforms (rather than mere ledgers, such as Bitcoin) with the capacity to support disparate kinds of applications (such as financial trading, identity management, reputation systems, contractual agreements, etc.).[3]

A key issue pervading the current debate about blockchain technology is the distinction between public and private blockchains – also called permissionless and permissioned, respectively. Permissionless blockchains, such as the original Bitcoin ledger, allow anyone to download an identical copy of the database and participate in the network, thus distributing control to each node and providing the means to develop censorship-resistant applications.[4] Permissioned blockchains allow instead for the distribution of identical copies of the database among a limited amount of trusted parties. Private blockchains have become increasingly popular in the financial sector since the beginning of 2015, in concomitance with the early regulations that endowed Bitcoin with the status of a commodity, thereby neutering the disruptive thrust of the p2p currency and legitimizing blockchain technology in the financial realm.[5] This is because

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[3] Blockchain technology is a somewhat ill-defined term to describe the realm of possibilities offered by the evolution of the Bitcoin architecture. Vitalik Buterin – the co-founder of one of the most prominent start-ups in the contemporary blockchain ecosystem, Ethereum – proposes the term "crypto 2.0." As he puts it, crypto 2.0 is "about the use of decentralized, cryptographic and trust-minimizing technologies to improve freedom, cooperation and efficiency in our lives." Vitalik Buterin, "State of the Onion Report" (Conference Presentation, Blockchain Workshops, Sydney, December 11, 2015), https://docs.google.com/presentation/d/1CxYZbJCryTM2Jz_b6a9_DRe5oD_51ZMjB8vxtfdA2oA/mobilepresent?slide=id.p&usp=embed_facebook. Similarly, IT research firm Gartner prefers the term "metacoin platforms" to blockchains "because these do not necessarily use blocks in a chain, and are more than a ledger (a record of transactions) but constitute a programmable platform." Ray Valdes, David Furlonger, and Fabio Chesini, "The Bitcoin Blockchain: The Magic and the Myths" (Gartner, April 8, 2016), 10. Further, for Gartner, metacoin refers to "a post-Bitcoin generalized platform that can support different kinds of value exchange, including those that don't have direct monetary value." Ray Valdes and Neil MacDonald, "Maverick* Research: In a Post-Bitcoin World, Metacoin Platforms Enable the Programmable Economy" (Gartner, October 28, 2014), 15. While acknowledging and agreeing with the limitations of the term 'blockchain technology,' here I will use the current industry vernacular for the sake of simplicity and clarity.

[4] This is because, in order to entirely shut down the Bitcoin network, one would have to disconnect each full node in the network. In practical terms, this is impossible, given the distributed nature of Bitcoin.

[5] In September 2015 the US Commodity Futures Trading Commission declared that Bitcoin ought to be regulated under the Commodity Exchange Act. Commodity Futures Trading Commission, "CFTC Orders Bitcoin Options Trading Platform Operator and Its CEO to Cease Illegally Offering Bitcoin Options and to Cease Operating a Facility for Trading or Processing of Swaps without Registering," PressRelease, (September 17, 2015), http://www.cftc.gov/PressRoom/PressReleases/pr7231-15. Different countries have regulated Bitcoin differently. For instance, Australia classifies Bitcoin as property, Russia as foreign currency, while in the UK it is treated a 'private money.' For an updated and comprehensive list of the legality of Bitcoin by Country, see: "Legality of Bitcoin by Country," *Wikipedia, the Free Encyclopedia*, last modified July 23, 2016, https://en.wikipedia.org/wiki/Legality_of_bitcoin_by_country.

blockchain technology promises to facilitate the fast and secure transfer of the ownership of digital assets, reducing settlement latency and increasing the security and supposed transparency of record-keeping systems through time stamping. Yet as many commentators highlight, the very notion of a permissioned blockchain is an oxymoron.[6] As a matter of fact, permissioned blockchains aim to build applications on top of a technological foundation – the Internet – that is the fruit of 'permissionless innovation,'[7] which entails the possibility of exploring new technologies without seeking prior approval.

In accordance with the core design principles of the Bitcoin ledger, permissionless blockchains provide instead important tools for the realization of other kinds of network, thus extending the benefits of p2p communication, decentralization, and transparency to different modes of organization. Several projects are exploring the potentialities of public blockchains for the validation of provenance and chain of custody (such as Provenance), for transparent notarization (e.g. Stampery), for data storage and transmission, one example of which is Maidsafe, extending up to encompassing governance 2.0 projects (e.g. BitNation). While the real novelty of the blockchain lies in its permissionless origins, the debate over private and public blockchains testifies to the protean character of blockchain technology and the multiplicity of applications it allows for. Furthermore, the blockchain, as a network model that derives from an eminently monetary technology, problematizes the customary clear-cut division between markets and social organizations. Instead it suggests that market exchange is immanent to modes of organization that are not necessarily financial, opening up new possibilities for the creation of not-only-financial circuits, beyond the neoliberal logic that characterizes contemporary socio-political and economic systems.

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[6] As Andreas Antonopoulos quips: "It is kind of like the difference between Che Guevara and a Che Guevara T-shirt being worn by a hipster in Brooklyn. So what do [the banks] do? They look at bitcoin and say 'Let's see. It is an open, borderless, decentralized, transparent, and peer-to-peer currency. Fantastic! Can we have that without the open, decentralized, borderless, transparent, peer-to-peer, and instead add a nice dose of heavy control?'" Andreas M. Antonopoulos, "Peer-to-Peer Money in a Historical Context" (reinvent.money Conference, Rotterdam, 2015), https://www.youtube.com/watch?v=n-EpKQ6xIJs&feature=youtu.be.

[7] See: Eli Dourado, "Bitcoin Isn't Money — It's the Internet of Money," *The Ümlaut*, January 8, 2014, http://theumlaut.com/2014/01/08/bitcoin-internet-of-money/.

In light of these premises, this chapter aims to assess the emancipatory potential of blockchain technology against the immanent normativity, evolving in real time, of what legal scholar Antoinette Rouvroy dubs "algorithmic governmentality"[8] – a mode of control for which humans are a mere agglomerate of raw data. In other words, this chapter asks: how can we negotiate the alleged inevitability of algorithmic governmentality with the prospect of "governance-by-design"[9] offered by the blockchain for the constitution of truly distributed, collaborative organizations? And how does the mode of governance established by the blockchain compare to the current automated, and nearly autonomous, system of control that, as Frank Pasquale argues, is turning the global West into a "black box society,"[10] due to the inaccessibility of the processes by which algorithms organize important aspects of daily life, such as reputation, finance, and knowledge? In order to answer these questions, I will now turn to the problem of algorithmic governance at the present political-economic, but also cultural, juncture – highlighting the reversibility that is immanent within the issue of control in the contemporary algorithmic ecosystem.

7.3 "All Watched Over by Machines of Loving Grace": Algorithmic Governance, Platform Design, and the Disappearance of the (Socio-)Political Subject[11]

In the 2005 sci-fi novel *Accelerando,* Charles Stross describes a not too distant future in which the solar system is taken over by "Economics 2.0" – "superior deterministic resource allocation algorithms"[12] endowed with life-form features and legal powers that are responsible for the collapse of capitalism, trading beyond and below the threshold of human perception and for which humans are a mere commodity.[13] Economics 2.0

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[8] Antoinette Rouvroy, "The End(s) of Critique: Data-Behaviourism vs. Due-Process," in *Privacy, Due Process and the Computational Turn. Philosophers of Law Meet Philosophers of Technology.*, ed. Mireille Hildebrandt and Ekatarina De Vries (London: Routledge, 2012), 288–331.

[9] See: Primavera De Filippi, "Governance by Design," 2015, https://www.youtube.com/watch?v=hpzGy5t4baQ; Rachel O'Dwyer, *Blockchain Workshop #1 Governance by Design* (Ireland, 2015), https://www.youtube.com/watch?v=yq6KgauDd88.

[10] Frank Pasquale, *The Black Box Society: The Secret Algorithms That Control Money and Information* (Cambridge: Harvard University Press, 2015).

[11] *All Watched Over by Machines of Loving Grace* is the title of a 1967 poem by Richard Brautigan, subsequently used by Adam Curtis for his 2011 series of documentaries about the impact of cybernetics on contemporary life. See: Richard Brautigan, *All Watched Over by Machines of Loving Grace* (San Francisco: Communication Company, 1967); Adam Curtis, *All Watched Over by Machines of Loving Grace*, Documentary, (2011).

[12] Charles Stross, *Accelerando* (New York: Ace, 2006), 266.

[13] "Basically, sufficiently complex resource-allocation algorithms reallocate scarce resources … and if you don't jump to get out of their way, they'll reallocate *you.*" Ibid., 256 (emphasis in original).

perfectly encapsulates the two facets of Distributed Autonomous Organizations (DAOs) – both the dream and the nightmare heralded by blockchain technology. Dave Babbit defines a DAO as “a decentralized network of narrow-AI autonomous agents which perform an output-maximizing production function and which divides its labor into computationally intractable tasks (which it incentivizes humans to do) and tasks which it performs itself.”[14] Vitalik Buterin further clarifies that DAOs are entities endowed with internal capital in which the automation lies at the core of the system, while humans are relegated to the edges.[15] DAOs are one instance of the possibilities introduced by the “crypto 2.0” phase of blockchain development.[16] As a matter of fact, while the original Bitcoin protocol only possessed a limited functionality (by necessity, as I will explain below), with the divorce of the data structure from the monetary unit, the potentialities of blockchain technology have grown exponentially. Blockchains, Buterin explains, have layers that can accommodate multiple applications, especially those applications that, in the spirit of Bitcoin, minimize the need to trust centralized institutions by enforcing the negotiation and performance of an agreement through cryptography – that is, ‘smart contracts,’ of which DAOs are an instantiation. While the concrete development of fully distributed autonomous agents is still in its infancy, due to the current limitations of AI research into the foundations of intelligence, the blockchain architecture provides the means to think about this possibility in concrete terms for the first time.

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[14] Dave Babbitt, “Crypto-Economic Design: A Proposed Agent-Based Modeling Effort” (SwarmFest 2014: 18th Annual Meeting on Agent-Based Modeling & Simulation, Univeristy of Notre Dame, 2014), 11/36, http://www3.nd.edu/~swarm06/SwarmFest2014/Crypto-economicDesignBabbit.pdf.

[15] Vitalik Buterin, “DAOs, DACs, DAs and More: An Incomplete Terminology Guide,” *Ethereum Blog*, May 6, 2014, https://blog.ethereum.org/2014/05/06/daos-dacs-das-and-more-an-incomplete-terminology-guide/. At the time of this writing the first implementation of a DAO – The DAO – has been activated. For its distributed governance structure The DAO has been aptly defined as “a venture fund with plenty of virtual capital but no capitalists.” Nathaniel Popper, “A Venture Fund with Plenty of Virtual Capital, but No Capitalist,” *The New York Times*, May 21, 2016, http://www.nytimes.com/2016/05/22/business/dealbook/crypto-ether-bitcoin-currency.html. On 17 June 2016 The DAO was hacked causing the fund to lose the equivalent of $60 million in Ether, the cryptocurrency used to fuel the fund. This event raises attention to the issue of ‘code as law’ underlying the ideological foundations of the DAO enterprise. As a matter of fact, the anonymous hacker refused to return the stolen funds precisely on the premises that, since ‘code is law,’ the exploit was inbuilt in the protocol and therefore the hack was to be deemed entirely legal. See: Michael Del Castillo, “The DAO Attacked: Code Issue Leads to $60 Million Ether Theft,” *CoinDesk*, June 17, 2016, http://www.coindesk.com/dao-attacked-code-issue-leads-60-million-ether-theft/; chris4210, “An Open Letter to the DAO and the Ethereum Community,” *Steemit*, June 21, 2016, https://steemit.com/ethereum/@chris4210/an-open-letter-to-the-dao-and-the-ethereum-community.

[16] Buterin, “State of the Onion Report.”

The debate about the potentials and challenges offered by the blockchain as a mode of governance inserts itself in the larger discussions about the ubiquity of algorithmic modes of management and control. As a matter of fact, an increasing number of activities – such as labor, education, healthcare, but also movement, identity, emotions, and creativity – are subjected to pervasive practices of quantification, evaluation, and standardization carried out by a complex system of networked computational agents for economic purposes. In this context, smart contracts promise a transparent and equitable way to augment people's autonomy by economically emancipating individuals and social groups from State apparatuses and by technically empowering them in the face of corporate monopolies. Setting aside for the moment moral and ethical concerns about the legitimacy of such computational practices, it should be noted that, not only have algorithms extended economic calculation to aspects that traditionally were not considered quantifiable but, importantly, they have become indispensable for the smooth running of daily life, at least in the global West. In the cultural context, this particularly affects the arts and humanities, where economic quantification and outcome-based evaluation models do not provide an adequate metric to assess the value of cultural projects, flattening the heterogeneity of cultural and pedagogical initiatives and neutralizing their potentially disruptive impact on neoliberal modes of subjectivation – an issue to which I will return in the following chapter.

Antoinette Rouvroy describes the new mode of management, regulation, and biopolitical control instantiated by computational networked technology in terms of algorithmic governmentality.[17] To Rouvroy, algorithmic governmentality is a direct manifestation of neoliberal power, defined by Michel Foucault as the extension of the economic form of the enterprise to all aspects of social life.[18] Drawing on both post-structuralist philosophy and legal theory, Rouvroy describes algorithmic

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[17] Rouvroy, "The End(s) of Critique"; Antoinette Rouvroy and Thomas Berns, "Gouvernementalité Algorithmique et Perspectives d'Émancipation," *Réseaux* n° 177, no. 1 (April 1, 2013): 163–96.
[18] Michel Foucault, *The Birth of Biopolitics: Lectures at the College De France, 1978-1979*, trans. Graham Burchell (Basingstoke: Palgrave Macmillan, 2008), 241. Drawing on Foucault, Philip Mirowski expounds the intertwining of economic calculation and algorithmic logic in the neoliberal mode of governance. As we saw, Mirowski explains that the neoliberal free-market ideology that pervades the economic orthodoxy heavily relies on computation not only for purposes of information processing and transmission but also as the fundamental metaphor according to which its worldview is constructed, turning power into an exercise of all-encompassing control. See: Philip Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (Cambridge: Cambridge University Press, 2002); Philip Mirowski, *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown* (London: Verso, 2014).

governmentality as the unprecedented regime of power characterized by the increasing use of data-mining and profiling systems and the diffusion of "data behaviorism." The latter is defined as an agnostic and immanent normativity evolving in real time that distances from previous statistical approaches, such as benchmarking and hierarchy, that presuppose instead a certain a priori world-view.[19] Thus, algorithmic governmentality differentiates itself from government by law since it directly affects the virtual plane of potentialities rather than the statistical prediction of probabilities that pertains to the material plane of people and behaviors. By targeting the "*inactual, potential* dimension of human existence,"[20] algorithmic governmentality deprives the subject of "the possession of oneself."[21] It does so through a process of 'dividuation' as described by Gilles Deleuze via Gilbert Simondon, that I discussed in previous chapters.[22] This constructs a synthetic legal subject that is constantly required to perform its conformity to the algorithmic code through the adoption of the techno-capitalist applications required by such a mode of governance, such as smart environments, biometrics, intelligent surveillance, and individualized recommendation systems.[23] Thus, algorithmic governmentality subsumes politics, due process, subjectivation, and critique into an all-encompassing mode of capture that, as Rouvroy states, knows no negativity in that it allows for "no organization of questioning or challenge of either cognitive or normative productions."[24]

This understanding of the pervasiveness and ubiquity of algorithmic modes of control is echoed by legal scholar Frank Pasquale, who foregrounds the key role that sorting, ranking, and rating algorithms play in important aspects of social life – such as reputation, search, and finance.[25] Pasquale exposes the biases inbuilt in these algorithms that, however, can only be ascertained a posteriori, precisely due to the black-boxed

[19] Rouvroy, "The End(s) of Critique," 299–300.
[20] Ibid., 315 (emphasis in original).
[21] Ibid.
[22] "In the societies of control … what is important is no longer either a signature or a number, but a code: the code is a *password,* while on the other hand the disciplinary societies are regulated by *watchwords* (as much from the point of view of integration as from that of resistance). The numerical language of control is made of codes that mark access to information, or reject it. We no longer find ourselves dealing with the mass/individual pair. Individuals have become '*dividuals,*' and masses, samples, data, markets, or '*banks*.'" Gilles Deleuze, "Postscript on the Societies of Control," *October* 59 (1992): 5 (emphasis in original).
[23] Rouvroy, "The End(s) of Critique," 310.
[24] Ibid., 316.
[25] Pasquale, *The Black Box Society*.

nature of such computational processes.[26] Importantly, Pasquale stresses that in this mode of governance – which he aptly calls "The Blob"[27] due to its porous and smooth contours – the boundaries between governments and markets are increasingly blurred. This scenario opens up to a larger dilemma: although proprietary software cannot be trusted, because it cannot be audited, these algorithms (such as Google's PageRank or Facebook's EdgeRank, the FICO credit score formula, and the multitude of proprietary financial-analysis algorithms) have become increasingly naturalized in the contemporary architecture of planetary computation. While Pasquale emphasizes the importance of policymakers in rendering the 'black box society' intelligible, the doubt remains that even policymakers, insofar as they are merely human, are entangled in the shadowy web of The Blob, hindering the possibility of change through legal means.

It is against this backdrop that blockchain technology stands out as both the promise of emancipation and as a 'Techno-Leviathan.' Stan Larimer – who first coined the term Distributed Autonomous Corporations (DACs), which provided inspiration for the subsequent technological evolution of the Bitcoin protocol, such as Ethereum and Tendermint – was the first to view Bitcoin as "an unmanned company"[28] by stressing the incorruptibility and transparency of its rules, as they are validated by a distributed network of computers and inscribed on the blockchain for all to see and publicly audit. For Larimer, the imposition of regulations from above is a deterrent to business innovation; instead he argues for the creation of emergent unmanned organizations whose characteristics he recasts according to Isaac Asimov's three laws of robotics – integrity, incorruptibility, and self-preservation. Thus, he affirms, Bitcoin will be able to fight the corruption that inevitably results from centralized forms of control: "Unlike their flesh and blood peers, DACs will be sovereign corporations governed with inhuman integrity."[29] Such an ideologically infused techno-utopian view, that emphasizes the incorruptibility and trustworthiness of the machine in comparison to the weaknesses of human beings, is taken up by Brett Scott to illustrate the perils of the

[26] For instance, Pasquale discusses the Kafkaesque world of credit scoring, in which attempting to verify one's score results in reducing it (ibid., 24). Furthermore, he highlights several cases of racially biased credit scores algorithms. Ibid., 41.
[27] Pasquale, *The Black Box Society*, 10.
[28] Stan Larimer, "Bitcoin and the Three Laws of Robotics," *Let's Talk Bitcoin*, September 14, 2013, http://letstalkbitcoin.com/bitcoin-and-the-three-laws-of-robotics/.
[29] Ibid.

mainstream narrative of empowerment foregrounded by Bitcoin.[30] For Scott, the rhetoric of emancipation through blockchain technology engenders instead a binary politics to which humans can only participate passively by way of yes or no, one or zero. This narrative, Scott observes, conceals an individualistic worldview that presupposes selfish, autonomous agents rather than agents whose best interest is the participation in collective activities. For these reasons, Scott warns, a blockchain-based governance may result instead in a Techno-Leviathan.

Mediating between these two extreme views is the work around the concept of governance-by-design. Primavera de Filippi contrasts governance-by-design with regulation-by-code.[31] While the latter is a top-down, deterministic mode of governance, not dissimilar from Rouvroy's notion of algorithmic governmentality, the former corresponds to the emergent regulations produced by communities in the process of organizing themselves through technology. In this context, the blockchain architecture's capacity for disintermediation and immediacy undoubtedly offers new exciting resources to favor commons-based peer-production. Yet as Rachel O'Dwyer remarks, the blockchain-based logic of consensus conceals an intrinsic *aporia* in the design of democratic platforms since it prevents struggle, negotiations, and confrontations that are essential to healthy democracies.[32] O'Dwyer dampens the claims around the blockchain's emancipatory potential by inscribing it into a genealogy of technics and devices that, by dispelling the need for politics and discourse, replaces the political with the economic. Instead O'Dwyer calls for alternative models of governance that would transcend Bitcoin's consensus model, and that may instead enable ways of bringing different views and opinions together.

In order to assess the potentials of the blockchain in light of such perspectives, I believe that it is fundamental to step back and measure the current advancements in blockchain technology against the 'original' blockchain, by which I mean the architecture of the Bitcoin stack. The reasons for this move are self-evident: first of all, the Bitcoin

[30] Brett Scott, "Visions of a Techno-Leviathan: The Politics of the Bitcoin Blockchain," *E-International Relations*, June 1, 2014, http://www.e-ir.info/2014/06/01/visions-of-a-techno-leviathan-the-politics-of-the-bitcoin-blockchain/.
[31] Rachel O'Dwyer, "Commons Governance and Law with Primavera De Filippi," *Commons Transition*, July 31, 2015, http://commonstransition.org/commons-centric-law-and-governance-with-primavera-de-filippi/.
[32] O'Dwyer, *Blockchain Workshop #1 Governance by Design*.

blockchain is the oldest one and has the longest track-record of successes; secondly, it has the largest market capitalization compared to competitors such as Ethereum, Ripple, or Eris; furthermore, its ecosystem is the most developed in terms of corollary technologies (such as BitPos and BTMs).[33] Ultimately, in spite of the many critiques and weaknesses of its structure, Bitcoin remains a fairly safe, cheap, and efficient way to transfer value across points in time and space, proving its resilience and resistance to attacks. My proposition is that, in spite of its alleged resolution, the experiment of Bitcoin provides an object lesson that has been often overlooked in debates around the design of platforms to support commons-based organizations, as I will explain in the following section.

7.4 The Lesson of Bitcoin: It's Not All About the Blockchain[34]

The first clarification to be made is that, in the Bitcoin protocol, monetary unit and network of exchange are inseparable: Bitcoin *is* both a digital currency and a platform. This is because, as I explained in chapter three, each Bitcoin consists in the inscription of the transmission of the ownership of value from one party to another in an open ledger maintained by a p2p network of computers. One Bitcoin unit corresponds to a chain of digital signature, and not to a finite object; it is a computational event. From the standpoint of Simondon's theory, each Bitcoin can be understood as an elementary technology, in that it materially "incorporates its own genesis"[35] in the form of a Merkle tree. In doing so, Bitcoin shifts the focus from the practice of accumulation of wealth characteristic of the capitalist paradigm, today exacerbated by financial power, to transactions – that is, relations of exchange – eliminating the need to trust third parties

[33] BitPos is an Australian blockchain payment system that allows merchants to receive payments in Bitcoin. BTM is the equivalent of an ATM for Bitcoin. It allows customers to convert national fiat currencies into Bitcoin and vice versa.
[34] The title of this section refers playfully to the October 2015 cover of *Bloomberg Magazine*, which features Blythe Masters claiming that "it's all about the blockchain." Masters is now CEO of Digital Asset Holdings, a fintech start-up focused on blockchain technology for the financial sector – that is, permissioned blockchains that, as I argued above, do not constitute any novelty. At most, the adoption of permissioned blockchain technology by financial institutions it is an instance of the attempts by power contingents to capture and neutralized the technical novelty of the Bitcoin protocol. It is also interesting to note that Blythe Masters was instrumental in the engineering of credit default swaps in the 1990s that, as I explained in chapter five, were one of the culprits of the recent global recession. See: Matthew Leising and Edward Robinson, "Blythe Masters Tells Banks the Blockchain Changes Everything," *Bloomberg.com*, September 1, 2015, http://www.bloomberg.com/news/features/2015-09-01/blythe-masters-tells-banks-the-blockchain-changes-everything.
[35] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 20.

and doing away with the profiling and ranking practices of control at the center of Frank Pasquale's and Antoinette Rouvroy's critique.

In this section I argue that the novelty of the Bitcoin stack is not the blockchain *per se*; rather, it lies in a radically new approach to the operations of value creation and exchange that, from an allagmatic perspective, corresponds to a new combination of the technical operations of reification and recursion. This is achieved through the coupling of a radically new architecture of power and an internal incentive structure that allowed for the emergent organization of the distributed network constituted by the early Bitcoin ecosystem, as will be clear in the unfolding of this discussion. Thus, while algo-financial markets constitute a further step in the continuous evolution of fiat money, as the previous chapters have explained, the invention of cryptocurrency seems to introduce a break in the mechanist-capitalist paradigm, and could be considered a veritable invention, one that corresponds to the establishment of "a new regime of functioning"[36] between individuals (both technical and biological). As a matter of fact, Bitcoin threatened to disrupt the financial establishment, at least initially, precisely by proposing an entirely new operational logic that offered a decentralized, anonymous, global, and irreversible payment system that existed entirely outside of institutional finance.

Bitcoin is a p2p network built on top of the Internet. As such, each node possesses equal power and equal capacity to produce and consume the services provided by the network. Further, this entails that all nodes share the responsibility of providing the services that allow for the network to exist. As Andreas Antonopoulos aptly puts it, the p2p network engendered by the Bitcoin stack corresponds to a "flat topology"[37] – a conceptually and architecturally flat power structure in which all participants to the network share the burdens and the benefits that derive from the maintenance of the autonomy of the network from third parties. In addition to the p2p flat power structure, Bitcoin introduces another radical novelty, which consists in the combination of a new mechanism to achieve distributed consensus with an incentive scheme that is internal to the network. In other words, it is the nodes themselves that act as incentives for

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[36] Gilbert Simondon, "La Mentalité Technique," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 301.
[37] Andreas M. Antonopoulos, *Mastering Bitcoin* (Sebastopol: O'Reilly Media, 2014), 139.

participation, eliminating the risk of dishonest behavior but also, more importantly, preserving the decentralized and open structure of Bitcoin. Thanks to this peculiarity, Bitcoin allows untrusted and pseudonymous parties to collectively create a trusted network – not only of value exchange but, perhaps more importantly, of value *creation*. While Bitcoin is today less decentralized and more hierarchical – an issue I will return to later on – the flat power structure and the internal incentive system are two core design principles that, I argue, need not to be overlooked in the design of collaborative platforms. The activity that encapsulates these disparate functions is mining, which is what permissioned blockchains are doing away with.

Bitcoin mining – whose fundamental role in preserving the distributed character of the network is today most often overlooked – consists in the process of lending computer power to the network in order to: 1) create new value by unlocking new coins to be added to Bitcoin's money supply; 2) distribute the value thus created in a decentralized manner, further improving the security and efficiency of the network. In return miners gain two kinds of reward: a percentage of new coins unlocked in the mining process and transaction fees.[38] As Andreas Antonopoulos observes:

> Mining is the invention that makes bitcoin special, a de-centralized security mechanism that is the basis for peer-to-peer digital cash. The reward of newly minted coins and transaction fees is an incentive scheme that aligns the actions of miners with the security of the network, while simultaneously implementing the monetary supply.[39]

In addition to such an internal incentive scheme, mining can be described according to two functions that correspond to the operations that grant the autonomy and resilience of the Bitcoin network: a proof-of-work (PoW) validation method and a voting mechanism to achieve distributed consensus. Although these functions are often talked

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[38] Bitcoin is scarce by design, meaning that, like a precious metal, there are only a certain number of coins to be put in circulation (21 million). Thus, the activity of mining will inevitably lead to diminishing returns. Specifically, Bitcoin is subjected to a controlled supply encoded in the Bitcoin generation algorithm, which modulates how much currency can be created and at which rate. The number of coins generated by each block that is discovered through the mining process is set to halve every 210,000 blocks, or approximately four years. Once all the coins are put into circulation, miners will be incentivized solely through transaction fees – that is, a sum of money that is taken from the transacting parties and paid to miners as part of the process of appending a transaction to the blockchain.

[39] Antonopoulos, *Mastering Bitcoin*, 178.

about separately, in practice they are deeply intertwined. Each time a transaction is effectuated, each full node verifies that the transaction is valid and broadcasts it to the whole network.[40] Transactions are picked up by mining nodes and aggregated into candidate blocks. In order to be added to the blockchain, miners have to find a solution to the PoW algorithm that makes the block valid. This entails the application of computational brute force to solve a mathematical puzzle until a specific hash value is produced – that is, a unique fixed-length number meeting certain requirements that constitutes "a digital fingerprint of the input."[41] The winning miner then creates a new block, which is subsequently validated again by all nodes and propagated to the network. This further step is necessary in order to ensure that miners act honestly to get their blocks incorporated into the blockchain and obtain their rewards. If a miner acts dishonestly, not only does he/she lose the reward but also wastes the computational effort (and therefore, electricity costs) incurred in the solution of the PoW algorithm. Ultimately, nodes assemble valid blocks into chains and vote for the chain with the most PoW (that is, the proof of the highest difficulty factor applied to it) to be added to the main blockchain. This process allows the network to solve the so-called Byzantine Generals problem – the problem of achieving an emergent consensus among unknown, therefore untrusted, participants. The internal incentive structure inbuilt in the design of the Bitcoin stack – by which nodes act as incentives for each other toward the benefit of the whole network – makes Bitcoin and blockchain inseparable. Permissioned blockchains lack such an incentive structure, turning the blockchain into a mere database-like system.

Thus Bitcoin proposes a normative and genetic mode of relationality that is radically different from the algo-financial logic described in chapter five. This is evidenced by the technical operations involved in the process of value creation and distribution underlying the Bitcoin protocol that, once again, can be examined through the lens of the allagmatic operations of reification and recursion. As I explained, in contemporary finance, recursion corresponds to the iterative process by which abstract value is

[40] Antonopoulos defines a full node as "a client that stores the entire history of bitcoin transactions (every transaction by every user, ever), manages the user's wallets and can initiate transactions directly on the bitcoin network. This is similar to a standalone email server, in that it handles all aspects of the protocol without relying on any other servers or third party services." In contrast, miners are full nodes that, in addition to 'listening' to the transactions and data being transmitted across the network, also have the task of creating new blocks to be added to the chain of transactions (that is, the blockchain). See: Ibid., 6.
[41] Ibid., 193. This is because a hash is the result of a one-way function, which is easy to compute but practically impossible to reverse given a certain output.

generated and immediately accumulated 'in potential' through reordering. Put differently, the process of reification of digital money (that is, the objectification of the imponderability of risk through the codification of a computational value to which a price is dynamically assigned) either precedes or directly follows from the recursive reordering of digital objects for further monetization. In contrast, in the original Bitcoin stack, recursion occurs *within* the process of concretization that allows for the creation of a coin as a chain of transactions. As I explained in chapter three, each Bitcoin contains its own 'genesis' in the form of a Merkle tree. As Antonopoulos explains, "a merkle tree is constructed by recursively hashing pairs of nodes until there is only one hash, called the *root*, or *merkle root.*"[42] Furthermore, the recursive process is once again activated during the search for the 'parent transactions' in the case of orphan transactions to be added to the main chain.[43] In other words, while the logic of algorithmic finance proceeds through a movement of reification through recursion, in Bitcoin recursion occurs *within* the process that leads to the taking-consistency of new transactions as the inscription of cryptographic digital signatures in a public database.

Bitcoin is not reified a priori but emerges from a series of modulative recursions – that is, the algorithmic operations that constitute the Bitcoin network. In this sense, as I explained in chapter three, a Bitcoin transaction is always already a transduction that, through the solution of a cryptographic problem by the heterogeneous network composed by humans and machines, establishes "a new regime of functioning"[44] – a qualitatively different ensemble composed by new forms of relation across all participating nodes. Thus the logic of financial markets and the process of value creation underlying the Bitcoin protocol entail two antithetic approaches to the creation and distribution of value and, through amplification, have the potential to impact the

[42] Ibid., 170 (emphasis in original).
[43] As transactions are received and verified by the network, they are added to transaction pools in order to be distributed to the nodes to be confirmed. Antonopoulos clarifies that, in certain cases in which nodes cannot identify a transaction, such 'orphan transactions' are temporarily added to 'orphan pools' until the parent transaction arrives and confirms the validity of the orphan transaction: "If valid, they are removed from the orphan pool and added to the transaction pool, completing the chain that started with the parent transaction. In light of the newly added transaction which is no longer an orphan, the process is repeated recursively looking for any further descendants, until no more descendants are found. Through this process, the arrival of a parent transaction triggers a cascade reconstruction of an entire chain of interdependent transactions by re-uniting the orphans with their parents all the way down the chain." Ibid., 160.
[44] Simondon, "La Mentalité Technique," 301.

organization of collective formations in different ways.[45] Comparing mining to the activity of currency minting deployed by State powers, Denis Roio argues that with mining "participation has substituted violence in the physical implementation of the currency authentication."[46]

However, the Bitcoin stack presents certain limitations. First of all, Bitcoin has been criticized for the environmental costs of the mining process. In a 2010 forum post, Nakamoto argued that "the utility of the exchanges made possible by Bitcoin will far exceed the cost of electricity used. Therefore, *not* having Bitcoin would be the net waste."[47] However, in the current socio-economic context, the utility that derives from Bitcoin does not justify its economic and environmental costs. As a matter of fact, Bitcoin mining has become increasingly expensive since the SHA-256 hashing algorithm has been co-opted by hardware manufacturers producing ASIC (Application-Specific Integrated Circuit) chips that have created increasingly faster – but also more expensive and more energy-intensive – mining hardware, raising barriers of entry to the Bitcoin ecosystem and favoring centralizing tendencies.[48] In addition to this, the geopolitics of Bitcoin show that, while nodes are polarized in the West of the world,[49] mining is increasingly centralized in the East, leading to concerns about the

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[45] In contrast to the limited capabilities of the Bitcoin protocol, the aforementioned The DAO admits a function that offers the possibility for recursive calling vulnerability, being a Turing-complete machine. The increasing complexity of the operations admitted by The DAO and its universality, compared to the constrained Bitcoin protocol, are what caused The DAO to be attacked. Vitalik Buterin, "Critical Update Re: DAO Vulnerability," *Ethereum Blog*, June 17, 2016, https://blog.ethereum.org/2016/06/17/critical-update-re-dao-vulnerability/; Zikai Alex Wen and Andrew Miller, "Scanning Live Ethereum Contracts for the 'Unchecked-Send' Bug," *Hacking Distributed*, June 16, 2016, http://hackingdistributed.com/2016/06/16/scanning-live-ethereum-contracts-for-bugs/.

[46] Denis Roio, "Bitcoin, the End of the Taboo on Money" April 6, 2013, 6, http://www.dyndy.net/2013/04/bitcoin-ends-the-taboo-on-money/.

[47] Satoshi Nakamoto, "Bitcoin Minting Is Thermodynamically Perverse," *Bitcoin Talk*, August 7, 2010, https://bitcointalk.org/index.php?topic=721.msg8114#msg8114 (emphasis in original).

[48] See: Nathan Schneider, "After the Bitcoin Gold Rush," *The New Republic*, (February 24, 2015), http://www.newrepublic.com/article/121089/how-small-bitcoin-miners-lose-crypto-currency-boom-bust-cycle. In comparison to Bitcoin, the cryptocurrency Dash uses a more complex mining algorithm, X11, which makes it harder to create suitable ASIC chips to speed up mining. Furthermore, X11 is considered a 'greener' algorithm for it requires less wattage. Through the adoption of X11, Dash aims to create an ecosystem in which hobbyist miners can take part, in order to allow for the distribution and growth of the cryptocurrency. From my own brief experience as a Darkcoin (now Dash) miner in 2014, what was striking for me was the support I immediately received by pseudonymous characters in the various forums on the topic, such as Reddit. See: Evan Duffield and Daniel Diaz, "Dash: A Privacy-Centric Crypto-Currency," White paper (Dash, 2015), https://www.dash.org/wp-content/uploads/2015/04/Dash-WhitepaperV1.pdf.

[49] Bitnodes.21.co provides a real-time map of the reachable Bitcoin nodes found in countries around the world. "Bitnodes," *Bitnodes*, 2016, https://bitnodes.21.co/.

maintenance of the distributed character of the network: reportedly, almost 80 percent of hash power is in the hands of four companies based in China.[50]

Furthermore, the metaphor of 'mining' has led to the reinforcement of ideological narratives. As just seen, the term mining is somewhat misleading, as miners act more like clerks, validating and clearing transactions, instead of extracting gold.[51] As Bill Maurer et. al argue, the metaphor of mining has led to a "digital metallism"[52] that made Bitcoin popular among libertarian fringes. Maurer et. al further argue that Bitcoin's digital metallism, coupled with the kind of algorithmic governance established by its code, leads to the obfuscation of the code and labor involved in Bitcoin "when Bitcoin adherents become latter-day goldbugs."[53] According to Antonopoulos, the gold-mining metaphor has given rise to a profound misunderstanding by which the activity of value creation has come to be seen as a goal in itself rather than a medium for the distribution of such a value:

> While mining is incentivized by this reward [of newly minted coins], the primary purpose of mining is not the reward or the generation of new coins. If you view mining only as the process by which coins are created you are mistaking the means (incentives) as a goal of the process. Mining is the main process of the de-centralized clearinghouse, by which transactions are validated and cleared. Mining secures the bitcoin system and enables the emergence of network-wide consensus without a central authority.[54]

In other words, from a perspective that takes seriously the algorithmic operations that constitute the Bitcoin architecture – that is, an allagmatic perspective – mining is the *medium* through which the production and distribution of the p2p values is achieved throughout the network, and not the endgame.

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[50] For a recent update see: Jordan Tuwiner, "Bitcoin Mining Centralization," *Bitcoin Mining*, May 12, 2016, https://www.bitcoinmining.com/bitcoin-mining-centralization/.
[51] The mining metaphor comes from Nakamoto him/her/themselves. As explained in the Bitcoin white paper, the activity of validating transactions and unlocking new coins is analogous to "gold miners expending resources to add gold to circulation." Nakamoto, "Bitcoin," 4.
[52] Bill Maurer, Taylor C. Nelms, and Lana Swartz, "'When Perhaps the Real Problem is Money Itself!': The Practical Materiality of Bitcoin," *Social Semiotics* 23, no. 2 (2013): 269.
[53] Ibid., 274.
[54] Antonopoulos, *Mastering Bitcoin*, 178.

Undoubtedly today Bitcoin has become the emblem of "distributed capitalism,"[55] as I will further discuss below, testifying to the limits of technological determinism but also challenging the assumptions about decentralization. In other words, it proved that decentralization alone is not enough for the realization of equitable platforms. Yet in spite of the ideologies associated with cryptocurrency, the heterogeneity of the current experimentations with permissionless blockchains and alternative networks, some of which I will discuss in more detail in the next chapter, testifies to Bitcoin's radical indeterminacy in regard to its political orientation – that is, it proves the autonomy of technics in relation to political structures. The Bitcoin blockchain has also been critiqued for its connections with illegal activities, its lack of a clearly defined internal governance structure, its scalability problems, and its lack of resistance to centralization tendencies. Yet in spite of such weaknesses, the Bitcoin network has demonstrated extraordinary resilience and resistance to attacks.[56] While the connection with illegal activities is a problem – albeit determined by external factors and not endogenous to the data structure and architectural principle of the network – this chapter insists that the governance system engendered by Bitcoin is a positive example of the emergent properties of the Bitcoin network.

In addition to this, the Bitcoin blockchain demonstrates the importance of the monetary aspect in the context of social organizations. Or put differently, it demonstrates the fact that organizations need a system of incentives in order to function. Today, financial incentives are predominant in the contemporary power configuration, which is mapped onto the financial economy. Yet, as will be clear in the following section, my point is that economic incentives do not necessarily need to be based on individualistic utilitarian parameters such as price and capitalization. While the incentive structure of the Bitcoin network has been rightly critiqued for the weaknesses hardcoded in the protocol, along with the practice of mining for its environmental costs, its protocol still has import for the constitution of collaborative platforms. In order to illustrate this, in the next section I will suggest a conceptual exercise of separation between the value immanent to Bitcoin as a monetary technology, and the exogenous price it has acquired through its subsumption into the financial system.

[55] See: Vasilis Kostakis and Michel Bauwens, *Network Society and Future Scenarios for a Collaborative Economy*, ebook (Basingstoke: Palgrave Pivot, 2014).
[56] See: Valdes, Furlonger, and Chesini, "The Bitcoin Blockchain: The Magic and the Myths."

7.5 The *Nomos* of Code: The Metaphysics of Price and the Value of Bitcoin

As I explained in the introduction, this project starts from the assumption that money is first and foremost a social machine, as it is assumed to be in the trajectory opened by Georg Simmel.[57] Furthermore, as we saw, the etymology of the term 'money' implies a mnemo-technical function that distances it from contemporary financial utility.[58] From this standpoint, every monetary technology – as a *medium* of exchange and a unit of account – already reflects a certain accountability. However, with the addition of the function of store of value to the monetary architecture and its conflation with price, fiat money has become the means for the quantification and capitalization of the imponderable risk inherent in economic exchange. From this standpoint, as I described in chapter two and three following Massimo Amato and Luca Fantacci's argument, accounting loses its accountability, allowing financial capitalism to progressively extend its reach in a horizontal movement to encompass more and more aspects of the world.

For the first time in three centuries, Bitcoin troubles these assumptions. Being, architecturally, an actual blockchain – an open ledger that registers, in blocks, only the positive transactions that occur in it – Bitcoin is a bookkeeping system with only one column; it knows nothing of debt. Bitcoin proceeds only forward (and sometimes laterally, as it happens with forks and orphan chains). In addition to this, Bitcoin's incentive structure is hardcoded but also open-source. As described above, the blockchain offers a transparent and decentralized way of verifying and validating transactions without the need of any central authority. Further, the network of 'miners' guarantees the security of the ecosystem, while the Bitcoin code modulates the amount of wealth that can be circulated. In truth, it testifies to an economy of excess, rather than scarcity – in spite, or perhaps precisely because of, its limited supply.

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[57] Georg Simmel defines money "a pure means and tool in relation to a given end." Georg Simmel, *The Philosophy of Money*, ed. David Frisby, trans. Tom Bottomore and David Frisby (New York: Routledge, 2004), 211.

[58] Bernard Stiegler, "Anamnesis and Hypomnesis: The Memories of Desire," in *Technicity*, ed. Arthur Bradley and Louis Armand (Prague: Litteraria Pragensia, 2006), 15–41. On this topic, see also: Massimo Amato and Luca Fantacci, *The End of Finance* (Cambridge: Polity, 2011), 242–52.

This, as I explained in chapter three by drawing on Ole Bjerg,[59] provides Bitcoin with unique features: Bitcoin is scarce, like gold, but has no materiality that would endow it with an intrinsic value; further, its value is shared but cannot be determined by fiat because of its decentralized nature. Bitcoin is, by design and definition, a *medium* and a *measure* but not a store of value. In Nakamoto's white paper, there is no mentioning of an 'economic value' of Bitcoin but only of 'hash value' – that is, the result of a calculation performed by a cryptographic algorithm (in the case of Bitcoin, SHA-256 applied twice, as described above) in order to assign a unique value to each transaction and avoid the double-spending problem – or in other words, in order to timestamp the data involved in a block of transactions through a proof-of-work. Bitcoin realizes its 'economic value' only in the moment in which it loses it, by inscribing a price in the blockchain and liberating the transfer of goods and services. In other words, Bitcoin's value is not 'stored' anywhere but concretely emerges from the systemic dynamics of the network, through the recognition of and participation in a shared worldview encoded in the blockchain. Thus, for the first time, Bitcoin turns money into a commons, as Denis Roio remarks.[60] Bitcoin's value is purely technical – or better, algorithmic.

In regard to the decentralized character of Bitcoin, Michel Bauwens explains that p2p networks introduce an open infrastructure that allows for: transparency, participation, open access, shareability, and the ability to fork.[61] These features, following Simondon, constitute the "technical normativity" introduced by the invention of Bitcoin:

> Technical normativity modifies the code of values in a closed society … Each society that, by admitting a novel technics, introduces values inherent to that technic, operates at the same time a structuration of its code of values.[62]

[59] Ole Bjerg, "How Is Bitcoin Money?," *Theory, Culture & Society* 33, no. 1 (2016): 53–72.
[60] Roio, "Bitcoin, the End of the Taboo on Money," 8.
[61] Robin Good, "P2P and Open Infrastructures: The Society of Openness Comes of Age," *Robin Good's Master New Media*, October 26, 2010, http://www.masternewmedia.org/p2p-and-open-infrastructures-the-society-of-openness-comes-of-age/.
[62] Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 341.

As I already observed, for Simondon a technical invention, such as Bitcoin, possesses a normativity, which is "intrinsic and absolute"[63] and that alone instantiates change in collective and individual values and exigencies. It is then up to socio-economic factors to establish whether to take up the invention and welcome it into their community. The technical normativity of Bitcoin – its technical value – resides in the capacity to create an internal incentive structure immanently connected to a flat power structure, that allows for the emergence of a distributed, transparent, and open network characterized by a common orientation. The Bitcoin flat topology activates a mode of collective participation based on incentives that are coterminous with the nodes themselves, and not based in the global neoliberal market. As Lawrence Lessig put it, on the Internet, "code is law."[64] However, the example of Bitcoin testifies to the fact that different algorithmic architectures can create different normative structures. From this standpoint, one can understand the law of code in terms of Deleuze and Guattari's remark on the *nomos* – that is, "a very special kind of distribution, one without division into shares, in a space without borders or enclosure."[65] As I explained in chapter two, the birth of technology marks the passage to an economic reality. While capitalism has been so far the prevalent mode of economic 'distribution' through its alliance with mechanist technology, the *nomos* of digital networked objects offers the possibility to establish an entirely different economy.

Looking at money as an elementary technology provides the conceptual means to think money apart from its current, capitalist form; importantly, it allows one to divorce the technical value of money from its current equivalence with price. Jon Roffe, whose theory of the market I have discussed in chapter four and five, provides a minimal definition of value that is able to grasp the multifaceted nature of this term and at the same time distinguish it from price.[66] Drawing on Elie Ayache, Roffe argues that prices are meaningless signs – intensive quantities – inscribed in the surface of the market that bear no relation to anything beyond the market itself. Values are instead qualitative and predispositional features of social reality, meaning that "values always instantiate a particular *orientation* toward the world, functioning in the present by ordering *projected*

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[63] Ibid.
[64] Lawrence Lessig, *Code. Version 2.0* (New York: Basic Books, 2006).
[65] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), 380.
[66] Jon Roffe, *Abstract Market Theory* (Houndmills: Palgrave Macmillan, 2015).

futures on the basis of a selective construction of the past."[67] In other words, while prices are "quanta of the real"[68] – events in and of the market – values are coded flows (in Deleuze and Guattari's vocabulary) – absolute qualities with the capacity to orient, or direct, social life by ordering the future on the basis of past information. Yet under the techno-cultural system known as capitalism, Roffe explains, the market becomes the "surface of the social,"[69] resulting in the retroactive recording of prices as "the unconscious of the social"[70] – that is, as value systems. This is similar to what I have illustrated in the previous chapter via the discussion of algorithmic trading. Through the insertion of spatiotemporal key points in the axiomatic of signification of living systems, the computational events that correspond to the individuation of price impact psycho-collective formations in imperceptible ways.

As illustrated above, the novelty of the Bitcoin stack – as an economic and organizational metamodel – shook the foundations of finance and markets precisely by exiting the logic of pricing; instead, it shifted the focus onto the formal architecture of monetary and social flows by establishing a new operative logic of value creation encoded in the blockchain. In other words, what enabled the infant Bitcoin project to jumpstart is that it was, quite literally, priceless; or at most, its price was determined by its very material electricity costs.[71] While the determination of the Bitcoin price is beyond the scope of this thesis, and irrelevant to an understanding of its technical value, what is important to note is that the monetary incentives of the Bitcoin ecosystem were oriented toward the larger values underlying the p2p network – decentralization, transparency, resilience – and not pegged to quantitative prices determined by financial speculations (that is, established by fiat in the market of commodities). From this standpoint, what initially made Bitcoin work as a commons was the fact that the managing of the communal resources was moved by the circulation of the values afforded by the technology itself, and not by prices or exchange rates.

[67] Ibid., 26–27 (emphasis added).
[68] Ibid., 69.
[69] Ibid., 98.
[70] Ibid., 151.
[71] See: LibertyStandard 2009 in Peter Šurda, "Economics of Bitcoin: Is Bitcoin an Alternative to Fiat Currencies and Gold?" (Diploma Thesis, WU Vienna University of Economics and Business, 2012), 41, http://dev.economicsofbitcoin.com/mastersthesis/mastersthesis-surda-2012-11-19b.pdf.

7.6 Enabling Constraints: Coding Incentives, Freeing Values

Put differently, the incentive structure inbuilt in the mining process – the efforts as much as the benefits that derive from it – constitutes the "enabling constraints" that have allowed the Bitcoin ecosystem to take consistency as a platform for relations of exchange.[72] Brian Massumi defines enabling constraints as:

> …sets of designed constraints that are meant to create specific conditions for creative interaction where something is set to happen, but there is no preconceived notion of exactly what the outcome will be or should be. No deliverable. All process.[73]

Enabling constraints allow for the taking-consistency of open-ended experiments in modes of organization – "'enabling' because in and of itself a constraint does not necessarily provoke techniques for process, and 'constraint' because in and of itself openness does not create the conditions for collaborative exploration."[74] They are processual technics of relation and could be understood, following Simondon, as 'modulative relays' – "technical structures that correspond (in the 'allagmatic' way) to the operation of modulative amplification, which enables information as the particular regime of causality distinct from mechanical causality."[75] In other words, like modulative amplification, enabling constraints are limits that, through negative feedback, provide the means for the dynamic emergence of an allagmatic organization.

In management theory, incentive schemes "represent mechanisms that seek to influence the behavior of the intended recipient in ways determined by the designer of the

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[72] Erin Manning and Brian Massumi define a platform for relation as follows: "A platform for relation is a setup, system, or set of procedures that is already tendentially operative, but rather than affording a specific function at first approach, is more suggestive of it. A platform for relation does work, it embodies a certain technicity, but it is designed in such a way that the limits and parameters of its potential functioning are not readily apparent." Thinking about the Bitcoin protocol in these terms provides the means to grasp its emergent features and its immanent openness to experimentations, as the heterogeneity of the current blockchain ecosystem testifies to. Erin Manning and Brian Massumi, *Thought in the Act: Passages in the Ecology of Experience* (Minneapolis: University of Minnesota Press, 2014), 101.

[73] Joel McKim, "Of Microperception and Micropolitics: An Interview with Brian Massumi, 15 August 2008," *Inflexions: A Journal for Research-Creation*, no. 3 (October 2009): 15.

[74] Manning and Massumi, *Thought in the Act*, 94.

[75] Gilbert Simondon, *Communication et Information: Cours et Conférences*, ed. Nathalie Simondon and Jean-Yves Chateau (Chatou: Éditions de la Transparence, 2010), 28.

scheme,"[76] according to the design of either internal or external motivation. Traditionally, incentives are designed by taking into account the relation between rewards and evaluation.[77] The evaluation parameters are outlined first, in order to design suitable reward schemes. However, in the capitalist ecosystem, value – and by extension evaluation parameters – becomes subsumed into pricing mechanisms, as I have explained above following Jon Roffe. Similarly, while the rewards inbuilt into Bitcoin have remained invariant, the evaluation process determining the magnitude of Bitcoin's incentive structure has become progressively reoriented toward price – evidence of the persistence of the sense of capitalist power in the emerging Bitcoin ecosystem. As a matter of fact, with the rise of MtGox[78] – the first Bitcoin exchange – and the increasing interest by Silicon Valley's venture capitalists, the value system Bitcoin was weaving around its technology became overridden by pricing mechanisms.[79] This happened through large-scale marketing operations that aimed to increase the adoption of Bitcoin not as a currency but as a store of value – precisely like gold – although Bitcoin's track record shows that the market 'value' of Bitcoin is in fact very volatile. This process, started in 2012, marks the moment in which Bitcoin officially became the *object* of a market (that is, a commodity) before it became the *medium* for a market to exist. Ironically, the most successful example of the use of Bitcoin as a medium of exchange is to be found in the now defunct drug crypto-haven Silk Road.[80] As mentioned above, this is in stark contrast with the admittedly paranoid

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[76] John Martin, *Key Concepts in Human Resource Management* (London: SAGE, 2010), 149.
[77] Michael Gibbs, "Designing Incentive Plans: New Insights from Academic Research," *WorldatWork Journal* 21, no. 4 (2012): 29–47.
[78] Based in Tokyo, MtGox was the first global platform that offered the possibility to buy Bitcoin through national fiat currency, thereby initiating the financialization of Bitcoin in 2010. Given the monopolistic role that MtGox played, it was instrumental in the skyrocketing of the price of Bitcoin, until it was hacked and had to file for bankruptcy in 2014. In spite of the decentralized nature of Bitcoin, MtGox reproposed the centralized model of financial exchanges. One of the most fervent advocates and promoters of Bitcoin was Roger Ver who, as early as 2011, started a massive marketing campaign for Bitcoin, contributing to bringing the cryptocurrency to global awareness. See: Nathaniel Popper, *Digital Gold: Bitcoin and the Inside Story of the Misfits and Millionaires Trying to Reinvent Money* (New York: Harper, 2015), 76, 127–28.
[79] Popper, *Digital Gold*.
[80] Silk Road was an online marketplace based on the Dark Web (thus only reachable through the Tor browser) that allowed anonymous parties to deal drugs in exchange for Bitcoin. It was founded by Ross Ulbricht in 2010, who was inspired by the libertarian writings of Ludwig von Mises. As Nathaniel Popper reports, Ross Ulbricht's intent was to "creat[e] an economic simulation to give people a first-hand experience of what it would be like to live in a world without the systemic use of force" (ibid., 70). Carnegie Mellon economics professor Nicolas Christin reportedly stated that, "Silk Road doesn't really sell drugs. It sells insurance and financial products … It doesn't really matter whether you're selling T-shirts or cocaine. The business model is to commoditise security." Andy Greenberg, "The Dread Pirate Roberts: Internet's Multimillionaire Druglord," *Forbes India*, September 26, 2013, http://forbesindia.com/article/cross-border/the-dread-pirate-roberts-internets-multimillionaire-

cypherpunk values of trustlessness, privacy, and emancipation from centralized powers in which the genealogy of Bitcoin is rooted – evidence of the autonomy of technics and technology from its origin but also of the possibility of its further repurposing.[81]

In other words, the Bitcoin blockchain testifies to the importance of the monetary aspect within social organizations, demonstrating that organizations need to be based on a system of internal incentives in order to function, especially on a large, global scale. The absolute normativity of the Bitcoin technology consists in the fact that the creation and circulation of value in common is achieved through direct participation in the network. In contrast to this, in neoliberal capitalism the evaluation process has been overcoded by the event of price. Bitcoin's system of incentives is still based on individual economic rewards; however, the challenge for a commons-based blockchain is to design an incentive structure whose rewards are founded on the evaluation of both the efforts and contributions of every node of the network in accordance with the p2p values identified by Bauwens. Additionally, the incentive scheme of such a commons-based blockchain would also need to prevent the folding back onto the neoliberal metric of value *par excellence* – that is, price. This entails the careful design of an incentive structure that, on the one hand, would move beyond economic utilitarian value (that is, price) and, on the other hand, would eschew the logic of 'value storing' characteristic of the contemporary monetary architecture in order to acknowledge other kinds of values – such as psychological, social, and ecologic 'profitability,' as Félix Guattari puts it.[82]

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druglord/36181/3#ixzz2galPpfe0'. See also: Joshuah Bearman, "The Untold Story of Silk Road, Part 1," *WIRED*, April 28, 2015, http://www.wired.com/2015/04/silk-road-1/.

[81] In *Crypto* Steven Levy uncovers the intertwined origins of the Internet, modern cryptography, and digital money. The 'democratization' of cryptography started in the late 1970s with Whitfield Diffie and Martin Hellman's discovery of public key cryptography. It was largely promoted by the "cryptoactivism" of libertarian fringes, epitomized by figures such as Phil Zimmerman, inventor of Pretty Good Privacy, and Eric Hughes and Tim May that, in 1988, published the Crypto Anarchist Manifesto. Steven Levy, *Crypto: How the Code Rebels Beat the Government Saving Privacy in the Digital Age* (New York: Penguin Books, 2002), 187–225. See also: Timothy C. May, "The Crypto Anarchist Manifesto," *Activism: Cypherpunks*, November 22, 1992, http://www.activism.net/cypherpunk/crypto-anarchy.html.

[82] I have already cited this passage from *The Three Ecologies* in the opening of chapter two. It is worth reproducing it here at length, given the affinity of Guattari's thought with the commons-based blockchain project I am discussing, and the relevance of this observation for an analysis of the present juncture: "I have already stressed that it is less and less legitimate that only a profit-based market should regulate financial and prestige-based rewards for human social activities, for there is a range of other value systems that ought to be considered, including social and aesthetic 'profitability' and the values of desire. Until now, these non-capitalist domains of value have only been regulated by the State; hence, for example, the esteem in which national heritage is held. We must stress that new social associations – such as institutions recognized for their social utility – should broaden the financing of a more flexible non-private, non-public Third Sector, which will be forced to expand continuously for as long as human labour gives way to machinization. Beyond recognizing a universal basic income – as a right rather than

In order to move beyond the paradigm initiated with the introduction of fiat money – that is, the system that relies on the function of money as store of value and postulates liquidity as the "architectural principle"[83] of the financial infrastructure, as I discussed in chapter four – Amato and Fantacci propose to divorce money from credit, and replace the architectural principle of liquidity with a principle of clearing inspired by the International fairs of the Renaissance and Keynes's proposal for the Bancor at Bretton Woods in 1944. Importantly, the principle of clearing gives primacy to the settling of the relations of credit instead of treating credit as an object, a thing, to be traded for a price. Materially, this implies the redesign of the system of accounting and of money itself. For Amato and Fantacci, the problem of the contemporary financial system is precisely that money is a liquid commodity, which can be traded almost seamlessly through digital networks of exchange.

As the volume of electronic transactions keeps increasing, overtaking cash payments,[84] an important distinction needs to be made between money-as-cash, or banknotes, and money-as-credit, or liquidity, such as the money that we commonly use each time we effectuate cashless, electronic transactions (e.g. to pay bills via online banking, rent, mortgages, tuition fees, superannuation, etc.). Liquid money – that is, the money that is today created, measured, traded, and circulated by digital networked systems – is essentially a commodity on par with other liquid assets such as stocks and bonds, an immaterial store of value. By contrast, cash such as banknotes predominantly fulfills the function of money as a medium of exchange, which is not a commodity to be exchanged for another price, but a token that allows for the 'inscription,' or recording, of transactions and subsequent circulation of other commodities. In other words, commodity, or credit, money is subjected to the category of price, as well as being a *medium* for the inscription of price.[85]

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as some kind of 'New Deal' – the question becomes one of how to encourage the organization of individual and collective ventures, and how to direct them towards an ecology of resingularization." Félix Guattari, *The Three Ecologies*, trans. Ian Pindar and Paul Sutton (London: The Athlone Press, 2000), 64–65.

[83] Amato and Fantacci, *The End of Finance*, 224.

[84] Kevin Peachey, "Cashless Payments Overtake the Use of Notes and Coins," *BBC News*, May 21, 2015, http://www.bbc.com/news/business-32778196.

[85] In the current configuration, hard cash is a token printed by a Country's central bank that stands for an "interest-free government borrowing." See: Tyler Durden, "What A Cashless Society Would Look Like," *Zero Hedge*, January 31, 2016, http://www.zerohedge.com/news/2016-01-31/what-cashless-society-would-look. Because it is not directly linked to any account, cash is free to circulate and can be used

Because money becomes liquidity through what Amato and Fantacci call a "legal fiction"[86] – that is, an institutive act – the authors propose to counter this fiction through a series of institutional reforms to be coordinated at a global level. Such reforms would proceed through the re-establishment of distinctions in the functions of money, in order to counter the 'agnotological' maneuvers that, as we saw, have blurred the differences between money, credit, and liquidity, thus contributing to the structural opacity of the financial ecosystem. Further, Amato and Fantacci suggest a form of finance modeled upon Islamic finance, in which relations of credit are not incentivized by an 'interest' measured in price, but instead fostered through a 'common interest' between both creditor and debtor in the success of the enterprise. In order to achieve this, Amato and Fantacci propose to abandon "the bookkeeping artifice"[87] of so called fair value and instead shift to a logic based on cost and revenue accounting. Put differently, they suggest a move from a logic of fictional value to a logic of concrete pricing that can only be defined a posteriori.[88] This way money would fulfill its functions as a means to facilitate exchange, and a measure of the value of the exchanged commodities, without having to become a store of value itself.[89]

In other words, Amato and Fantacci envision a system that, through the imposition of a series of constraints onto the monetary architecture, would 'free' values from their monetary support and enable the taking-consistency of a market economy that is radically different from the capitalist-neoliberal one. Massimo Amato did implement such a system in Nantes in 2011; a 'valueless money' that he calls "eutopic money" – a

anonymously – that is, each bearer that enters in possession of a banknote can use it. 'Liquid money' instead – the kind of money discussed by Amato and Fantacci – corresponds to the money deposited in 'current accounts' and exchanged in financial markets. Because liquid money is inherently electronic, it is immediately traceable back to an owner. Furthermore, its usage can be controlled by banks at will, without deposit owners' permission, as it happened in Greece in June 2015 before the bailout referendum. One of the merits of Bitcoin is that it renewed the attention on the differences between hard cash and electronic money that have been taken for granted for at least the last thirty years. I will go back to these issues in the concluding remarks of this thesis.

86 Amato and Fantacci, *The End of Finance*, 244.

87 Ibid., 248.

88 As I explained in chapter five, the issue with contemporary bookkeeping practices is that it allows one to account for credit and future yields as present 'liquid assets,' on the basis of 'evaluation practices' that are often biased and aim to inflate the capitalization of a company for the purpose of power. Instead, the logic of costs and revenues to be calculated a posteriori, as suggested by Amato and Fantacci, would prevent such inflationary maneuvers and reflect a company's actual worth.

89 Amato and Fantacci, *The End of Finance*, 242–52.

currency that is eminently local and closely circular.[90] Although remarkable, I believe that Amato and Fantacci's design proposal may be hard to achieve through an institutional act, given the vested interests of all the parties involved at a global level in keeping with the status quo. My proposition is that the Bitcoin protocol, with its focus on an internal, self-reflexive incentive scheme, may provide the means for the emergence of truly distributed networks, functionally defined on the bases of their common interests and values. Thus, instead of a 'eutopic money,' Bitcoin could allow for the concretization of a 'heterotopic money' – a money for spaces of otherness, which works in non-hegemonic conditions and realizes its value the moment in which it extinguishes it.[91] According to Amato and Fantacci this could be achieved only by replacing liquidity, as the architectural principle of the contemporary monetary and financial structure, with a principle of clearing that would give primacy to the settling of relations of debt and credit instead of monetizing and financializing them prior to their expiration. Central to this is a reconceptualization of money and its values that do not need to be necessarily conflated with price. This is because the clearing mechanism gives primacy to the function of money as a tool for *accounting* and as a *medium* for the exchange of goods and services. I will come back to these issues in the following chapter when I illustrate how the core design principles of the Bitcoin stack can enable the emergence of such a system.

7.7 The Politics of Money: Ontological Design and Speculative Engineering

To sum up, the original Bitcoin stack introduced a radically novel approach to the creation and distribution of value, which consists in the coupling of a flat power architecture, in which all nodes 'count' the same, with an internal incentive structure in which incentives are coterminous with the nodes themselves and eschew the capitalist mechanics of price. Further, Bitcoin upends the logic of derivatives, replacing the process of reification of value through recursion with an operatory schema in which recursion is *functional* to the transductive process of the taking-consistency of a Bitcoin

[90] Massimo Amato, *La Monnaie Eutopique*, TEDxNantes (Nantes, 2011), http://tedxtalks.ted.com/video/TEDxNantes-Massimo-Amato-La-Mon.
[91] Michel Foucault, "Of Other Spaces: Utopias and Heterotopias," trans. Jay Miskowiec, *Architecture / Mouvement / Continuité*, October 1984.

transaction.[92] This is achieved through a complex process of mining, which consists in two fundamental aspects: the PoW algorithm, which testifies to the effort sustained by the winning mining node to validate a block, and the Byzantine Generals consensus, which allows for the emergence of a trusted network from unknown participants. Yet while mining *per se* is the key activity that allows the network to maintain its distributed character through participation instead of violence, as Roio remarks, both PoW and Byzantine consensus have been highly critiqued – and rightly so – due to their environmental, social, and economic costs, and to the lack of resistance to the rhythms imposed by hardware manufacturers on the mining process. Furthermore, the binary logic of the Nakamoto consensus is ill-equipped for the realization of healthy democracies, as O'Dwyer observes.

In spite of these downsides, and in light of the wealth of experiments with cryptocurrency and blockchain technology, as discussed above, my argument is that governance-by-design is not only possible but also necessary. *Contra* the doomsday scenarios depicted by Rouvroy and Pasquale, this chapter insists on a more nuanced understanding of the different kinds of normativity that can be instantiated by different kinds of 'codes.' In other words, the promise of the blockchain as an infrastructure for distributed commons lies in the suggestion of an immanently participative and generative architecture, in this case found in the mining process. The challenge, from this standpoint, consists in leveraging Bitcoin's design principle, while at the same time overcoming the limitations of Bitcoin's PoW algorithm and Nakamoto consensus. This means that incentives need to not be monetizable, or perhaps they need to be monetizable differently, which entails first of all the identification and formulation of a combination of rewards and constraints that would reflect the common interest of a group of individuals beyond the current logic of social-financial networks. As Hui and Halpin observe in the context of social networks design:

> A collective social networking is possible, and is one based on the revealing of ourselves and our being-in-the-world-with-others, the 'group' based around a common project or calling. A project is also a projection,

[92] As I explained in chapter three, this is because in the Bitcoin protocol the money-token directly emerges from the network dynamics and does not pre-exist them. In contrast, fiat money has existed in the material form of paper before being digitalized in the last thirty years.

> that is, the anticipation of a common future of the collective individuation of groups. … By projecting a common will to a project, it is the project itself that produces a co-individuation of groups and individuals.[93]

A commons is first and foremost a social enterprise; therefore these remarks resonate particularly in the context of the design of collaborative platforms that, as discussed above, already possess "open standards that are based on this conception of groups"[94] such as permissionless blockchains. Furthermore, Hui and Halpin observe that "the only successful examples of alternative digital social networks are ones that integrate a collective functionality for grassroots political projects."[95] Yet the vicissitudes of grassroots political projects, such as Occupy, also testify to the fact that political emancipation must take into account an economic component for their long-term sustainability.

Looking at money as a technology allows one to grasp its immediately political dimension. As Amato and Fantacci put it: "Money can only exist within a clearly defined political space. Money is a tool of autonomy in the dual sense of demanding it and strengthening it."[96] Therefore, its design needs to provide the means for opening up new spaces of possibility for a clear and transparent redefinition of political and economic responsibility. Acknowledging the political dimension of the value of money also means acknowledging the fact that money always belongs to a clearly defined community of exchange, of which money reflects the values and needs. This means recognizing the singularity of economic relationships that don't need to be necessarily rooted in territorial boundaries but could be also *functionally* defined (both at supra- and at infra-national level), and made *complementary* with one another, instead of giving rise to antagonistic relations – such as in the case of the Eurozone, due to a unique generalized currency.[97] What is needed, from this standpoint, is a common project, which implies the definition of the political orientation of *a* money within a clearly defined social space, along with a *projection* onto alternative universes of value.

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93 Yuk Hui and Harry Halpin, "Collective Individuation: The Future of the Social Web," in *Unlike Us Reader: Social Media Monopolies and Their Alternatives*, ed. Geert Lovink and Miriam Rasch (Amsterdam: Institute of Network Cultures, 2013), 115.
94 Ibid.
95 Ibid., 112.
96 Amato and Fantacci, *The End of Finance*, 250.
97 Ibid.

In light of the vast body of literature and examples taken into consideration in this chapter, my conclusion is twofold. On the one hand, the discussion suggests that there may be not just one kind of algorithmic governmentality; or better, that algorithmic governmentality can, and must, be harnessed, in order to design equitable systems precisely by leveraging the objectivity and transparency of data at the center of Rouvroy's critique. On the other hand, this chapter showed that governance-by-design is not only possible, but also necessary. However, first and foremost this needs to entail a form of 'ontological design' as Terry Winograd and Fernando Flores put it.[98] As they observe:

> The most important designing is *ontological.* It constitutes an intervention in the background of our heritage, growing out of our already existent ways of being in the world, and deeply affecting the kinds of beings that we are. In creating new artifacts, equipment, buildings, and organizational structures, it attempts to specify in advance how and where breakdowns will show up in our everyday practices and in the tools we use, opening up new spaces in which we can work and play. Ontologically originated design is therefore necessarily both reflective and political, looking backwards to the tradition that has formed us but also forwards to as-yet-uncreated transformations of our lives together. … The designing process is part of this 'dance' in which our structure of possibilities is generated.[99]

Ontological design can only be achieved through a veritable invention – such as the Bitcoin protocol that, by operating a reversal in the logic of recursion and reification, and creating a system of internal, reflexive incentives paired with a flat power structure, has introduced a novel logic of collective individuation. This has opened up unprecedented possibilities for the design of governance structures through a novel approach to money – an ontological kind of design. This may lead to a practice of

[98] Terry Winograd was the mentor of Google's founder Larry Page, while Fernando Flores was the former finance minister of Salvador Allende. The Invisible Committee, *To Our Friends*, trans. Robert Hurley (South Pasadena: Semiotext, 2015), 109. Both Google and Project Cybersyn before it – the cybernetic system of management of the Chilean economy devised by Stafford Beer under Allende in the 1970s but never implemented – certainly constitute two interesting examples of ontological design. See also: Eden Medina, *Cybernetic Revolutionaries: Technology and Politics in Allende's Chile* (Cambridge: The MIT Press, 2014).
[99] Winograd and Flores, *Understanding Computers and Cognition*, 163 (emphasis in original).

speculative engineering of modes of organization that acknowledge the heterogeneity of the values produced by relations of exchange, by which I mean the open-ended metamodeling of new forms of relation for collective formations, that I will further explore in the next chapter in relation to the cultural plane. However, for governance-by-design to be effective in the realization of blockchain-based collaborative networks, it needs to hardcode a system of enabling constraints that would orient the emergence and direction of a platform for relation toward a common project – not only in terms of rewards but also in terms of the efforts sustained for the achievement of the common goal. This entails the design of a dynamic internal incentive structure that would replace financial value with social and cultural utility beyond capital accumulation. This would provide the means to free values from the monetary support and let them circulate in a community through *trans*-actions – that is, transductive exchange.

The plethora of blockchain-based projects currently in development testifies to the metastability immanent to the Bitcoin ecosystem. In spite of the critiques advanced with regard to the alleged ideological foundations of Bitcoin, the heterogeneity of blockchain experiments shows that technology and politics are in a dynamic relation of co-structuration. As Gilbert Simondon puts it: “It is within the perspective of permanent change of technical and socio-political structures that technical thought and socio-political thought can coincide.”[100] In other words, in order to direct the emergence of collective platforms toward truly distributed and collaborative systems, focusing solely on design implementations is not sufficient to exit the contemporary algo-financial paradigm. Instead, there needs to be an a priori project(ion) based on a specific political orientation that would be reflected in the internal process of creation and distribution of wealth, but that would also dynamically accommodate the normative novelty of the blockchain. As Hui and Halpin suggest, projection entails the steering of perception and awareness.[101] In the next chapter I specifically focus on the possibilities offered by the blockchain for the activation of distributed networks aimed to encourage cultural experiments in light of the homogenizing effect of the neoliberal mode of organization and control that characterizes contemporary cultural production. Although much work has to be done in this direction, my wager is that the participation in such networks may further translate into a renewed political awareness and empowerment.

[100] Simondon, *Du Mode*, 231.
[101] Hui and Halpin, “Collective Individuation: The Future of the Social Web.”

Bitcoin is dead, long live Bitcoin. While the Bitcoin experiment may indeed have resolved with a victory for venture capitalists and algo-traders,[102] its 'code' – both in terms of the open-source software available on GitHub and in terms of the absolute normativity that derives from the processes of value creation and distribution inbuilt in the protocol – may provide an *invaluable* starting point, quite literally, for the realization of distributed, equitable, and sustainable ecosystems, not only economic, but also cultural, social and ecologic. It remains to be seen whether the development of cryptocurrency, in experimenting with open-ended approaches to the technology at our disposal, represents a true departure from the predictive mechanist paradigm discussed in the previous chapters of this thesis. Ultimately, its potential lies in a newfound 'common sense,' a '*sense* of the commons' achieved in cooperation with technologies rather than in antagonism or separation that, as I explained in the previous chapter and will further discuss in the following, can only be achieved via a *trans*-gression from the necessity of teleological progress and of interindividual societal relations: a transindividuation. As Simondon observes: "isn't it that all creation is a transgression?"[103]

[102] See: Mike Hearn, "The Resolution of the Bitcoin Experiment," *Medium*, January 14, 2016, https://medium.com/@octskyward/the-resolution-of-the-bitcoin-experiment-dabb30201f7#---262-344.puwe6jpse.
[103] Gilbert Simondon, "Sauver l'Objet Technique (1983)," in *Sur La Technique: 1953-1983* (Paris: Presses Universitaires de France, 2014), 449.

8. Artful Blockchains and Algo-Financial Power: From the Automation of Art's Value to the Autonomy of Techno-Aesthetics

Axiom of inclusion: whatever is of the market is pertinent to the philosophy of the market – Jon Roffe[1]

If the value-process were reducible to the labor-process, or vice versa, then both art and inflation would be impossible – Julieta Aranda et al.[2]

Ultimate unit is aesthetic *– Gregory Bateson*[3]

8.1 Art, Finance, and Technics

Chapter five and six illustrated that algorithmic finance possesses a power of social and aesthetic ordering, which lies in the operatory analogy between the computational operations of reification and recursion and the logic of derivatives, and in their amplification to the psycho-collective sphere. From this standpoint, making sense of this mode of power requires going beyond the limits of representation and instead entails a direct engagement with the techno-social milieu in order to grasp the 'feel' of algorithmic operations in their unfolding. Chapter seven further elucidated the real novelty of the Bitcoin architecture: a flat power topology coupled with an internal self-reflexive incentive structure that, together, allow for the emergence of a new logic of value creation and distribution – that is, a new rhythm to the process of information within the socio-economic ecosystem. Following this trajectory, this chapter proposes that the best way to understand how the axiontology of contemporary power is deployed in the collective sphere is through its relation to culture, in particular contemporary art. If it is true, as chapter six suggested, that art is the field most attuned to the techno-aesthetic feel of the imperceptible algorithmic operations that structure the current axiomatic of power, this chapter aims to test the extent to which art may be able to establish a *new* sense of power.

[1] Jon Roffe, *Abstract Market Theory* (Houndmills: Palgrave Macmillan, 2015), 150.
[2] Julieta Aranda et al., "Editorial," *E-Flux*, no. 70 (February 2016), http://www.e-flux.com/announcements/new-issue-new-editor-new-book/.
[3] Gregory Bateson, *Mind and Nature* (London: Fontana Paperbacks, 1980), 28.

The heterogeneity and indeterminacy of contemporary art – in terms of aesthetics, media, more or less explicit social and political orientation, economic worth, and institutional involvement – has allegedly become the genre-defining feature of today's cultural sphere.[4] While a discussion of the ontology of art is not the main goal of this chapter, I believe it is important to start from a definition of the object of enquiry, albeit a partial and arbitrary one, before moving on to the investigation of the relations between art and the logic of algorithmic finance. In this context too, Gilbert Simondon provides important conceptual tools to define the function of art. Although he never formulated a comprehensive theory of either art or aesthetics, Simondon's philosophy is particularly relevant to the scope of this chapter. As Ludovic Duhem observes, Simondon's thought on art and aesthetics "does not appear as a theme to be developed, but as a *problematic* to be solved, inasmuch as it constitutes a tension internal to Simondon's own work."[5] Simondon abandons the ontological privilege traditionally granted to art and instead relativizes it within his theory of the phases of culture, developed in the third part of *Du Mode*.[6] Here he focuses instead on the role of "aesthetic thought." Aesthetic thought is the analog to, and constant reminder of, the primitive magical unity (what Simondon calls *apeiron*):

> At the neutral point, between technics and religion, aesthetic thought appears at the moment of redoubling of the primitive magical unit; [aesthetic thought] is not a phase but a permanent reminder of the rupture of the unity of the magical mode of being, and of the search for future unity.[7]

In this context, aesthetic thought has the function of preserving what was ruptured in the dephasing, or redoubling, of the magical unity into religion and technics – that is, the reticular structure of key points that constituted the direct mediation between human

[4] See: Suhail Malik, *On the Necessity of Art's Exit from Contemporary Art* (Falmouth: Urbanomic, 2016).
[5] Ludovic Duhem, "Simondon e la Questione Estetica," *Il Protagora*, no. 12 (December 2008): 370 (emphasis in original).
[6] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 179–201. Furthermore, Simondon outlines the genesis of artistic invention and the specificity of the art object in the fourth part of *Imagination et Invention* and interrogates the difference between the technical object and the art object in *L'Individuation à la Lumière des Notions de Forme et d'Information*, in addition to the aforementioned writing on techno-aesthetics. See: Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 339–55; Gilbert Simondon, *Imagination et Invention (1965-1966)* (Chatou: Éditions de la Transparence, 2008), 157–60; Gilbert Simondon, "On Techno-Aesthetics," trans. Arne De Boever, *Parrhesia* 14 (2012): 1–8.
[7] Simondon, *Du Mode*, 160.

beings and the world.[8] Aesthetic thought preserves such a reticular structure involving technics and religion:

> [Aesthetic thought] is technical because it is built in *lieu* of natural being, and because it uses the power of the application of technical objects to the natural world to make the world of art; it is religious in the sense that this world incorporates the forces, the qualities, the characters of the ground that technics leave aside … Aesthetic thought, remaining in the interval between religious subjectivity and technical objectivity, limits itself to concretize the qualities of ground in the middle of technical structures; thus it makes aesthetic reality a new mediation between the human and the world, an intermediary world between the human and the world.[9]

In this context, art becomes endowed with a transductive power: "art is what establishes the transductivity of the different modes in relation to each other."[10] Thus, in accordance with Simondon's theory of the phases of culture, art possesses a genetic function: it contains the 'seed' according to which a renewed relation between human beings and world can be accomplished through novel individualizations. Following this line of thought, in this chapter I understand art as a metastable field of forces, whose function is to embody – though perhaps not necessarily to resolve – the incompatibilities between different modes of thought. As I explained in chapter one, the modes of thought that art transductively mediates are technical thought, with its narrow focus on the element, and religious thought, which instead aims for a universal reach, in addition to their further theoretical and practical dephasings – that correspond to scientific knowledge and ethics, respectively.[11] Thus, drawing on Simondon's theory, my investigation of contemporary art will not initially refer to any specific artist or artwork. Instead I aim to address the field of contemporary art as it defines and constitutes itself through dynamic relations of exchange with its institutional-financial milieu. Specifically, in the unfolding of this chapter I will argue that the underlying logic of contemporary art increasingly reflects the logic of financial derivatives underscored in chapter five. However, I will also investigate the emergence of

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[8] Ibid., 182.
[9] Ibid., 182-183.
[10] Ibid., 199.
[11] Ibid., 160.

experimental practices that are opening up novel possibilities for transductive encounters that unfold beyond and below the social sphere. My proposition is that these practices have the power to orient – to individuate – art, and culture in general, in new directions.

For its contentious entwinement with both the financial-institutional world and digital networked technology, the loosely defined field of contemporary art is highly topical for two main reasons: first, for its privileged position within the cultural-institutional context; secondly, for its pre-dispositional attunement to the axiological plane, the plane of value determination – that is, of what and how something is worth. Here we can follow Jon Roffe's axiom of inclusion, according to which everything that belongs to the market (for it is priced) is relevant to a philosophy of the market.[12] On the one hand, contemporary art is enclosed in a double bind by which it can be 'free' only through continuously seeking and accepting liquidity injections (in the form of grants, donations, sales) by the same institutional power it wants to emancipate itself from; on the other hand, art's insistence on 'value' creation puts it at odds with the primacy of pricing as social ordering characteristic of contemporary financial power that I explained in previous chapters. This has led to obvious debates about the incommensurability between art pricing and art's value, especially in light of the intertwining between automation and the creative effort that characterizes artistic production. While the former relies on complex computational models and abstract financial metrics, the latter encompasses the material, semiotic and, today, operational conditions that constitute art's worth, including the human and nonhuman socio-technical ensemble and the corresponding "informational milieu"[13] that refuses to find any correspondence in the market, in spite of the apriority of pricing for evaluation purposes. What is at stake in this context is the automation, and autonomy, of art's value through algo-financial operations.

[12] Roffe, *Abstract Market Theory*, 150.
[13] Drawing on Gilbert Simondon, Tiziana Terranova defines an informational milieu as "a milieu composed of dynamic and shifting relations between [the] 'massless flows' [of information].'" Tiziana Terranova, *Network Culture: Politics for the Information Age* (Ann Arbor: Pluto Press, 2004), 8. Curator Ceci Moss takes up this concept to "describe the dynamic process of exchange among artist, artwork, and network" in a way that would overcome old dichotomies and instead grasp the onto-epistemological shifts introduced by the ingression of computation into culture. Ceci Moss, "Expanded Internet Art and the Informational Milieu," *Rhizome.org*, December 19, 2013, http://rhizome.org/editorial/2013/dec/19/expanded-internet-art-and-informational-milieu/.

In light of these premises, this chapter explores the possibilities for the field of contemporary art to emancipate itself from its subjection to the logic of price through the blockchain – the underlying data structure of the Bitcoin protocol, the first native electronic currency. Chapter three and seven provided an analysis of Bitcoin and showed that the technical value immanent to its data structure troubles the traditional understanding of economic value, thus foregrounding the potential to endow financial transactions with a different social logic. Bitcoin is relevant to this discussion for it introduced, albeit temporarily, a rupture in contemporary financial power by establishing a new operative logic of value creation and transmission encoded in software. From this standpoint, this chapter neither proposes an economic study of contemporary art, nor approaches finance from an art perspective. Rather, by engaging with the field of contemporary art from within its institutional-financial milieu, I am interested in unraveling the socio-technical conditions that operate the structuring of a single axiomatic of signification – a single reticular structure – within which a shared *sense* of contemporary art's value qua price (as instantiation of the political-economic power of finance) develops – and which, in many cases, also exposes such an understanding to critiques.

After introducing the terms of the debate and investigating the relation between the logic of finance and the logic of the 'post-media' condition of art,[14] building on the findings of the previous chapter, I present art experiments that attempt to emancipate contemporary art from its institutional-financial milieu through the blockchain – both legally and economically. The last section of this chapter explores practices that, although not pertaining to the institutionalized field of contemporary art, manifest an artfulness that may lead to new experiments in value creation and distribution with important consequences for cultural production. By discussing such projects, my goal is

[14] My understanding of post-Internet and/or post-media era is informed by, but not limited to, Félix Guattari's account of the digitalization and singularization of previous mass media and, in the field of art theory, by Artie Vierkant's thesis on post-Internet as a stylistic approach resulting from the contemporary socio-technical juncture. See: Artie Vierkant, *The Image-Object Post-Internet*, 2010, http://jstchillin.org/artie/pdf/The_Image_Object_Post-Internet_a4.pdf; Félix Guattari, "Towards a Post-Media Era," in *Provocative Alloys: A Post-Media Anthology*, ed. Clemens Apprich et al., trans. Alya Sebti and Clemens Apprich (Lüneburg: Post-Media Lab & Mute Books, 2013), 26–27. More broadly, I understand it as the normalization of the pervasiveness of digital networked technology in everyday life, which corresponds not only to a different artistic style, aesthetic, or epistemic framework but also, more deeply, to an ontological challenge to previously unquestioned terrains such as money and art. See also: Andreas Broeckmann, "Postmedia Discourses" (Working paper, 2013), http://www.mikro.in-berlin.de/wiki/tiki-index.php?page=Postmedia+Discourses.

to test the potentialities and limitations of new technology vis-à-vis the pervasiveness of algo-financial power in the art field and in culture at large – or what Suhail Malik and Andrea Phillips call the "financiality" of contemporary art. As the authors explain: "Financiality here designates that finance is a primary condition for, rather than consequence of, capitalization and price-setting and that, as such, price and capital are not predicated on production, use-value, consumption, or other bases external to finance."[15] Ultimately, I gesture toward ways for art to reengineer its own value away from the automated, and automatic, pricing mechanisms of today's algo-finance and present further reflections on contemporary power and the value of art.

8.2 Art and Capitalization

In April 2016 the leak of the so-called Panama Papers – a cache of 11.5 million documents dating from 1977 to 2015 – revealed the secretive dealings of more than two hundred million shell companies set up by Panama-based corporate service provider Mossack Fonseca.[16] Among the politicians, sports personalities, celebrities, and financial institutions from more than two hundred countries implicated in the global network of financial relations, art figured primarily as an asset class, used to store and conceal value in order to avoid taxes and restitution claims.[17] The Panama Papers provided an unprecedented outlook on the deep connections between the global art market and the secretive world of offshore finance, whose covert operations were reportedly instrumental to the institutionalization of the contemporary global art market.[18] This revelation evidenced that art is not immune to market dynamics; quite the contrary, market logic has become immanent to cultural and social life, often

[15] Suhail Malik and Andrea Phillips, "Tainted Love: Art's Ethos and Capitalization," in *Art and Its Commercial Markets: A Report on Current Changes and with Scenarios for the Future*, ed. Maria Lind and Olav Velthuis (Berlin: Sternberg Press, 2012), 220–21.

[16] Catherine Dunn, "Dirty Little Secrets: Inside the 'Wikileaks' of the Ultra-Rich and Ultra-Powerful," *Fusion*, 2016, http://interactive.fusion.net/dirty-little-secrets/; ICIJ, "The Panama Papers," *The International Consortium of Investigative Journalists*, 2016, https://panamapapers.icij.org/.

[17] Benjamin Sutton and Claire Voon, "Panama Papers Shed Light on the Shadowy Art Market," *Hyperallergic*, April 12, 2016, http://hyperallergic.com/289250/panama-papers-shed-light-on-the-shadowy-art-market/.

[18] As the report by the International Consortium of Investigative Journalism (ICIJ) disclosed, Mossack Fonseca was involved in the record auction of the Victor and Sally Ganz collection in November 1997 that allegedly started the "art market's wild enthusiasm for modern art." Jake Bernstein, "The Art of Secrecy," *The International Consortium of Investigative Journalists*, April 7, 2016, https://panamapapers.icij.org/20160407-art-secrecy-offshore.html. See also: Sarah Cascone, "Panama Papers Reveal Ganz Collection Secret," *Artnet News*, April 8, 2016, https://news.artnet.com/market/picasso-panama-papers-ganz-collection-469646.

operating beyond and below the threshold of visibility and perception, as chapter six explained.

From an economic perspective, art is considered according to a dual nature: on the one hand, art objects are considered 'consumer durables' in that they do not provide any monetary benefits; on the other hand, however, they are increasingly considered as an alternative capital asset class that yield a return for their appreciation over time in secondary markets.[19] The unique nature of each artwork entails an irreducible subjective component in the evaluation process, which results in the illiquidity that characterizes art as an asset.[20] The peculiar and inherently paradoxical condition of art as an object of economic exchange has led economist William Baumol to infamously define art investments as "a floating crap game," noting that the prices of art objects do not follow the 'natural' market equilibrium but tend to drift aimlessly according to the "fickleness of taste whose meanderings defy predictions."[21] As a matter of fact, investments in art markets have traditionally been discouraged by economists for they are opaque and poorly regulated (if regulated at all), entail high transactions, insurance, and storage costs, and are exposed to high liquidity risk due to the emotional, fleeting nature and limitedness of both supply and demand.[22] Yet in the current climate of economic uncertainty, art has become increasingly commoditized, collateralized, and deployed as an alternative asset, thus becoming, according to investment banks and consulting agencies, an ideal tool for inflation hedging.[23] Such institutions affirm that this is due precisely to art's alleged low correlation to traditional asset classes, as art investments are fuelled by emotional and social value, in contrast to the dry pricing mechanisms of traditional markets. The appeal of art as an asset class is evidenced by recent statistics: in 2015 the global art market achieved total sales of $63.8 billion, 46 percent of which derives from contemporary art auctions.[24]

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[19] Clare McAndrew, "An Introduction to Art and Finance," in *Fine Art and High Finance: Expert Advice on the Economics of Ownership*, ed. Clare McAndrew, ebook (New York: Bloomberg Press, 2010), 40.
[20] Ibid., chap. 1.
[21] William J. Baumol, "Unnatural Value: Or Art Investment as Floating Crap Game," *The Journal of Arts, Management and Law* 15, no. 3 (Fall 1985): 58.
[22] McAndrew, "An Introduction to Art and Finance," 32.
[23] Deloitte and ArtTactics, "Art & Finance Report 2014," 2014, http://www2.deloitte.com/content/dam/Deloitte/at/Documents/Tax/art-finance-report.pdf.
[24] Eileen Kinsella, "What Does TEFAF 2016 Art Market Report Tell Us About the Global Art Trade?," *Artnet News*, March 9, 2016, https://news.artnet.com/market/tefaf-2016-art-market-report-443615.

Contra the rhetoric advanced by investment banks, according to which art constitutes an attractive investment due to its low correlation to traditional asset classes, Suhail Malik and Andrea Phillips argue that contemporary art embodies the "truth of finance"[25] precisely for its failure to comply with standard free-market logic. Specifically, the authors maintain that contemporary art offers better access to the reality of the speculative logic of global finance precisely because it is stripped of "the legitimizing, retro-fitted measurements and theories seeking to justify earnings on the basis of production (Marxism) or consumption (neoclassical liberalism)."[26] Instead, drawing on Jonathan Nitzan and Shimshon Bichler,[27] whose work I discussed in previous chapters, Malik and Phillips assert that art unveils the logic of capitalization as instantiation of power "without any recourse to socio-political accountability."[28] As I explained in chapter five, Nitzan and Bichler propose that capitalization is better grasped through a relation between a hype index, which corresponds to investors' irrational evaluation process, and a risk coefficient that defines the degree of confidence of investors in their own predictions. Nitzan and Bichler maintain that, in the reality of financial markets, capitalization thus calculated becomes the operational logic for social ordering through pricing – or creordering. Following their thesis, Malik and Phillips further observe that, by misplacing hype with "the love of art,"[29] which affects the degree of confidence in relation to shifts in liquidity, contemporary art effectively obfuscates the operations of "social ordering for the sake of privatized earnings and is therefore directly power."[30] In other words, contemporary art is pure expression of the logic of capitalization, that is, of what 'counts' as power today; or better, of *how* power counts today.[31] Because of the immanence of the logic of capitalization to contemporary art, Malik and Phillips suggest, contemporary art cannot be conceptualized in separation from markets and institutions.

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[25] Malik and Phillips, "Tainted Love," 212.
[26] Ibid., 220.
[27] Jonathan Nitzan and Shimshon Bichler, *Capital as Power: A Study of Order and Creorder* (London: Rutledge, 2009).
[28] Malik and Phillips, "Tainted Love," 224.
[29] Ibid., 210.
[30] Ibid., 223.
[31] See also: Suhail Malik, "The Value of Everything," *Texte Zur Kunst*, no. 93 (March 2014): 66–79.

While this argument certainly resonates with the current cultural climate – as evidenced by recent critiques of art fairs and biennales throughout the world[32] – my goal in the following sections is to complicate the relation between art and finance by shifting the focus onto the technical ensemble of operations and structures that provide the architectural foundation for the entwinement of these seemingly opposite fields. My proposition is that, while it may be true that the logic of algorithmic finance has taken over art and culture, it may also be the case – precisely due to art's mediating role between the indeterminacy and autonomy of technics and the universality of 'religious thought,' as Simondon put it – that art may not only emancipate itself but also contribute to the project of countering the planetary scope of algorithmic finance with the invention of a novel logic of perception and evaluation. However, as I will show, this may entail a redefinition not of what art is but of how it operates in the digital ecosystem.

8.3 Automation and the Value of Art-After-the-Internet

Given the key role that ubiquitous digital technology has played in both the constitution and expansion of global markets and in the standardization of management practices, approaching the problematic relation between contemporary art and its institutional-financial milieu is by necessity a socio-technical affair. This requires an acknowledgement of the changes introduced by the normalization of the recursive processes of discretization, matching, and sorting of algorithmic technology into everyday life. While an in-depth discussion of the technical and technological dimensions of the art milieu goes beyond the scope of this chapter, here I should immediately specify that, by invoking a focus on the 'socio-technical' I do not advocate a technological deterministic approach. Quite the opposite, informed by Simondon's

[32] Reviewing the 2016 edition of Art Basel, Ari Akkermans observes the ways in which the conservative choices of exhibitors and artworks reflect the current political-economic uncertainty: "it seems that in many situations conversations about and around art have become substitute for a public domain that is forever receding under the pressure of capital." Ari Akkermans, "Hints of the Real World in Art Basel's Elitist Bubble," *Hyperallergic*, June 22, 2016, http://hyperallergic.com/306912/hints-of-the-real-world-in-art-basels-elitist-bubble/. The ninth edition of the Berlin Biennale also received mixed reviews for its entanglement with the "economic and image-saturated straitjackets of contemporary culture." Jason Farago, "Welcome to the LOLhouse: How Berlin's Biennale Became a Slick, Sarcastic Joke," *The Guardian*, June 14, 2016, https://www.theguardian.com/artanddesign/2016/jun/13/berlin-biennale-exhibition-review-new-york-fashion-collective-dis-art. See also: Dorian Batycka, "The 9th Berlin Biennale: A Vast Obsolescent Pageant of Irrelevance," *Hyperallergic*, June 24, 2016, http://hyperallergic.com/306932/the-9th-berlin-biennale-a-vast-obsolescent-pageant-of-irrelevance/.

philosophy of individuation and technics, this perspective recognizes the radical indeterminacy at the heart of processes of techno-collective individuation, which is what allows for invention and for the constitution of new power formations and value systems.[33]

Although some of the technical operations underlying the logic of capitalization predate modern finance, as I described in previous chapters, the automation of transactions at the foundation of global markets has undeniably played a central role in the amplification of the logic of differential accumulation to the organization and ordering of the social. Following on from the argument presented in chapters five and six, while I do acknowledge the ontological singularities that characterize contemporary art, markets, and algorithmic technology – and, importantly, I do not aim to advance any claims about their relations or resolve these irreducible differences – I believe that there is an operatory analogy between these fields, as they manifest common tendencies in the dynamisms of their respective operations of value creation and distribution, such as the reification of value in the guise of digital objects and the dynamic re-ordering of interactive processes through recursive positive feedback.

The logic of reification of value through recursion that I identified in chapter five is particularly evident in the ill-defined "post-Internet"[34] condition of contemporary art, affecting not only notions of objecthood, authorship, and the cycle of production-distribution-consumption of art but also art's ontology and value(s). In this respect, Victoria Ivanova reflects on the ambiguities embedded in contemporary art's value and "the schism that exists at the level of contemporary art's ontology."[35] According to Ivanova, art's singularized ontology, and the conceptualization of value that derives from it, have caused a rupture between "on the one hand, the socio-cultural and political claims of artworks and, on the other hand, their economic and infrastructural realities."[36] Starting from these premises, Ivanova demonstrates that, with the advent of conceptual art, art's materiality as a harbinger of value is replaced by a conception of art as "a plane for negotiating semantics"[37] thereby freeing art from the material constraints

[33] Simondon, *L'Individuation*, 339–55.
[34] Vierkant, *The Image-Object Post-Internet*.
[35] Victoria Ivanova, "Art's Values: A Détente, a Grand Plié," *Parse*, no. 2 (November 2015): 92.
[36] Ibid.
[37] Ibid., 93.

of its objects and opening it up to a discursive encounter with social conditions and operations through the gesture of critique. Yet, Ivanova continues, by abstracting themselves from their material substrate, the ontological and political claims on art's singularity become increasingly at odds with its infrastructural and economic reality, which progressively neutralizes art's critical thrust and subsumes it into the logic of the market as an instantiation of contemporary power. According to Ivanova, the result is that, at least since the mid-1990s, contemporary art has become an exercise in self-branding – that is, of strategies to increase artists' viewership and hype; a process that has been further exacerbated by the advent of digital networked technology. Thus, Ivanova suggests, contemporary art cannot break free from financial power since it is "ultimately geared towards capitalization as a means to market success rather than as a strategy for socially transformative intervention."[38]

Following a similar trajectory, Stefan Heidenreich observes that the value of art today is best expressed by liquidity: "The use of liquidity is an example of the metaphorical appropriation of technology by art. … When gold was the stuff of hoards, art was placed in frames painted gold. Today, having broken gold's monopoly on liquid wealth, it is liquid which limns the surface of the post-Internet work."[39] Yet, is the persistence of liquidity only a matter of 'metaphorical appropriation' manifested in the style or taste of a work? Or does the value of contemporary art reflect the reality of market liquidity as such? In the specific context of the visual arts, this issue is also addressed in Hito Steyerl's critique of circulationism: "Circulationism is not about the art of making an image, but of postproducing, launching, and accelerating it. It is about the public relations of images across social networks, about advertisement and alienation, and about being as suavely vacuous as possible."[40] As Steyerl suggests, liquidity has become the operational principle of contemporary art, in conjunction with the digital networked infrastructure underlying its circulation. From this standpoint, my wager is that the shifts registered in the conceptualization of art's value are related to the operational and operation*able* concrete abstraction of algorithmic technology, whose operations of sorting, tagging, and ranking do not merely correspond to a technical

[38] Ibid., 104.
[39] Stefan Heidenreich, "Freeportism as Style and Ideology: Post-Internet and Speculative Realism, Part I," *E-Flux*, no. 71 (March 2016), http://www.e-flux.com/journal/freeportism-as-style-and-ideology-part-i-post-internet-and-speculative-realism/.
[40] Hito Steyerl, "Too Much World: Is the Internet Dead?," in *Too Much World: The Films of Hito Steyerl*, ed. Nick Aikens (Berlin: Sternberg Press, 2014), 37.

ordering of data but, more pervasively, are also a social ordering, as I explained in chapter five; in the present context, this is exemplified by the Facebook newsfeed.[41]

Thus, pushing the trajectory of the financiality of contemporary art further, there seems to be a parallel between the increasing automation of the financial sector discussed in chapter four[42] – aimed at the maximization of differential accumulation through the elimination of the human element – and recent tendencies in the socio-cultural realm. This is made evident by platforms such as ArtRank and Artsy. ArtRank is an art market analysis platform that uses data-mining and machine-learning algorithms to inform subscribing collectors and institutions, upon payment, about the latest collecting opportunities, which reportedly facilitated a 4,200 percent return on investments over a 16-months period.[43] The peculiarity of ArtRank is that it short-circuits the process of value creation, doing away entirely with the social interaction required by art-after-the-Internet in the attention economy.[44] Instead ArtRank ranks artists directly on the basis of their sellability according to complex correlations among datasets that involve Google Trends and Instagram data, in addition to "Internet presence, auction results, market saturation, market support and CV data—education, representation, et cetera."[45] In other words, ArtRank treats artists' names as commodities, and sorts them according to hype on the basis of the circulatory logic of the market. As Bloomberg aptly puts it: "ArtRank gives art the stock market treatment."[46] In a way, ArtRank exacerbates the condition of "Artists without Art" identified by Brad Troemel et al. in regard to social networks dynamics, in which artists are clustered into homogenous groups according to

[41] See: Brad Troemel, "Athletic Aesthetics," *The New Inquiry*, May 10, 2013, http://thenewinquiry.com/essays/athletic-aesthetics/; Brad Troemel, Artie Vierkant, and Ben Vickers, "Club Kids: The Social Life of Artists on Facebook," *DIS Magazine*, 2012, http://dismagazine.com/discussion/29786/club-kids-the-social-life-of-artists-on-facebook/.
[42] Because of the very nature of financial operations (i.e. based on pure information processing) 54 percent of jobs in finance are reportedly at high risk of automation, more than any other skilled industry. The diffusion of high-frequency and automated trading strategies and the introduction of robo-advisers on Wall Street are clear examples. See: Nathaniel Popper, "The Robots Are Coming for Wall Street," *The New York Times*, February 25, 2016, http://www.nytimes.com/2016/02/28/magazine/the-robots-are-coming-for-wall-street.html; Hugh Son and Margaret Collins, "The Rich Are Already Using Robo-Advisers, and That Scares Banks," *Bloomberg.com*, February 5, 2016, http://www.bloomberg.com/news/articles/2016-02-05/the-rich-are-already-using-robo-advisers-and-that-scares-banks.
[43] "FAQ | ArtRank™," accessed April 8, 2014, http://artrank.com/pages/faq.
[44] See: Moss, "Expanded Internet Art and the Informational Milieu"; Troemel, "Athletic Aesthetics."
[45] Andrew M. Goldstein, "Art Rank Founder Carlos Rivera on Why He's Leading the Flipper Revolution—and Why It Can't Be Stopped," *Artspace*, June 11, 2015, http://www.artspace.com/magazine/interviews_features/carlos-rivera-art-rank-interview.
[46] Anna Altman, "Buy, Sell, Hang on Your Wall," *Bloomberg Businessweek*, November 13, 2015, http://www.bloomberg.com/news/articles/2015-11-12/artrank-gives-art-the-stock-market-treatment.

the activity of sorting, ranking, and matching algorithms, that ultimately turn art-after-the-Internet into self-referential closed loops, so that "the artist-viewer and other artist-viewers are caught in a sphere of perpetual reception and distribution."[47] In the context of ArtRank, Stefan Heidenreich's comment on the contemporary condition of art sounds particularly revealing: "Artists are priced according to their implicit volatility. When still young, they appear as prized call options with very good potential – potential they lose as they grow older. Volatility expectations shrink as they near their expiration date."[48]

On the other hand, the condition of Artists Without Art is matched by Art Without Artists, which does not only refer to the alleged subsumption of art into "the Curatorial" – a thesis sustained by Anton Vidokle[49] – but to the more pervasive and silent activity of platforms such as Artsy that, once again, sort, rank, and match artworks, galleries, collectors, and audience with the ultimate goal of striking a deal. Part social network, part recommendation engine, part digital auction house, Artsy replaces the Curatorial through the Art Genome Project – an initiative that consists in classifying art through a vast system of tags, sustained not so much by machine intelligence but by a much less futuristic "curatorial labor" of a group of "Mechanical Turks."[50] At the time of writing, Artsy possesses a database of over 350,000 images by 50,000 artists, classified according to 1,000 'genes,'[51] freely available on the repository GitHub.[52] Artsy supposedly aims at the 'democratization of art' in the digital age but this vision is not mutually exclusive with its other much more concrete goal – that of increasing its own capitalization, as most start-ups attempt to do.[53]

Due to the black-boxed nature of such algorithms, it is hard, if not impossible, to assess the efficacy of these methods of valuation and recommendation on the cultural sphere.

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[47] Troemel, Vierkant, and Vickers, "Club Kids."
[48] Heidenreich, "Freeportism as Style and Ideology."
[49] Anton Vidokle, "Art Without Artists?," *E-Flux*, no. 16 (May 2010), http://www.e-flux.com/journal/art-without-artists/.
[50] Jason Farago, "Art.sy and the Myth of the Online Art Market," *New Republic*, October 22, 2012, https://newrepublic.com/article/108893/artsy-and-the-myth-the-online-art-market.
[51] "About | Artsy," accessed March 24, 2016, https://www.artsy.net/about.
[52] madeleine, "Artsy/the-Art-Genome-Project," *GitHub*, March 18, 2016, https://github.com/artsy/the-art-genome-project.
[53] It is worth noting that Artsy is financially backed by the likes of Google's former CEO Eric Schmidt, Jack Dorsey of Twitter, Paypal's co-founder Peter Thiel, among others. Melena Ryzik, "Art.sy is Mapping the World of Art on the Web," *The New York Times*, October 8, 2012, http://www.nytimes.com/2012/10/09/arts/design/artsy-is-mapping-the-world-of-art-on-the-web.html.

As Jeremy Wade Morris shows in the case of the music sector, the incessant feedback between users, automated cultural intermediaries (which Morris calls "infomediaries"), and cultural content can give rise to a "data fundamentalism"[54] based on the belief on the complete objectivity and omnipotence of data. As ArtRank founder Carlos Rivera puts it: "With the amount of data we have today, absolutely anything can be quantified."[55] In addition to this, 'curation by code' – as Morris defines this practice – has an increasingly important role in the valuation process. Christian Bessy and Pierre-Marie Chauvin underscore the power of cultural intermediaries in the valuation process of non-quantifiable products, such as artworks:

> Art dealers not only assess the value of artists by using existing and predetermined valuation frames (made by museums or critics for example), they participate in constructing these frames through their engagement in the birth of artistic movements, aesthetic conventions but also "price conventions" that circulate on markets.[56]

In the case of 'curation by code,' however, the frame of valuation is determined by algorithmic operations that mine, sort, and rank data, while at the same time they are utterly alien to the milieu of reference.

What is at stake in the cases of both ArtRank and Artsy is the automation of the value of art triggered by the circulatory dynamics of pricing mechanisms as a way by which to accrue future 'value' in the present through monetization – a logic that doesn't differ from the way in which financial securities work. In chapter five I explained how derivatives markets proceed according to the double movement of binding and blending identified by Dick Bryan and Michael Rafferty.[57] Similarly, automated recommendation systems "fuel a recursive loop of future cultural recommendations,"[58] thereby instantiating a logic similar to that of derivatives markets that aims to bind the future to

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[54] Crawford in Jeremy Wade Morris, "Curation by Code: Infomediaries and the Data Mining of Taste," *European Journal of Cultural Studies* 18, no. 4–5 (August 1, 2015): 459.
[55] Goldstein, "Art Rank Founder Carlos Rivera on Why He's Leading the Flipper Revolution—and Why It Can't Be Stopped."
[56] Christian Bessy and Pierre-Marie Chauvin, "The Power of Market Intermediaries: From Information to Valuation Processes," *Valuation Studies* 1, no. 1 (April 17, 2013): 97–98.
[57] Dick Bryan and Michael Rafferty, *Capitalism with Derivatives: A Political Economy of Financial Derivatives, Capital and Class* (Houndmills: Palgrave Macmillan, 2006).
[58] Morris, "Curation by Code," 460.

the present and blend the singularities of artworks and art practices into computational metrics. Furthermore, the future value of such recommendations is immediately monetized in the present, according to the tendency observed by Massimo Amato and Luca Fantacci.[59] Recasting these movements according to Simondon's allagmatics, it becomes evident that the logic of derivatives is concretized in the technical operations that allow for these systems to function: automated systems reify art's value and its corresponding monetary value into digital objects (such as images, videos, gifs, likes, and shares, etc.) and, through recursive loops, sort, rank, and circulate such objects, generating new value in the process. From this standpoint, the 'value' of contemporary art becomes subsumed into the pricing mechanisms of the market and loses any ontological primacy, instantiating instead the creordering logic of capitalization.[60] As Stefan Heidenreich states: "Assessing a 'real' value [of art] is impossible, because reality is an effect of the transaction."[61]

However, precisely because of art's metastable condition within the financial-institutional milieu that co-constitutes it, artists, theorists and critics have long questioned its entanglement with markets and digital networks.[62] In this context, since the invention of Bitcoin, many artists and cultural practitioners have started experimenting with cryptocurrency and the blockchain in order to disentangle art from its institutional-financial milieu, as a recent project by curatorial platform Torque and London-based gallery Furtherfield exemplifies.[63] In the next section I aim to assess the extent to which projects at the intersection of art, finance, and technology actually break with the financiality of contemporary art by experimenting with the blockchain architecture.

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[59] Massimo Amato and Luca Fantacci, *The End of Finance* (Cambridge: Polity, 2011).
[60] Nitzan and Bichler, *Capital as Power*.
[61] Heidenreich, "Freeportism as Style and Ideology."
[62] The work of Tatiana Bazzichelli, which is aimed to uncover the relations between hacktivism, and social and political movements, is emblematic in this context. See: Tatiana Bazzichelli, *Networking Art: The Net as Artwork* (Aarhus: Digital Aesthetics Research Center, 2006); Tatiana Bazzichelli and Geoff Cox, eds., *Disrupting Business: Art & Activism in Times of Financial Crisis* (Brooklyn: Autonomedia, 2013).
[63] "Artists Re:Thinking the Blockchain" is a publication and discourse program launched by London-based gallery Furtherfield and Torque Books aimed to "augmen[t] the arrival of the blockchain into the arts." At the time of writing it is in crowdfunding phase. For more information, see: Torque and Furtherfield, "Artists Re:Thinking the Blockchain," 2016, http://www.crowdfunder.co.uk/artists-rethinking-the-blockchain?tk=208334da9b174c4145e1fec75e784e1b261ff238.

8.4 The Case of Blockchain-Based Art Making

As I explained in previous chapters, while the novelty of Bitcoin has been captured by financial power apparatuses that have turned it into a commodity to be traded for a price,[64] Bitcoin's underlying data structure, the 'blockchain,' has gained increasing attention. Although it lacks the function of mining that, as I explained in the previous chapter, is the key design invention of Bitcoin, blockchain technology still provides a transparent, peer-to-peer, and decentralized way of recording, verifying, and validating transactions without the need of any central authority. For this reason, it has been widely adopted by libertarian contingents and financial institutions, but it also promises important applications for the realization of distributed commons.[65]

The enthusiasm stirred by cryptocurrency as a medium of artistic enquiry is telling of the intimate relation between art and the socio-technical (therefore, also economic) system of which it is part. Below I introduce two projects that pertain to the field of (more or less institutionalized) contemporary art that, by experimenting with blockchain technology, aim to challenge contemporary art's entanglement with its institutional-financial milieu and exit the extractive, circulatory logic of financial power. Such projects – Monegraph and Plantoid – approach the problematic relation between art and finance by acknowledging the socio-technical reality of contemporary art and engaging with its embeddedness in the market. My goal in the following sections is to assess whether these experiments really break with the pervasive financiality of contemporary art as an instantiation of the logic of contemporary power. I should also specify that I am not interested in the aesthetics proper to these projects *as* artworks. Instead I am interested in the ways in which they propose a new 'perceptual' and operational architecture for the production and distribution of value vis-à-vis the financiality of contemporary art, accounting at once for the normative and genetic dimensions of the technical operations that underlie these projects – that is, for the ways in which they organize social flows and generate new value(s) or, borrowing from Simondon's philosophy, for the ways in which they orient psycho-collective individuation.

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[64] Pete Rizzo, "CFTC Defines Bitcoin and Digital Currencies as Commodities," *CoinDesk*, September 17, 2015, http://www.coindesk.com/cftc-ruling-defines-bitcoin-and-digital-currencies-as-commodities/.

[65] See: David Bollier, "The Blockchain: A Promising New Infrastructure for Online Commons," *David Bollier: News and Perspectives on the Commons*, April 3, 2015, http://bollier.org/blog/blockchain-promising-new-infrastructure-online-commons.

8.4.1 Monegraph: If You Like it then You Should Put a Blockchain on it

Monegraph – short for ‘monetized graphics’ – is a software platform for digital creators invented by artist Kevin McCoy and technologist Anil Dash at the 2014 edition of Rhizome’s *Seven on Seven*. By adding an ‘authorship layer’ to the blockchain, Monegraph allows artists to take control of their creations and track their works’ movements, while preventing their permissionless reproduction. By means of Namecoin – one of the hundred ‘altcoins’ sprung from the original Bitcoin protocol – digital artworks are embedded with a cryptographic authentication signature that validates the provenance of a work while at the same time allowing artists to track their works’ movements. Anil Dash observes that “physical artists” have traditionally used two instruments to “invent value around their work”[66] – that is, provenance of an artwork and verification of its originality. In the realm of digital computation, artists cannot use these instruments, with important repercussions on the value, but also on the format and visibility of their works.

To illustrate how Monegraph works, Dash gives the example of an animated .gif designed by Jennifer and Kevin McCoy. In order to validate the provenance of the .gif and verify its originality, Dash explains that only two steps are necessary: a public claim to the ownership of the work; and secondly, a record of that claim on the blockchain and the representation of the work. Thus in order to validate the .gif Monegraph proceeds according to three steps: first, the .gif is created; secondly, the claim to the authorship (or ownership) of the work is publicly tweeted; lastly, the information about the provenance of the .gif is recorded on the blockchain (in this case, the Namecoin blockchain) and given a unique ID number. Thus every time a work registered through Monegraph is circulated, artists gain a fee.

By dispensing with any third party such as art dealers and galleries (that for digital works are in any case scarce), the Monegraph model essentially sets in motion a process of ‘uberization’ of art “with the goal of turning media into tradable assets that pay

[66] Anil Dash, “A Bitcoin for Digital Art,” *The Message*, May 9, 2014, https://medium.com/message/a-bitcoin-for-digital-art-8c7db719e495.

creators every time they are bought, sold, or licensed."[67] Yet, like the ubiquitous ride-sharing company, the illusion of artists' empowerment and freedom from institutional control comes with the dangers of forced dependence on the provisions of an algorithmic third party that, however, still retains strong links with the institutional field, being currently developed under NEW Inc., the first museum-led incubator powered by The New Museum.

By pursuing the dream of authenticity and institutional autonomy, Monegraph points to a very near future in which art may indeed become a currency, but one that is privatized, hyperfinancialized, and hypercapitalized upon. As TechCrunch's writer Josh Constine states, Monegraph "uses cryptography to bring meatspace scarcity to online art,"[68] thereby reproposing the immaterial commodity paradigm characteristic of liquid assets that has been identified by Amato and Fantacci, which allows for differential accumulation through in(de)finite circulation. In technical terms, Monegraph abides by the logic of reification through recursion. In contrast with the cases discussed above, a work on Monegraph becomes reified the moment in which it is registered on the Namecoin blockchain and acquires a unique ID number. Furthermore, the circulation of images online allows for the work to acquire increasing reputation capital. Monegraph also underscores the fact that it is in the economic exchange of a digital artwork that the speculative logic of contemporary power manifests in its clearest form. While a digital artwork – like any digital asset, such as synthetic derivatives – exists only as bits of code that may protocologically integrate with the semantic architecture of the World Wide Web, the 'thingness' of the work derives from the phenomenal perception of its 'value' conveyed through the socio-technical apparatus the work is embedded in.

It is not too hazardous to imagine, in a hypothetical future, that Monegraph may radicalize the logic of circulation characteristic of the 'post-Internet' condition, distributing blockchain-based artworks across all networks of exchange at the rhythm of spamming. Thus it may turn art into an exercise of hyperbolic clickbait in which the 'value' of a work is directly correlated to the reputation levels of its publicly available chain of ownership, shares, and retweets that will inevitably be recorded on the

[67] "Monegraph," *NEW INC*, accessed January 2, 2016, http://www.newinc.org/monegraph/.
[68] Josh Constine, "Monegraph Uses Bitcoin Tech So Internet Artists Can Establish 'Original' Copies of Their Work," *TechCrunch*, May 9, 2014, http://social.techcrunch.com/2014/05/09/monegraph/.

artwork's unique key and available for all to see. Further, digital platforms like Monegraph may become institutionalized, thereby replacing (or perhaps simply reinforcing) their brick-and-mortar counterparts (that is, museums), and accelerating the shift from a public ethos of care that characterized museums' role in the industrial age to a privatized and irrational love of art carried forth by private-public institutions – a thesis exposed by Malik and Phillips.[69]

8.4.2 Plantoid: The Concretization of Distributed Autonomous Art

In their work Plantoid, the French collective Okhaos adds an aesthetic layer to the distributed logic of the blockchain, pushing further the quest for art's autonomy from institutional powers – quite literally. Based on the Ethereum blockchain, a Plantoid exemplifies a system of distributed automated governance, based on smart contracts and endowed with internal capital, which relies on humans' aesthetic appreciation to reproduce itself. The leading principle of the Plantoid is to make art autonomous, by directly funding the artwork instead of funding artists. Humans serve as "symbiotic pollinators"[70] as they provide the Plantoid with the nectar it needs to reproduce itself – Bitcoin. Each Plantoid carries a QR code that connects it to a Bitcoin wallet. When visitors 'tip' the Plantoid with Bitcoin, the Plantoid comes to life and rewards the human with a dance of colors and sounds coming from its steel petals: a direct transaction between aesthetic pleasure and digital currency. When the Plantoid has reached enough funds to reproduce itself it hires an artist, or a set of artists, and gives them the task of creating a new Plantoid through smart contracts. The design of the newborn Plantoid – the aesthetic parameters as well as the business logic – is determined by an evolutionary algorithm, while the participation in the network is coordinated through the blockchain in order to guarantee the distributed character of the governance system. Each time a Plantoid reproduces itself, a percentage of its funds is transferred back along the lineage as a means of expressing gratitude to its ancestors and to remunerate, through Bitcoin, the human element that has enabled the reproduction of the Plantoid in order to incentivize "good aesthetics/genetics."[71] In short, the Plantoid realizes a truly aesthetic economy in which relations emerge through

[69] Malik and Phillips, "Tainted Love," 234.
[70] Okhaos, "Plantoid," accessed December 10, 2015, http://okhaos.com/plantoid/.
[71] Ibid.

the disintermediated conversion of 'beauty' and love of art into money that binds artists, designers, art, and audience into a symbiotic relationship with each other.

A Plantoid can be considered a first instantiation of the dream of Distributed Autonomous Art (DAA), in which the indeterminacy and autonomy of art finds its self-realization through the imagination of new ecosystemic orders with the support of Turing-complete blockchain technology. As explained above, Malik and Phillips suggest that contemporary art's ethos cannot be trusted for it is compromised by and embedded in a system in which the power of capitalization dictates contemporary art's dynamics.[72] The Plantoid circumvents this conundrum by embracing art's place in the market – coupling Bitcoin and distributed algorithmic governance to emancipate art from capitalist financial markets. Yet the trust-no-one attitude may end up reinforcing the principles guiding contemporary art's ethos, exploiting artists by first turning their creative effort into mere labor and further by underpaying them – something that resonates with the contemporary paradigm. Or perhaps, in a not too distant future, humans may be equally incentivized through rewards in stock options based on the total 'value' of the DAA – that is, its capitalization. Further, by insisting on the aesthetic and genetic autonomy of the art object-network, not only does DAA decenter the position of the human but also conceals the activity of artists and technicians in the art informational milieu.

In other words, a Plantoid engenders the logic of the black box of algorithmic finance. From this standpoint, the dream of DAA may instead turn into a nightmare not dissimilar from the already-mentioned "Economics 2.0" in Charles Stross' sci-fi book *Accelerando* – autonomous corporations that trade beyond and below the threshold of human perception, and that progressively integrate into a predatory hive mind leaving humans in blissful, because skeumorphically and affectively concealed, misery. Interestingly, the Plantoid's "evolutionary self-sustaining pyramid scheme,"[73] by which the work rewards its ancestors and creators with a 5 percent royalty fee, has also been

[72] Malik and Phillips, "Tainted Love."
[73] Jason Potts, "Do Plantoids Dream of Electric Arts Council Grants?," *The Conversation*, December 14, 2015, http://theconversation.com/do-plantoids-dream-of-electric-arts-council-grants-52263.

praised for its potential applications in Multi-Level Marketing (MLM)[74] – a business model, traditionally involving direct selling to consumers (that often entails also a large affective component, as in cases such as leading cosmetic manufacturer and distributor Avon), in which the sales force is compensated not only through their own sales but also by the success of other sales people.

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To sum up, the projects briefly discussed above avail themselves of the possibilities offered by the normative power of blockchain technology to emancipate contemporary art from financial logic according to opposite strategies at the extremes of the art-institutional spectrum. While Monegraph affirms art's place within institutional settings by leveraging the digital scarcity afforded by the Bitcoin protocol and adding an ownership layer to the blockchain, Plantoid aims instead to free art from its institutional-financial milieu by mobilizing the distributed logic of the blockchain and adding an aesthetic layer to it. However, the ways in which they both operationalize value vis-à-vis pricing are similar. On the one hand, by creating a system that relies on artificial scarcity and transferability, Monegraph treats art as a commodity, a store of value. Yet the value of each artwork depends on the pricing mechanisms triggered by the process of differential circulation – the more the circulation, the more the alleged 'value.' On the other hand, Plantoid doesn't impose any value and/or pricing system; instead, by giving primacy to the phenomenal relation between the work and the audience, and instituting a direct conversion of aesthetic appreciation into money (and vice versa, as in the case of the Plantoid's pyramid scheme) Plantoid instantiates the in(de)finite conversion between love and hype, wealth and power, by supporting a model of derivative creation that obscures the inner workings of the financial/genetic/aesthetic machine. In other words, Plantoid doesn't go beyond the black box logic and aesthetics of current financial markets, in the sense that it makes it difficult, if not impossible, to discern the operations that allow for the transformation of aesthetic reward into financial value and vice versa. In spite of the novelty of the underlying technology, the operational logic of these projects does not differ from

[74] Lana Smiley, "Money Earning Blockchain-Based Iron Sunflower to Change Future of MLM Business," *CoinTelegraph*, January 16, 2016, http://cointelegraph.com/news/116068/money-earning-blockchain-based-iron-sunflower-to-change-future-of-mlm-business.

contemporary monetary flows in which the difference between commodity and currency is flattened onto the "moving ground"[75] of liquidity, which grants the "tradeability"[76] between price and quantity of appreciation accumulated (that is, shares, likes, and coins), which in turn depends on market sentiment and on the circulatory processes dictated by the Invisible Hand of the blockchain.

Thus, in spite of the noble intentions, these projects do not *really* break with the current 'sense of power.' However, they do illuminate important aspects of the pervasiveness and extension of contemporary algo-financial logic, both in relation to the burgeoning cryptoeconomy and to contemporary (though more or less institutionally independent) art. As a matter of fact, these experiments still fall into contemporary art's singularized ontology and cannot effectively operate a critique of the socio-technical reality they are embedded in, as Ivanova outlined above. In doing so, they testify once again to the retroactivity of value vis-à-vis the contingent event of price identified by Jon Roffe, and propose a model of value creation and distribution that mirrors the logic of derivatives outlined in chapter five – a logic that proceeds according to a process of reification of value through recursive circulation. This means that the normative power of the blockchain's operative logic – which these projects are instantiation of with their focus on either authentication or decentralized governance – alone is not able to emancipate art from contemporary financial logic, testifying to the limits of technological determinism in light of the challenges posed by the operational and sub-perceptual reality of algo-financial power. The same goes for money, as the recent capture of Bitcoin demonstrates in the field of monetary architecture and policy. Without diminishing the important contributions that the above experiments are providing to the debate on cryptofinance, a fundamental question remains about the *orientation* of art in relation to the cultural and political landscape in light of changing socio-technical (therefore, also institutional-financial) paradigms. In other words, does making *money* reflect the ethos of contemporary art? Or is 'blockchain-based art' merely radicalizing art's ethos of capitalization with its authentication, transparent circulation (that is, tracking), and autonomization-automation of digital art?

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[75] Elie Ayache, *The Blank Swan: The End of Probability* (Chichester: Wiley, 2010), 56.
[76] Ibid.

8.5 Making *Money* and *Making* Money

The above questions will be answered in the remainder of this chapter. To begin with, it is important to note that, precisely because of its embeddedness in a socio-technical system within which it shares modes of operations, art *is* fundamental to the project of steering socio-technical forces (such as finance, institutions, art, money) away from financial capital due to its capacity to intervene formally in the aesthetic plane – precisely, the plane of perception and of the coding of values. According to Gilbert Simondon, the reality of perception is not the seizing of forms, but consists in "*the invention* of a form"[77] that does not exist *a priori* but only *a praesenti*, rendering perception describable in its *functioning* within a system but only graspable as it unfolds within the same system. As such, perception possesses its own logic that is reinvented each time new forms take consistency. Therefore, if the reality of contemporary power is the market, and the market is contingent, as chapter four argued, art plays a pivotal role in the invention – and structuration – of a new logic of perception that would break with the axioms of contemporary algo-financial power.

A similar observation has been made by Randy Martin in relation to the logic of value creation that is immanent to both finance and art.[78] In a brilliant discussion of "social kinesthetics and derivative logics," Martin observes that there exist parallels between the bodily movements of dancers and skaters and the "choreographies of currency."[79] Specifically, Martin explores the logic of derivatives and shows how the production of value from risk that derivatives perform is analogous to the ways in which dance, and art more generally, generates value for itself and for the social through self-production, self-representation, and self-dissemination. Taking the examples of contact improvisation, skating, and hip-hop, Martin observes that these are all "risk-generating practices that have to do with a kind of sensibility of arbitrage, of moving in the spaces in between."[80] Indeed, Martin argues, there is an immense untapped social value in financial markets that can, and must, be set free through the same movements that dance uses in order to leverage and hedge the risk that it itself generates. As Martin states, this

[77] Simondon, *L'Individuation*, 231 (emphasis in original).
[78] Randy Martin, "Dance and Finance—Social Kinesthetics and Derivative Logics" (Experimental Media and Performing Arts Center (EMPAC), October 9, 2013), https://vimeo.com/95306125.
[79] Ibid.
[80] Ibid.

can be achieved by "abiding a disunity in participation"[81] – as the heterogeneous assemblage of markomata that I have described in chapter four does – which creates a value that "ripples out" into the world.

Thus, in spite of the recent "resolution of the Bitcoin experiment"[82] and the widespread rhetoric about the 'naturalness' of markets brought forth by the economic orthodoxy and neoliberal contingents,[83] the rise of cryptocurrency demonstrates that the socio-technical reality that underlies both art and finance is inherently artificial, and therefore malleable and open to interventions – to interstitial movements and "derivative practices," as Martin calls them.[84] This means that what is at stake for both art, as manifestation of the truth of finance, and for finance, as realization of the abstraction of value,[85] are not art and finance *per se,* but their modes of existence that depend on the techno-social allagmatic architecture they are embedded in and participate with, and on the value(s) system(s) they create.

In light of Ivanova's observations described above, it should be noted that there seems to be a striking analogy between the shifts that occurred in the value of money and the value of art since modernity. These follow a similar pattern to that of the relation between economic value and the value that is 'stored' by money that I have identified in chapter two. As already discussed, the origin of fiat money can be traced back to the invention of central banking in the UK in the seventeenth century, just before the introduction of the gold standard.[86] However, it is perhaps with the end of the Bretton Woods system in 1971 that money, like art, has become subjected to a "complete semantic overhaul"[87] that replaced a notion of intrinsic value rooted in the materiality of

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[81] Ibid.
[82] Mike Hearn, "The Resolution of the Bitcoin Experiment," *Medium*, January 14, 2016, https://medium.com/@octskyward/the-resolution-of-the-bitcoin-experiment-dabb30201f7#---262-344.puwe6jpse.
[83] See: Philip Mirowski, *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown* (London: Verso, 2014), 54–56.
[84] Martin, "Dance and Finance."
[85] "With finance capital in particular, it is not just that financial 'products' are like contemporary art. They *are* contemporary art. The great lost work of our time is all those Powerpoint presentations used to sell one or other financial product or speculative instrument. Why do they not have pride of place in our museums? The great financial institutions are not so much the house and croupier of a casino as art dealers, peddling the intangible to the solvent." McKenzie Wark, "On Scrooge and His Art Collection: A Little Xmas Offering," *Public Seminar*, December 3, 2013, http://www.publicseminar.org/2013/12/on-scrooge-and-his-art-collection-a-little-xmas-offering/ (emphasis in original).
[86] Amato and Fantacci, *The End of Finance*, 183–96.
[87] Ivanova, "Art's Values," 93.

gold and silver as direct referent (commodity money), with a conception of value by fiat – as expression of socio-political and economic forces – that is not operationalized through production but instead reflects the operations of consumption. Money is created by the State in order for its citizens to use it and fuel the taxation system; analogously, for it to be effective, the gesture of critique presupposes an audience consumer of art that would respond to it.

In other words, the early 1970s marked both the liberation of the monetary sign from any underlying object (such as gold) and the concretization of the semantic shift in art (although, arguably, the latter began at the end of the previous century). Or one could say, with Deleuze and Guattari, that art presupposes a concept of value that only later is engendered in money.[88] Importantly, that period also coincides with the rise of electronic stock markets and the development of computational technology to perform ever increasingly complex calculations of stocks' 'value' over time (such as the infamous Black-Scholes formula) that effectively operationalize money by making it indeterminate, self-referential, and in endless circulation. As Matteo Pasquinelli notes, the technological condition of our epoch has thus rendered the linguistic model insufficient to grasp the complexities of money and capital.[89] The same could be said of today's contemporary art that, in most cases, derives its value from ranking algorithms and automated computational operations that quantify prospective value through socio-financial metrics, such as Google's and Facebook's social graphs, while categorizing users (thereby also artists) into homogenous groups that reduce the democratic potential of the early Web and turn art-after-the-Internet into closed loops of self-referential artists' clusters.[90]

In other words, contemporary art's value, like contemporary money's value, today corresponds neither to the materiality and uniqueness of their elements, as the manifestation of a power rooted in production, nor to a commonly acknowledged 'meaning' attached to it by fiat and reflected in a logic of consumption that extended from the 1970s to the 1990s. Yet the contemporary modes of existence of both art and

[88] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 2005), chaps. 9, 13.
[89] Matteo Pasquinelli, "Capital Thinks Too: The Idea of the Common in the Age of Machine Intelligence," *Open! Platform for Art, Culture & the Public Domain*, December 11, 2015, http://onlineopen.org/capital-thinks-too.
[90] See: Troemel, Vierkant, and Vickers, "Club Kids."

money seem to reinstantiate the logic of reification (of value, of objecthood) through in(de)finite recursive loops. The persistence of the 'objecthood' of art – of its singularized ontology, as Ivanova calls it – makes each work a store of value by fiat, that cannot face the operational challenges posed by the concrete abstraction of algorithmic processes. The same can be said for money: although Bitcoin has no objecthood of its own, Bitcoin is still trapped in the mechanist axiomatic of signification that gives capitalist power its sense. In order to withdraw from this logic, what Ivanova's and Pasquinelli's arguments seem to point to is the necessity of a new conception of value that eschews the subjection to the logic of price, and that is able to embrace the concrete abstraction, and universal (because indeterminate) reach of digital networked technology to open up new modes of engagement with the world.

This is to suggest that art – in its techno-social nature – should acknowledge its place in the market, embrace its monetary analog as index power and change *how* it functions techno-logically (both in normative and genetic terms) in order to realize itself *as* art. Just as Bitcoin in 2009 ended the "taboo on money"[91] by opening up new universes of economic, technical, and social possibilities, perhaps art could equally – or better, analogically – end the taboo on contemporary art. Although Bitcoin has already been subsumed into the logic of financial capital, art that engages with blockchains and the Bitcoin protocol may be able to invent a new system of values *for itself*, as a systemic entity, as Ivanova argues via Jack Burnham. This might truly realize Jack Burnham's proposal for a "system esthetics"[92] in which art renounces its attachment to the object-world and dissolves itself in the socio-technical fabrics of the larger environment of which it is part.[93] In other words, instead of making *money* thereby re-proposing the ethos of contemporary art, art could be *making* money, by challenging the function of

[91] Denis Roio, "Bitcoin, the End of the Taboo on Money" April 6, 2013, http://www.dyndy.net/2013/04/bitcoin-ends-the-taboo-on-money/.
[92] Jack Burnham, "Systems Esthetics," *Artforum*, September 1968.
[93] As mentioned above, Victoria Ivanova argues that the problem of contemporary art's ontology is due to its prioritization of singularity over systematicity. This, according to Ivanova, has caused a rupture between the socio-cultural and political claims of artworks and the economic and infrastructural reality contemporary art is embedded with. In order to overcome this impasse, Ivanova suggests that contemporary art should look at Jack Burnham's "system aesthetics." Burnham argued that art should renounce its objecthood and embrace the infrastructural reality of the emerging computational technologies of the late 1960s. In Ivanova's words: "the ontological dispersal of art that Burnham wished for would have meant that art could make use of its status as *nothing-in-particular* and *potentially-everything* in becoming *that* which keeps sight of far-reaching horizons." Ivanova, "Art's Values," 96 (emphasis in original).

store of value upon which the differential logic of algo-financial liquidity, as the emblem of contemporary power, thrives.

Does this mean that there are no examples of art that truly break with the singularized ontology of contemporary art and instead embrace the systemic reach of today's informational milieu for scopes other than capitalization? Quite the opposite. I believe that there are many instances of creative endeavors that challenge value's entanglement with institutional-financial power and provide interesting examples of the design of culture-oriented blockchain-platforms.[94] By proposing new incentive structures and, above all, through the renunciation of a pre-established (that is, economic) 'value' as metric of art's worth, these experimental practices foster the emergence of organizations around the participation in common projects. In the next section I present two such experiments in the blockchain ecosystem that, in line with the veritable invention of Bitcoin foregrounded in the previous chapter, offer promising examples for the constitution of truly distributed organizations suited to the socio-technical requirements of an already distributed world.

8.6 Art-Based Blockchains: Metamodeling Money and the Ethics of Risk

Below I briefly introduce two projects that, in rather different ways, harness the potential of the blockchain via the leveraging of social technics – that is, transactions – to invent entirely new socio-economic systems: D-CENT's complementary currency toolkit and Robin Hood's cryptoequity services. The peculiarity of such projects is that they are eminently financial-monetary experiments aimed at the socio-cultural field. Thus they also testify to the centrality of the monetary technology for the realization of alternative circuits of value creation and distribution that are not only economic but above all collective. While they do not pertain, strictly speaking, to the realm of

[94] In order to further the argument I have presented in this section, here I make a conceptual leap, from art to creative endeavors. As I anticipated in chapter six, following Simondon, I understand art as a practice of invention that involves a technical effort – a haptic attunement with the techno-aesthetic object – rather than labor. In this sense, art always already involves a generative act. In the remainder of this chapter, I specifically refer to creative experiments that, while not identifying themselves as art, present a certain artfulness to them that radically challenges the understanding of contemporary art brought forth by the institutional establishment. As I will illustrate at the end of this chapter, these experiments also activate a process that replaces the function of 'value storage' with one of distribution of the heterogeneity of the values involved in the creative act. In doing so, these experiments can be said to be *making* money, thereby challenging traditional conceptions of the analogical ontology of money and art.

contemporary art (or precisely because of this reason) they constitute interesting examples of emergent modes of the art of self-governance that I discussed in chapter one in relation to Simondon's universal cybernetics. In particular, I will focus on the novel possibilities these projects offer for the cultural and pedagogical context, where money does not provide an adequate metric of value. These are the fields that, in the current climate of 'austerity,' have suffered the most from the reduction of government funding in major Western countries.[95]

8.6.1 D-CENT: Metamodeling Money for Communities of Interest

D-CENT is a project funded by the European Union for the design of digital complementary currencies that allows the members of a community to deliberate collectively on matters of currency supply, in order to improve wellbeing and social and economic activity. At the time of this writing its development is in progress in pilot communities in Iceland, Spain, Finland, and Italy. Specifically, D-CENT aims to achieve social sustainability by uniting the distributed and participative form of the blockchain network with the distributed and participative action of human actors in an open-source toolkit for the design of complementary local currencies modeled on Bitcoin. In other words, D-CENT is not a currency, but a metamodel for a currency that allows communities to design their own money according to their needs and interests. By metamodel I mean here an allagmatic architecture founded on dynamic operations of mutual adjustments that admits indeterminacy as a necessary condition for the concretization of a system. Following Félix Guattari, Gary Genosko and Andrew Murphie explain that:

> Metamodeling de-links modeling with both its representational foundation and its mimetic reproduction. It softens signification by admitting a-

[95] For instance, in Australia the number of grants to individual artists has decreased by 70 percent since the 2013-14 financial year. Alison Croggon, "The 70% Drop in Australia Council Grants for Individual Artists Is Staggering," *The Guardian*, May 18, 2016, http://www.theguardian.com/culture/2016/may/19/the-70-drop-australia-council-grants-artists-funding-cuts. Furthermore, the recent Federal Budget 2016-17 has proposed a further 20 percent cut to higher education, increasing student loan overall debt and hindering access to university education for students coming from a low socio-economic background. Universities Australia, "Uni Funding Cuts No Answer to Higher Education Financial Sustainability," April 7, 2016, https://www.universitiesaustralia.edu.au/Media-and-Events/media-releases/Uni-funding-cuts-no-answer-to-higher-education-financial-sustainability#.V0k7opN96cY.

signifying forces into a model's territory; that is, the centrality and stability of meaningfulness is displaced for the sake of singularity's unpredictability and indistinctness.[96]

In other words, metamodeling, like allagmatics, privileges the dynamism and heterogeneity of operations over the fixity and homogeneity of structures: "metamodeling operations … introduce movement, multiplicity, and chaos into models."[97] Furthermore, by 'softening signification,' metamodeling operations provide the means for the structuring of *new* signification, from which a new *sense* of power may emerge. Yet as Genosko and Murphie clarify, metamodels are "not … completely without constraints."[98] That is, they possess certain enabling constraints that, as I explained in the previous chapter, correspond to the modulations that, while limiting the form/force of the relational technic, "facilitate[e] co-generation of effects."[99] The enabling constraints that D-CENT introduces consist in the possibility offered to communities of interest to create their own incentive structures and code them in the cryptocurrency protocol, and in an architectural foundation that replaces liquidity with a principle of clearing.

The key design principle of D-CENT is that of validation through a 'Social Proof-of-Work' (PoW) that impacts the way in which authentication and decentralization are achieved within a community. The Social PoW "is the proof that a member in the system is endowed with coins as a reward to an action in the real world while abiding to community rules and enhancing collective values."[100] Thanks to the open-source nature of the Freecoin toolkit, the Social PoW can be designed according to the needs and wills of each specific community, coding "political and economic incentive mechanisms that foster the social good."[101] By doing so, D-CENT replaces the strictly deterministic and individualistic process of value creation implemented by the Bitcoin's PoW algorithm with a more interactive and inclusive participative process, in which the value created

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96 Gary Genosko and Andrew Murphie, "Models, Metamodels and Contemporary Media," *Fibreculture Journal*, no. 12 (2008), http://twelve.fibreculturejournal.org/.
97 Ibid.
98 Ibid.
99 Erin Manning and Brian Massumi, *Thought in the Act: Passages in the Ecology of Experience* (Minneapolis: University of Minnesota Press, 2014), 94.
100 Denis Roio et al., "Design of Social Digital Currency" (London: Nesta, 2015), 28, http://dcentproject.eu/wp-content/uploads/2015/10/design_of_social_digital_currency_publication.pdf.
101 Ibid., 29.

through the blockchain "is authenticated by users through self-management as the main organizational propeller."[102] Importantly, the 'inventors' of D-CENT explain that "the incentives to gain are not applied to mining (which may be operated by collectively owned mining infrastructure) but to actions whose values are recognized by the Social POW democratic decision process,"[103] thereby implementing trust and democratic participation in voting mechanisms among the members of a community.

One of the pilot projects of D-CENT is Commoncoin – a cryptocurrency for the Italian cultural center Macao to sustain cultural production. Commoncoin replaces the current financial principle of liquidity with the principle of clearing that, as I explained in the previous chapter, consists in creating a closed accounting system in which the balance between credit and debt is constantly kept close to zero. By doing so, Commoncoin upends the logic of fluidification of socio-economic relations characteristic of algorithmic governmentality, since it gives primacy to the settling of accounts rather than the in(de)finite monetization of potential credit. As Amato and Fantacci suggest,[104] the architectural principle of liquidity embedded in fiat money has two principal socio-economic consequences: it subsumes the qualitative and social character of values under economic calculation (measured in fiat money); and it prevents the settling of accounts, allowing for capitalism to reproduce itself in its undead state. Drawing on John Maynard Keynes,[105] Amato and Fantacci argue that liquidity does not exist for a community. This is because liquidity is not an intrinsic characteristic of financial markets, due to the structural, therefore irreducible, non-liquidity of the capital represented by financial securities, no matter how intangible the underlying. Further, Amato and Fantacci note, liquidity does not exist for the community precisely because one can never eliminate the risk associated with *being* a community. As a matter of fact, a commons is constituted not only by shared resources but also, more importantly, by the shared risk that the sharing of those resources entails, which in turn implies a novel, shared accountability. In addition to the creation of a clearing house, Commoncoin implements the circuit of value creation and distribution by emphasizing the processes

[102] Ibid.
[103] Ibid., 35.
[104] Amato and Fantacci, *The End of Finance*.
[105] "Of the maxims of orthodox finance none, surely, is more anti-social than the fetish of liquidity, the doctrine that it is a positive virtue on the part of investment institutions to concentrate their resources upon the holdings of 'liquid' securities. It forgets that there is no such thing as liquidity of investment for the community as a whole." John Maynard Keynes, *The General Theory of Employment, Interest and Money* (New York: Harvest/HBJ, 1964), 155.

of authentication and circulation of the money-tokens, and proposing a series of policies such as minimal wage for cultural workers, negative interest to favor circulation, the promotion of transactions generative of further value to be circulated, and basic income to stimulate the Commoncoin economy.[106]

8.6.2 Robin Hood Minor Asset Management: An Ethico-Aesthetics of Risk[107]

While D-CENT leverages the participatory potential of the blockchain to empower communities through monetary policy, Robin Hood makes use of the blockchain to reengineer and democratize finance. Robin Hood is the first – and, at the time of writing, only – hedge fund organized as a cooperative. Its asset under management (AUM) derives from the activity of a parasite algorithm that, through an extensive activity of data mining, mimics the moves of the best players on the New York Stock Exchange and redistributes the profits among the members of the cooperative. By dynamically replicating the decisions of the financial elite, Robin Hood produces a difference in kind – in other words, it creates a 'bad copy' of the model of financial accumulation in order to distribute financial value among the precariat.[108] In contrast to D-CENT's eminently local scope, Robin Hood possesses a universalist thrust that aims to directly counter the global reach of the contemporary financial machine(s). In order to overcome the limitations of the consensus model of the cooperative and the scalability issues that derive from it, Robin Hood harnesses the topology of the blockchain to adapt the needs of a cooperative to the twenty-first-century subjectivity. For Robin Hood the topology of the blockchain is already fitted for a rhizome model of

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[106] Macao, "A Proposal for a Currency Design," *M^C^O*, accessed May 19, 2016, http://www.macaomilano.org/spip.php?article47.

[107] During the time of my research, Robin Hood Minor Asset Management Cooperative (RHMAM) has split into diverse entities: Robin Hood Coop (RHC), Robin Hood Unlimited (RHU), and Economic Space Agency (ECSA). RHC is the hedge fund owned by the members of the cooperative that is sustained by the activity of the Parasite Algorithm. RHU is the entity aimed to develop the distributed blockchain-based platform. The development of RHU was initiated by RHC and subsequently passed to ECSA, which was formerly called Robin Hood Services. Given the common origins of these three entities, in this section I will use the term Robin Hood to address, interchangeably, RHC, RHU, and ECSA. However, it must be noted that there are no financial relations between RHC and ECSA. See: Tere Vadén, "FAQ on the Relationships between Robin Hood Coop, Robin Hood Unlimited and Robin Hood Services," *Robin Hood Coop Forums*, September 2015, http://discourse.robinhoodcoop.org/t/faq-on-the-relationships-between-robin-hood-coop-robin-hood-unlimited-and-robin-hood-services/149; Tere Vadén, "FAQ on Robin Hood Services," *Robin Hood Coop Forums*, September 6, 2015, http://discourse.robinhoodcoop.org/t/faq-on-robin-hood-services/145.

[108] Robin Hood Cooperative, "Equity, Options, Assemblage: Robin Hood 2.0," Grey Paper (Milan, May 1, 2015), 2, https://speculativematerialism.files.wordpress.com/2015/06/robin-hood-grey-paper-april-2015.pdf.

the economy, allowing for an "organization at n-1 dimension, whereby any element aspiring to a position of centrality is subtracted."[109]

In order to do so, Robin Hood takes a radically new approach to the consensus model of the Bitcoin blockchain. By replacing mining with the activity of value creation performed by the parasite algorithm, Robin Hood does away with the energy-intensive process of validation via PoW and instead institutes a scalable and potentially generalizable cryptoequity crowdfunding platform, thereby offering a medium to bridge the needs and interests of localized communities with the global scale and magnitude that is needed to counter a system such as contemporary neoliberalism. Importantly, Robin Hood conceptually separates debt from equity and, through a double movement of dedifferentiation (i.e. pooling) and redifferentiation (i.e. tranching) similar to the ways in which collateralized debt obligations are ordered and rated, redistributes risk in hyperfungible blockchain-based equity-tokens, whose common value emerges from the dynamic portfolio of the AUM of the cooperative. Members of the cooperative can then exchange these crypto-tokens to finance cultural and social projects, thus realizing a radically new model of p2p lending through a 'dividualistic' voting system. In doing so, Robin Hood shifts the focus to the hyperfungibility of synthetic financial tools rather than the hyperfungibility of underlying assets – the latter being instrumental to the perpetuation of the algo-financial paradigm – thereby opening up possibilities for the reengineering of automated trading mechanisms toward a collaborative paradigm of distribution of wealth. However, this model raises certain ethical questions: for instance, is there a difference between equity and debt at the level of operations and structure? And what is the social and ethical 'cost' of the value of the AUM, considering that it relies on investments effectuated by the biggest players on Wall Street?

In answering these questions, it is important to note that, while Robin Hood concerns itself with the "aesthetics of algorithmic production,"[110] it does not admit any moral claims in relation to its ethical orientation. Robin Hood's ethic is a "shameless," "monstrous" ethic that is "about being able to take action upon oneself and others" in

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[109] Ibid., 5.
[110] Pekka Piironen and Akseli Virtanen, "Democratizing the Power of Finance: A Discussion About Robin Hood Asset Management Cooperative with Founder Akseli Virtanen," in *MoneyLab Reader: An Intervention in Digital Economy*, ed. Geert Lovink, Nathaniel Tkacz, and Patricia De Vries (Amsterdam: Institute of Network Cultures, 2015), 98.

order to "reopen the field of the possible."[111] Yet its parasitic derivative practice, gestures toward an 'ethic of risk' that reminds one of the kinds of artistic movements described by Randy Martin that I anticipated in the previous section.[112] As Martin explains, both dance and contemporary finance entail an attunement to arbitrage – a leveraging of the differentials and the phase-changes across fields of force in metastable equilibrium. In this context, Robin Hood acknowledges and embraces the open-endedness of its platform and the contingency immanent to both exchange and computation itself, and aims to leverage such a risk, rather than zero it as financial markets aim to do (while, however, generating more risk in turn, as chapter four explained). Robin Hood embraces the "be[ing] mutually together but not one"[113] caused by the processes of dividuation operated by the financial-logistical apparatus, and appropriates it in order to provide the means for the creation of an entirely distributed, swarm-like machine that exists in the circulation of the values it produces.

This process corresponds to what Simondon calls "transindividual relation" – a level of relationality that "corresponds to groups of interiority [*groupes d'interiorité*], to a veritable individuation of a group [*individuation de groupe*]" and that unfolds "below biological, biologico-social, and interindividual relations."[114] This kind of relation entails a universal reach and can only be achieved through "the test of isolation."[115] As Simondon puts it: "the individual finds the universality of the relation at the end of the test that is imposed upon it."[116] This corresponds to the encounter between the individuating individual and the psycho-collective reality. As Muriel Combes observes:

> It is only in solitude that communitarian belonging is undone. Still, for the subject to become engaged in the constitution of the collective, first of all, means stripping away community, or at the very least, setting aside those aspects of community that prevent the perception of the existence of preindividual, and thus the encounter with transindividual: identities, functions, the entire network of human "commerce" – of which the principal currency of exchange, as Mallarmé so aptly showed, is language,

[111] Ibid., 102.
[112] Martin, "Dance and Finance."
[113] Ibid.
[114] Simondon, *L'Individuation*, 294.
[115] Ibid., 273.
[116] Ibid.

> the "words of the tribe" in their daily usage – which assigns each person to their place within social space.[117]

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In light of these premises, both D-CENT and Robin Hood constitute examples of the 'social kinesthetics' discussed above, by which Randy Martin indicates the rippling out of the value generated by both the movements of dance practices and by the choreographies of currency. Even more so, they instantiate the "dance" between "the emergence of new tools, … [the] changing awareness of human nature and human action" that underlies the process of ontological design outlined by Winograd and Flores, which I discussed in the previous chapter.[118] By focusing on relations and operations of exchange, rather than monolithic fixed structures, both projects metamodel the social through the instantiation of "movement-sensibilities"[119] – oscillations, to-and-fros, and an inhabiting of the gaps between the financial-institutional apparatus and the psycho-collective milieu without excluding any of these terms at any time.

At the time of writing both D-CENT and Robin Hood are yet to be implemented, therefore some of the questions they raise remain unanswered. However, their approaches have the potential to *trans*-form socio-economic and financial dynamics, not just metaphorically but concretely, through the appropriation of the processes of dividuation characteristic of logistical-financial neoliberalism and a reorientation of automation toward the collective. By coding incentives in a way that *projects* the interests of a group toward a common interest, as I illustrated in the previous chapter, both experiments allow for the divorce of price from values, and the recognition of the heterogeneity of the latter. Furthermore, by embracing an ethico-aesthetics of risk, founded on the recognition of contingency and heterogeneity among the members of a collective, they open up further spaces from which novel invention can arise. Ultimately, given their socio-cultural orientation, both Robin Hood and Commoncoin,

[117] Muriel Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, trans. Thomas LaMarre (Cambridge: The MIT Press, 2013), 38.
[118] Terry Winograd and Fernando Flores, *Understanding Computers and Cognition: A New Foundation for Design*, Reprint edition (Norwood: Ablex Publishing Corporation, 1990), 163.
[119] Martin, "Dance and Finance."

as a specific implementation of the D-CENT toolkit, could provide the means for the activation of distributed networks aimed to encourage cultural experiments in light of the homogenizing effect of the neoliberal mode of organization and control that characterizes contemporary cultural production, as I will elaborate in the concluding section below.

8.7 Autonomy, Invention, and Artfulness: Toward the Speculative Engineering of New Social Kinesthetics

In this chapter I have discussed the contested relation between finance and the cultural sphere through an exploration of the field of contemporary art. I have shown that contemporary art entertains a complex and at times contradictory relation with the institutional-financial milieu it is embedded in and that, in spite of its political and ontological claims to the singularity of its 'value,' remains entangled in a logic that is operationally analogous to that of financial derivatives – the logic of reification of value through recursive circulation. Further, I have analyzed two examples of art experiments that engage with blockchain technology to seek emancipation from institutional power, Monegraph and Plantoid. In spite of the new technological apparatus, I have shown that these experiments repropose different aspects of algo-financial power, thus proving the impossibility to move beyond the contemporary sense of power through technology alone. Furthermore, I presented two hybrid examples between art, finance, and technology that deal precisely with the problem of reverse-engineering the logic of value creation and distribution of the financial machine through the blockchain.

Although these projects do not pertain to the field of contemporary art strictly speaking[120] – or better, advance a conceptualization of art that, in the reality of capitalization, does not conform to the institutionalized understanding of the term[121] – their "artfulness," a term that Erin Manning defines as "the momentary capture of an

[120] In this context, it is important to note that Robin Hood's position in relation to art is one that acknowledges "the collapse of old forms of society and subjectivity" in order to create "a new form, a new combination, a paradox or a monster that doesn't fit the boundaries of your normal life, the easy flow of things and action." Piironen and Virtanen, "Democratizing the Power of Finance," 99.
[121] This is well explained by Robin Hood, that "uses art as an essential part of social organization, economy, politics and life – like art was used before it became something separate with its own axiological reference system, you know, in 'primitive' societies for example dance, sound, plastic forms, signs in the body, ground and objects were essential part of the political organization, rituals, religious processes." Ibid.

aesthetic yield in an evolving ecology,"[122] may lie in their experimental approach to the technology at hand, by mobilizing value systems and modes of being together. Drawing on Raymond Ruyer, Manning clarifies that artfulness entails a notion of "immanent directionality"[123] and of participation:

> Artfulness, the aesthetic yield, is about how a set of conditions coalesce to favor what Lapoujade calls a "seizing of the inside" that generates the field of expression we call participation. The art of participation is its capacity to activate the artfulness at the heart of an event, to tap into its yield.[124]

From this standpoint, artfulness can be understood as directly related to the making of a new sense of power – the taking-consistency of a new axiomatic of signification. Both D-CENT and Robin Hood – through their cryptocurrency toolkit and cryptoequity crowdfunding system, respectively – do so precisely via the creation of a new 'social kinesthetics' by hardcoding an internal system of incentives that facilitates participation into a common project toward the benefit of a collective. In other words, they are aesthetic vectors with the capacity to orient the sense of unity – aesthetic thought – toward a new, immanent directionality. Importantly, this is not a finality but an "entelechy," as Simondon discusses it in the context of techno-aesthetics.[125] As Elizabeth Grosz observes, entelechy corresponds to the "forms of orientation"[126] internal to matter that, as Muriel Combes further specifies, "gives way to relationality, here in the mode of technicality."[127] Therefore, while neither Robin Hood nor D-CENT identify themselves as art projects, there is a profoundly new techno-aesthetics to their operations that precisely lies in the novel participatory dynamics they instantiate with the support of blockchain technology. As Robin Hood's founder Akseli Virtanen puts it, Robin Hood uses art "to produce aesthetic surplus value, by trying to attach directly to art's power to create unforeseen and unthinkable (economic, political, social, emotional, organizational…) processes."[128] Thus, these experiments may indeed realize Félix

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[122] Erin Manning, "Artfulness," in *The Nonhuman Turn*, ed. Richard Grusin (Minneapolis: Minnesota Press, 2015), 63.
[123] Ibid.
[124] Ibid.
[125] Simondon, "On Techno-Aesthetics."
[126] Elizabeth Grosz, "Identity and Individuation: Some Feminist Reflections," in *Simondon: Being and Technology*, ed. Arne De Boever et al. (Edinburgh: Edinburgh University Press, 2012), 46.
[127] Combes, *Gilbert Simondon and the Philosophy of the Transindividual*, 94.
[128] Piironen and Virtanen, "Democratizing the Power of Finance," 99.

Guattari's project of an ethico-aesthetic paradigm to be reached in the post-media age, and counter the neoliberal aesthetic paradigm discussed in chapter six with autopoietic "nuclei of resistance of resingularisation and heterogenesis."[129]

From this standpoint, the trajectory of this discussion begs another, perhaps more fundamental, question: when contemporary art talks about value, what *kind* of value is it talking about, in light of the immanence of institutional-financial dynamics to the socio-cultural sphere? And for whom, given the finitude of the human sensorium vis-à-vis the in(de)finite processing and processual capabilities of algorithmic agents as vectors of collective individuation and power formations? Ultimately, answering these questions may entail an entirely new definition not of *what* art is, but of *how* art is in the age of planetary computation, in its immanent co-constitution with markets and social dynamics.

[129] Félix Guattari, *Chaosmosis: An Ethico-Aesthetic Paradigm*, trans. Paul Bains and Julian Pefanis, Reprint edition (Sydney: Power Institute, 2006), 105.

Conclusion. Whose Value?

E-money will certainly re-engineer the body of the state.
But it will not leave its borders immunologically intact –
Sophea Lerner[1]

At the beginning of 2016 popular media and specialized press turned their attention to the recent tendency of central banks in Europe and Japan to embrace negative interest rate policy (NIRP).[2] Simply put, with NIRP the interest rate paid to commercial banks for monetary deposits in central banks' 'electronic vaults' goes below zero. This means that, because the price of (fiat) money – the interest rate – is negative, saving *costs*.[3] Counter-intuitively, by lowering their interests below zero, central banks hoped to fuel the real economy by getting commercial banks to facilitate the borrowing of money by customers in an attempt to encourage spending. Yet empirical evidence shows that NIRP doesn't work. In Sweden, for instance, instead of fostering lending and spending, the only concrete result that NIRP has achieved is rising inflation, especially in the housing market. House prices have soared due to how easy it is to obtain mortgages, increasing the threat of speculative bubbles – a situation that reminds one of the dynamics leading to the subprime mortgage crisis of 2008.[4] In addition to the fact that NIRP contradicts any fundamentals of economic theory, it needs to be noted that beyond being an economic concern, NIRP is first and foremost a mathematical problem.

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[1] Sophea Lerner, "E-Money" (unpublished manuscript, 1995), PDF file, 11.

[2] The controversial policy started in 2009 in Sweden and slowly expanded through Europe between 2014 and 2015, when the European Central Bank started to lower its interest rate to -0.1 percent; furthermore, at the end of 2015, the US Federal Reserve announced that it may follow. For more information, see: Allison Jackson and Jason Margolis, "So What's the Deal with Negative Interest Rates?," *Public Radio International*, February 12, 2016, http://www.pri.org/stories/2016-02-12/so-whats-deal-negative-interest-rates; C. W., "Why Negative Interest Rates Have Arrived—and Why They Won't Save the Global Economy," *The Economist*, February 18, 2015, http://www.economist.com/blogs/economist-explains/2015/02/economist-explains-15; Claire Jones, "European Banks Uneasy over Deeper Negative Interest Rates," *Financial Times*, February 9, 2016, http://www.ft.com/cms/s/0/2ed4d1ae-cf48-11e5-831d-09f7778e7377.html?siteedition=intl#axzz4HMQeDXAi; Jana Randow and Simon Kennedy, "Negative Interest Rates," *Bloomberg View*, June 6, 2016, http://www.bloomberg.com/view/quicktake/negative-interest-rates.

[3] As Bloomberg explains, "Imagine a bank that pays negative interest. In this upside-down world, borrowers get paid and savers penalized. … Negative rates will either mark the start of a new era for the world's central banks, or finally expose the limit of their powers." Randow and Kennedy, "Negative Interest Rates."

[4] Luke Kawa, "HSBC: Sweden's Experience Shows Negative Rates Haven't Worked," *Bloomberg.com*, February 10, 2016, http://www.bloomberg.com/news/articles/2016-02-09/hsbc-sweden-s-experience-shows-negative-rates-haven-t-worked. See also: Georgi Kantchev, Christopher Whittall, and Miho Inada, "Are Negative Rates Backfiring? Here's Some Early Evidence," *Wall Street Journal*, August 8, 2016, http://www.wsj.com/articles/are-negative-rates-backfiring-heres-some-early-evidence-1470677642.

To illustrate the absurdity of the "bizarro world of negative interest rates,"[5] Mark Jeftovic suggests the analogy of a computer code. If zero interest rate policy (ZIRP) entails the "dreaded *divide by zero error*," NIRP corresponds to "crossing the event horizon of a black hole."[6] This is not just a metaphor. Given banks' reliance on computational systems of accounting and trading platforms that do not contemplate the possibility of a negative interest (because that has never been the case in the history of economics) the threat of an 'ERR:DIV0' is very real. As Jeftovic continues, NIRP highlights the separation of the financial economy from both the so-called real economy and government policy. If, as data suggest, financial gains are at an all-time high but dividend yields are in a downward trend, then "today most of the gains are coming from stock buybacks – and many of those are leveraged, paid for with borrowed money at … artificially low interest rates."[7] This is particularly evident in the tech industry, where start-ups compete for funds and, once they go public on the stock market, the money raised is used to pay their early investors, leaving 'unicorns' with no profit at all.[8] In this climate, while the 'Bitcoin army' has started amassing cryptocurrency waiting for the economy to be swallowed by the black hole of NIRP,[9] business has instead continued as usual. In other words, although the news that "the 'financial pulse' of the economy (that being the price of money) has flatlined"[10] has become common knowledge, nothing has changed: people continue to put money in banks, save for superannuation, apply for loans, etc.

This example perfectly encapsulates what I have attempted to demonstrate in this thesis: that is, that the sense of power – of economic power, precisely – persists in perception, extending beyond and below knowledge, directly shaping what Simondon calls the psycho-collective realm of existence. This also has important consequences for the

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[5] Jeff Sommer, "In the Bizarro World of Negative Interest Rates, Saving Will Cost You," *The New York Times*, March 5, 2016, http://www.nytimes.com/2016/03/06/your-money/in-the-bizarro-world-of-negative-interest-rates-saving-will-cost-you.html.
[6] Mark Jeftovic, "Trapped inside the Zero Bound: What It Means Now That We've Crossed the Economic Event Horizon," *Rebooting Capitalism*, January 14, 2016, http://rebootingcapitalism.com/2016/01/14/trapped-inside-the-zero-bound-what-it-means-now-that-weve-crossed-the-economic-event-horizon/ (emphasis in original).
[7] Ibid.
[8] In tech-industry jargon, unicorns are those start-ups that are *valued* above $1 billion. The fact that they do not make any profit evidences the discrepancy between valuation and profit.
[9] See, for example: Charlie McCombie, "Negative Rates, Cash Blocks Help Adopt Cryptocurrencies," *CoinTelegraph*, February 26, 2016, http://cointelegraph.com/news/negative-rates-cash-blocks-help-adopt-cryptocurrencies.
[10] Jeftovic, "Trapped inside the Zero Bound."

milieu in which economic activity unfolds – the Earth – whose resources, as chapter two noted, have almost entirely been depleted. In other words, in spite of the economy being broke and the financial world making no sense, the only thing that still *makes* sense is economic Power. It does so through the technologies that allow it to weave the signifying axiomatic upon which the individuation of the planetary ecosystem unfolds, starting with the most elementary of such technologies – fiat money. As I noted in chapter two, the peculiarity of fiat money is that, for the first time in the history of economic exchange, it is at once a medium of exchange, a unit of account and, importantly, a store of value. Through the function of value storage – a value, however, that was wrongly mapped onto the discoveries of the physical sciences up until the nineteenth century – fiat money has initiated the uncontested rhetoric of flows upon which the contemporary ecosystem of power is predicated, blurring distinctions between commodity and credit, debtors and creditors, value and price, and thus contributing to the structural lack of clarity of the financial architecture. I have further argued that, through daily usage, fiat money has provided the means for the interiorization and amplification of economic reasoning and economic value, understood as marginal utility, into all aspects of life.

Starting from these premises, chapter three offered a close analysis of the ontological infrastructure of digital money in order to foreground the discrepancies between the economic value embodied by fiat money and the technical value constituted by the fleeting materiality of the relational forms of exchange that unfold in the digital milieu. As a matter of fact, digital money admits of diverse modes of existence that cannot be conflated with one another, such as fiat money and Bitcoin. Chapter four further illustrated how the genetic and normative role of the incomplete axiomatic of computation has impacted price and the very constitution of markets, rewiring the concept of economic rationality to include crises in the functioning of the financial machine.

Chapter five broadened the scope of analysis to the collective sphere and investigated the technical operations that allow algo-financial power to shape the social through transductive reification and modulative recursion. Here I have demonstrated that the social power of algorithmic finance corresponds to an algorithm that proceeds according to the movements of reification (of risk, of value, of ulterior digital fiat money) through recursive reordering and circulation, and that incorporates the positive feedback of liquidity crises in its functioning to protract its working indefinitely. In other words, if capitalism, until early cybernetics, was postulated on the principle of homeostasis – that is, negative feedback – contemporary power accommodates instead the positive feedback of liquidity crises and, in doing so, is able to exert constant, but mutant, control on the social sphere. By taking a technical approach to financial logic based on Simondon's allagmatic theory, my goal has been to desubstantialize and relativize financial power, and show that the autonomy of technics provides margins for intervention in the operations of algorithmic finance. In chapter six, I further explored how this mode of power extends below human perception and, through the ingression of new spatiotemporalities, modifies the axiomatic of signification of the living. Here I have discussed the aesthetics of the black box of algorithmic trading and, embracing the impossibility of furnishing a cognitive representation of contemporary finance, I have argued for a haptic aesthetics – a techno-aesthetics of the feel.

Chapter seven was instead devoted to an exploration of the novelty of Bitcoin, which consists of a reinterpretation – a minor hermeneutic – of the technical operations of reification and recursion, thereby setting the foundations for a novel process of value creation and distribution. Yet I have also shown that, in spite of the technical novelty, Bitcoin has not been able to overcome the sense of algo-financial power. Lastly, chapter eight discussed the realm of contemporary art as an example of the ways in which the sense of algo-financial power plays out in the socio-cultural sphere. I have explained that, in spite of the ideological and ontological claims to the singularity of contemporary art, the latter is increasingly subjected to the logic of algo-financial power – whether with or without the support of blockchain technology. I have further argued that, on the one hand, this testifies to the limits of technological determinism in relation to the socio-political sphere. On the other hand, however, the openness and indeterminacy of post-industrial technical objects allows for radically new kinds of invention – that is, ontological inventions that, while challenging the relation between art and its institutional-financial milieu, open up novel horizons of possibility and modes of existence for art as it heads toward the constitution of a technical culture.

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From the standpoint of negative interest policy, if computational economics initially adopted mathematics to gain credibility, as I have shown in the thesis, it now seems as if economics itself is attempting to bend the axioms of arithmetic in its favor (e.g. dividing by zero) – perhaps a testimony to the in(de)finite character of the contemporary mode of power. Yet NIRP also means that the *value* of money is finally free from its subjection to price – and in fact, one could read the recent attempts by big banks and financial institutions to ban cash as a spin-off of this initiative.[11] From this standpoint, experimenting with alternative monetary technology and circuits of *value* creation and distribution makes more sense than anything else. In fact, it has the potential to make a *new* sense of the economy, and of the power that runs it. At this point, however, the initial problematic posed by the value of technics in relation to economic value – in particular, of technics of exchange and monetary technology – points toward two distinct possible directions, one socio-political and one economic. In the remainder of this concluding section I will discuss both issues. However, rather than providing exhaustive answers, the following paragraphs aim to act as a launching pad for further research and experimentations with values and technics of exchange.

Starting with the socio-political aspect, what this thesis has shown is that the value of algorithmic technology lies in its openness to what Simondon calls technical effort. Technical effort corresponds to the creative *act* of invention that provides technical objects with a new orientation and a new organizational paradigm. As such, it requires a particular kind of attunement with technology, one that precedes the separation of form from matter and instead relates directly to the process of information – that is, it entails modulation, instead of moulding.[12] Furthermore, this means that the relation between the technical and the socio-political is always in becoming and can never reach a stasis, which would instead entail the entropic death of the relation. As Simondon puts it, "it is

[11] This is because, while digital fiat money can be modulated by banks, hard cash is resistant to the imperatives of monetary policy. See: Tyler Durden, "What A Cashless Society Would Look Like," *Zero Hedge*, January 31, 2016, http://www.zerohedge.com/news/2016-01-31/what-cashless-society-would-look; Helen Nugent, "Is the Cashless Society a Good Thing? Definitely Not," *The Spectator*, May 24, 2016, http://blogs.spectator.co.uk/2016/05/cashless-contactless-cards/; The Editors, "Bring On the Cashless Future," *Bloomberg View*, January 31, 2016, https://www.bloomberg.com/view/articles/2016-01-31/bring-on-the-cashless-future; Megan McArdle, "It's All Fun and Games Until Somebody Loses a Bank Account," *Bloomberg View*, March 15, 2016, https://www.bloomberg.com/view/articles/2016-03-15/the-end-of-cash-and-the-rise-of-government-power; Brett Scott, "The War on Cash," *The Long and Short*, August 19, 2016, http://thelongandshort.org/society/war-on-cash.

[12] Gilbert Simondon, *L'Individuation à la Lumière des Notions de Forme et d'Information* (Grenoble: Millon, 2013), 47.

within the perspective of permanent change of technical and socio-political structures that technical thought and socio-political thought can coincide."[13] In my brief stint as a cryptocurrency miner, I directly experienced the productive metastability of the technical and socio-political Darkcoin milieu in the process of setting up the mining rig. This entailed gathering information on forums and specialized blogs, asking the Darkcoin community on Reddit for help, coding my way through the protocol, plugging into 'mining pools,' *feeling* the process of value creation through the strings of letters and numbers cascading on the terminal. The mining process – the most fundamental aspect of a cryptocurrency's network – generates a value that extends beyond the mere production of monetary units. It opens up the channels for a transindividual technical relation, by which one, alone, comes into *contact* with a heterogeneous assemblage of singular and impersonal nodes that, in spite of this, display an openness and generosity not accessible elsewhere on the World Wide Web. This is because, as I explained, each node acts as incentive for itself and for the larger individuating network. Like the ancient practice of weaving, in the case of cryptocurrency, the design of patterns and the gestures that create those patterns, together with the loom, that is, the technical apparatus – hardware, software, and wetware – are inseparable from each other.[14] The process of *in*-formation runs through every node, knot, and thought. From this standpoint, each act – even, or perhaps more so, the anonymous, impersonal, acts that have woven the original Bitcoin network together – is political, since it activates a change in the overall configuration of the relations and operations that link the nodes together. Granting openness and participation to such alternative networks of value creation and distribution through acts of information is fundamental to a project that aims at the reversal of the overarching sense of power. However, one needs to tread carefully. As I have observed in chapter one through the discussion of allagmatics, the line between a project that takes individuation seriously and the libertarian precept of 'methodological individualism' is a fine one. In order to avoid falling into the latter, it is fundamental to envision and activate a series of enabling constraints that would prevent individual benefits from escalating and trumping the benefits of the collective.

[13] Gilbert Simondon, *Du Mode d'Existence des Objets Techniques* (Paris: Aubier, 1989), 231.
[14] See: Sadie Plant, *Zeroes + Ones: Digital Women + the New Technoculture* (New York: Doubleday, 1997), 60–69.

This also means that, as appealing as "luxury communism"[15] may sound, the relation between human and machine is not and will never be smooth. As I illustrated in my discussion of Bitcoin, it is the metastability inherent in the encounter between human and machine that creates the conditions for invention. Risk and value are, quite literally, two side of the same coin. From this standpoint, the constitution of new networks of value(s) entails an ethics of risk. In other words, it is a matter of tending to the operations of information and to the modulation of risk without however annihilating the latter or flattening it onto the topological surface of capital relations. As Simondon puts it:

> There is an ethics to the measure that there is information, that is to say signification overcoming a disparation in the elements of beings, and making it so that what is interior is also exterior. The value of an act is not its universalizable [*universalisable*] character, according to the norm that it implies, but it lies in the effective reality of its integration in a network [*réseau*] of acts that is becoming. This is a network and not a chain of acts; … ethical reality is structured as a network, that is to say that there is a resonance of acts in relation to each other, not through implicit or explicit norms but directly in the system that [these acts] form and that constitutes the becoming of being. … The act is neither matter nor form, it is becoming in the process of becoming [*il est devenir en train de devenir*].[16]

From this standpoint, the socio-political value of the technics of exchange lies in the singularity of each act or gesture that, through resonance, composes an ethics of information, but also, as I argued above, of risk, as the case of Robin Hood illustrated. This points to the fact that information and risk are not dissimilar from each other. Both occasion a "difference that makes a difference,"[17] as Gregory Bateson would put it – an energetic, and genetic, *surplus* that cannot ever be entirely axiomatized by the law of price. In this optic, not only do information and risk entail the generation of difference;

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[15] See: Brian Merchant, "Fully Automated Luxury Communism," *The Guardian*, March 18, 2015, http://www.theguardian.com/sustainable-business/2015/mar/18/fully-automated-luxury-communism-robots-employment; Bernard Marr, "Are We Headed for 'Automated Luxury Communism'?," *Forbes*, June 30, 2016, http://www.forbes.com/sites/bernardmarr/2016/06/30/are-we-headed-for-automated-luxury-communism/#66309bc43dcb.
[16] Simondon, *L'Individuation*, 323–24.
[17] Gregory Bateson, *Mind and Nature* (London: Fontana Paperbacks, 1980), 242.

they also demand the unconditional acknowledgement of such a difference in order to prevent the latter from folding back onto the plane of equivalence of the universal *numéraire* of digital computation.

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The second answer to the question posed by the value of technics concerns economic value. As my introductory discussion of NIRP showed, the new policy of negative interest rate adopted by central banks means that money is now freed from its subjection to price. This is to say that, when the price of money is negative – when saving costs more than spending – the monetary *medium* of exchange and *measure* of account literally does not *store* value anymore. If anything it *exhausts* it, given the present configuration. As I described in chapter two following Philip Mirowski, the history of modern economic theories of value is an exegesis of conservation principles borrowed from physics. From this standpoint, Simondon's theory of individuation, which is precisely mapped onto the physical paradigm of quantum physics, constitutes the conservation principle *par excellence*, since it allows for the conservation of being through becoming. Thus individuation already provides a metamodel for a new value theory based, as described above, on the surplus generated by the resonance between acts of information in a network.

In addition to this, recent physical theories of evolution provide more scientific support for Simondon's theory – not through quantum physics but according to thermodynamics. As I explained in chapter two, thermodynamics only entered the realm of economic thought in the mid-twentieth century but its application was based on a false analogy between entropy and a deceitful 'Nature' to be annihilated at all costs. Today instead, in the trajectory opened by Ilya Prigogine,[18] MIT physicist Jeremy England has developed a mathematical proof that may be able to explain biological evolution in far-from-equilibrium systems, precisely through entropic dissipation.[19] England has shown that, in the microscopic realm, organizations take consistency

[18] See: Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam Books, 1984).
[19] "The principal aim of this work is to show that the microscopically detailed, quantitative relationship between irreversibility and entropy production … has significant, general thermodynamic consequences for far from-equilibrium, macroscopic processes such as biological self-replication." Jeremy England, "Statistical Physics of Self-Replication," *The Journal of Chemical Physics* 139, no. 121923 (2013): 139.

through the entropy that is dissipated in the system by means of the work (that is, energy) that the system itself performs on the entities belonging to it. Further, through *amplification,* such microscopic changes may impact macrostates, such as organic individuals. As England explains, "You start with a random clump of atoms, and if you shine light on it for long enough, it should not be so surprising that you get a plant."[20] This new proof may indeed set the foundations for a universal cybernetics of the like of that envisaged by Simondon. As a matter of fact, while England's claim remains limited to the field of physics, it is Simondon's metaphysics that provides the conceptual tools to extend this novel theory to the individuation of complex heterogeneous systems, and draw important conclusions for economics too.[21] While this is not the site for an exhaustive discussion of England's theory of dissipation-driven organizations, it is important to note that, by mapping the economic theory of value upon England-via-Simondon's physical paradigm, value becomes recast in terms of irreversible dissipation of energy – that is, transductive energy, which depends on the amount of work that is done by and through the engagement with a milieu. This, following England, may allow for the temporary reversibility of the second law of thermodynamics through irreversible entropic dissipation, which may in turn lead to the emergence of life.

In light of these advancements in physics, how would such a concept of energy impact economic theories of value? Or, to put it differently, how would the concept of economic value imbued in scientific thinking change in light of this discovery? And, given that contemporary money is considered a store of value, how would the monetary architecture have to be redesigned in order to reflect this novel entropic economy, in which the more energy an entity dissipates, the more evolutionary value it contributes to the entire system? While much work has to be done in this direction, my wager is that this renewed understanding of entropy may provide the basis for the creation of a monetary system that rewards for putting to use – that is, the more the exchange (money-medium) the more the account-*ability* (money-account) for each node, and vice versa. This may lay the foundations for a monetary system that is modulated by the dynamics immanent to the network. In a way, this is already what Commoncoin proposes through the introduction of a demurrage system (that is, a fee on uncirculated

[20] England in Natalie Wolchover, "A New Physics Theory of Life," *Quanta Magazine*, January 22, 2014, https://www.simonsfoundation.org/quanta/20140122-a-new-physics-theory-of-life/.
[21] Esra Atamer has discussed the relation between Prigogine's work and Simondon's theory of individuation in: Esra Atamer, "Dissipative Individuation," *Parrhesia* 12 (2011): 57–70.

money-tokens) that would favor the circulation of the value embodied by crypto-money. Furthermore, such a system could incentivize cooperation and participation in the networked dynamics that compose it. However, as I noted in chapter seven, the realization of such a network will need certain enabling constraints that would prevent opportunistic behaviors. In other words, it demands the a priori definition of a common project that would *project* the system toward a specific orientation. In broad terms, this corresponds to the direction of the evolution of the system. Ultimately, it may allow for the taking-consistency of a system that would reward its participating nodes – bits of dividuals – with purchasing power, a concrete power of purchase upon reality. Positing a genetic relation between risk and value provides the means to understand that, in a dissipative system, the higher the entropy, the higher the dissipation – or, as Simondon would put it, *irradiation* – of the values generated through exchange.

Furthermore, this reformulation of the economic value embedded in and irradiated by the technics and technologies of exchange may provide the means to move from the economy of depletion we live in today, that I described in chapter two, to truly dissipative ecosystems. This however may be possible only by means of an obligatory passage through exhaustion, which is exactly the point at which we are now. In the words of Peter Pál Pelbart, exhaustion entails the "passage from catastrophe to creation, as well as the substitutability of the 'nothing is possible' and the 'everything is possible.'"[22] In other words, exhaustion marks a turning point in the orientation-individuation of a system – the brink of a true phase-shift from which new ecosystemic dynamics may arise. Thus exhaustion needs not to be confused with negativity; instead, Pelbart insists via Deleuze, that the concept of exhaustion manifests an "unavoidable affirmativity, an 'obstinate Spinozism.'"[23] This shares many connotations with the thermodynamic operation of entropy defined above. Only the exhaustion of potential energy in a system may allow for the insertion of a novelty through an act – an instance of 'work' performed by the milieu through its constitutive elements. While these are only 'seeds of thought' for further research and experimentations, this discussion also points to the fact that, if neoliberalism has become environmental, power is not natural at all. If it were, it would already behave according to what Gregory Bateson calls the

[22] Peter Pál Pelbart, *Cartography of Exhaustion: Nihilism Inside out*, trans. Hortencia Santos Lencastre (Helsinki: n-1 publications, 2013), 105.
[23] Ibid., 108.

"pattern which connects."[24] While Bateson refers to the aesthetic unity that joins together the biological world, through a Simondonian twist I mean here the dissipative, amplificatory process of information that operates through energetic exchanges across different realms of existence. This means that, because power is not 'natural,' it can be reengineered precisely through a technical effort combined with an ethics and politics of risk involved in the act of information.

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To recap, above I have illustrated that, on the one hand, the socio-political trajectory of the value of technics points to the careful work of modulation of the acts involved in the weaving of net-works – mesh-works of value creation and distribution. On the other hand, the economic dimension of the value immanent to technics of exchange corresponds to the transductive dissipation of energy in a milieu with the ultimate purpose of defeating the heat death of the universe by providing the means for the crossing of the threshold that marks the emergence of life. It is not a matter of mere survival but, as Alfred N. Whitehead puts it, of promoting the "art of life,"[25] which is the purpose of the function of Reason – understood beyond the limiting rationality of the numbered number of economic calculation to instead encompass speculative reason. In other words, both trajectories point toward the higher value of technics – that is, promoting veritable evolution. From this standpoint, the paradoxical position of evolutionary computational economics and genetic trading strategies in respect to the environment entails further questions: in evolutionary economics who or what evolves? And how could we instead create a system for the co-evolution of natural and man-made resources in a way that would allow for the sustainability of the three ecological registers described by Guattari, discussed in chapter two?

While these questions would require another dissertation to be answered, the two aspects of the value of technics that I discussed above – the socio-political and the economic – suggest that a shift is possible. This could be achieved through a technical effort, a haptic engagement with our 'technologies for storing value' that would reflect

[24] Bateson, *Mind and Nature*, 16. To Bateson the 'pattern which connects' corresponds to aesthetic unity. This could be also understood in terms of Simondon's aesthetic thought and Raymond Ruyer's aesthetic yield, as I discussed in chapter eight through Erin Manning's definition of artfulness.
[25] Alfred North Whitehead, *The Function of Reason* (Boston: Beacon Press, 1958), 4.

socio-political values. My hypothesis is that this may constitute an important step toward the realization of a technical culture – a culture that would admit and acknowledge the autonomy of technics without however crashing it. In the specific context of cultural and pedagogical projects, the examples provided by D-CENT and Robin Hood in chapter eight could furnish fruitful tools for thinking about how to create the conditions to orient values toward the mobilization of large collectives aimed at fostering the heterogeneity of cultural experiments that may break with the current sense of power and favor the engineering of a new sense. These could be summarized in the following meta-propositions:

1. The common ownership of and participation in 'mining,' by which I mean the process of value creation and distribution, which may also entail the redesign of the Bitcoin mining algorithm and/or the repurposing of the energy created through mining toward productive uses (e.g. heating systems);

2. Broadening the scope of the concept of wealth beyond economic utility to encompass the value of what escapes outcome-based assessment and economic calculation, such as process-based art and research-creation initiatives;

3. The structuration of an immanent incentive structure that would reflect such an expanded concept of wealth and reject individual capital accumulation, for instance through demurrage, as D-CENT proposes;

4. The implementation of a novel accounting system through the distributed ledger of the blockchain, which demands a renewed accountability – an ethics of exchange;

5. A distributed voting system that would foster the heterogeneity of the cultural initiatives proposed by its participants, as Robin Hood's crypto-crowdfunding proposes;

6. The creation of a semi-closed system that would allow for the irreversible conversion of fiat currency into value-tokens, in order to prevent the extraction and conversion of social and cultural values into financial profit operated by neoliberal apparatuses;

7. Such a semi-closed system would also need to be accompanied, as I explained above, by an ethics of risk, which entails an openness to contingency and experimentation with risk-generating practices – the kinds of processes that allow for the creation and distribution of value;

8. The investment in collaborative activities toward the expansion of the circuit of value creation, distribution, and exchange within a community of interest;

9. Ultimately, the design of an agile, customizable series of tools that would allow for the reproduction, generalization, and extension of the platform.

*

At the dawn of the commercialization of the Internet in the mid-1990s, artist Sophea Lerner wrote that:

> Digital money is a symptom of changing configurations of capital and representation in an increasingly genetic economy where species and specie are merging and states struggle not simply to position themselves at the core in relation to a periphery but to perpetuate the distinction between the two in any meaningful way.[26]

Fast-forward twenty years, and developments in genetics have taken a strange, alien turn, orienting evolution away from biological systems and instead becoming increasingly concerned with the evolution of silicon-based machines aimed to "maintain cryptoscarcity over the standard for a new species of commodity money."[27] However, with the 'digitalization of everything,' it will become increasingly difficult to maintain the divisions upon which contemporary power thrives "immunologically intact."[28] In other words, if the architecture of fiat money enabled the taking-consistency and extension of the capitalist ecosystem, then digital money heralds a new era that has the

[26] Lerner, "E-Money," 2.
[27] Ibid., 11.
[28] Ibid.

potential to profoundly shake the signifying axiomatic upon which capitalist – and today, albeit differently neoliberal – power has extended its reach.

From this standpoint, Pierre Klossowski may provide a launching pad to explore the relation between humans, machines, and capital in radically new ways. Paraphrasing his concluding remark in *La Monnaie Vivante*:

> As soon as the bodily presence of the [post-]industrial slave is absolutely included in figuring the appraisable yield of what he or she can produce (their physiognomy being inseparable from their work), it is specious to draw a distinction between a person and their activity. Bodily presence is already a commodity, independent of and *over and above* the commodity itself that such presence contributes to producing. And now, [post-]industrial slaves must either establish a strict relationship between their bodily presence and the money it brings in, or replace the function of money, and be money themselves: simultaneously the equivalent of wealth, and wealth itself.[29]

While the impact of the digitalization of monetary and financial flows on the psycho-collective sphere raises fundamental questions on the nature and function of money in the contemporary ecosystem that are worth investigating, Simondon and Laruelle remind us that the power of humanity is in our *hands*, in the power of the senses.

[29] Pierre Klossowski, *La Monnaie Vivante*, 1970, https://www.scribd.com/doc/102285892/Klossowski-Pierre-La-Monnaie-Vivante (emphasis in original).

Bibliography

Aalbers, Manuel B. "The Financialization of Home and the Mortgage Market Crisis." *Competition & Change* 12, no. 2 (June 2008): 148–66.

"About | Artsy." Accessed March 24, 2016. https://www.artsy.net/about.

Akkermans, Ari. "Hints of the Real World in Art Basel's Elitist Bubble." *Hyperallergic*, June 22, 2016. http://hyperallergic.com/306912/hints-of-the-real-world-in-art-basels-elitist-bubble/.

Alt, Casey. "Objects of Our Affection: How Object Orientation Made Computers a Medium." In *Media Archeology: Approaches, Applications and Implementations*, edited by Erkki Huhtamo and Jussi Parikka, 278–301. Berkeley: University of California Press, 2011.

Altman, Anna. "Buy, Sell, Hang on Your Wall." *Bloomberg Businessweek*, November 13, 2015. http://www.bloomberg.com/news/articles/2015-11-12/artrank-gives-art-the-stock-market-treatment.

Amato, Massimo. *La Monnaie Eutopique*. TEDxNantes. Nantes, 2011. http://tedxtalks.ted.com/video/TEDxNantes-Massimo-Amato-La-Mon.

Amato, Massimo, and Luca Fantacci. *The End of Finance*. Cambridge: Polity, 2011.

Antonopoulos, Andreas M. *Mastering Bitcoin*. Sebastopol: O'Reilly Media, 2014.

———. "Peer-to-Peer Money in a Historical Context." Rotterdam, 2015. https://www.youtube.com/watch?v=n-EpKQ6xIJs&feature=youtu.be.

Aranda, Julieta, Brian Kuan Wood, Stephen Squibb, and Anton Vidokle. "Editorial." *E-Flux*, no. 70 (February 2016). http://www.e-flux.com/announcements/new-issue-new-editor-new-book/.

Ashby, W. Ross. *An Introduction to Cybernetics*. London: Chapman & Hall, 1957.

Atamer, Esra. "Dissipative Individuation." *Parrhesia* 12 (2011): 57–70.

Avellaneda, Marco. "Algorithmic and High-Frequency Trading: An Overview." presented at the Quant Congress USA, 2011. https://www.math.nyu.edu/faculty/avellane/QuantCongressUSA2011AlgoTradingLAST.pdf.

Ayache, Elie. "A Formal Deduction of the Market." In *Collapse: Casino Real*, edited by Robin Mackay, 959–98. Falmouth: Urbanomic, 2014.

———. "In the Middle of the Event." In *The Medium of Contingency*, edited by Robin Mackay, 19–35. Falmouth: Urbanomic, 2011.

———. *The Blank Swan: The End of Probability*. Chichester: Wiley, 2010.

Babbitt, Dave. "Crypto-Economic Design: A Proposed Agent-Based Modeling Effort," 11/36. Univeristy of Notre Dame, 2014. http://www3.nd.edu/~swarm06/SwarmFest2014/Crypto-economicDesignBabbit.pdf.

Baker, Malcom, and Jeffrey Wurgler. "Investor Sentiment in the Stock Market." *Journal of Economic Perspectives* 21, no. 2 (Spring 2007): 129–51.

Bardin, Andrea, and Giovanni Menegalle. "Introduction to Simondon." *Radical Philosophy*, no. 189 (February 2015). https://www.radicalphilosophy.com/article/introduction-to-simondon.

Bardini, Thierry. "Simondon, Individuation and the Life Sciences: Interview with Anne Fagot-Largeault." *Theory, Culture & Society* 31, no. 4 (July 2014): 141–61.

Barnosky, Anthony D., Nicholas Matzke, Susumu Tomiya, Guinevere O. U. Wogan, Brian Swartz, Tiago B. Quental, Charles Marshall, et al. "Has the Earth's Sixth Mass Extinction Already Arrived?" *Nature*, no. 471 (March 3, 2011): 51–57.

Barthélémy, Jean-Hugues. "Fifty Key Terms in the Works of Gilbert Simondon." In *Gilbert Simondon: Being and Technology*, edited by Arne De Boever, Alex Murray, Jon Roffe, and Ashley Woodward, translated by Arne De Boever, 203–31. Edinburgh: Edinburgh University Press, 2012.

Bateson, Gregory. *Mind and Nature*. London: Fontana Paperbacks, 1980.

Batycka, Dorian. "The 9th Berlin Biennale: A Vast Obsolescent Pageant of Irrelevance." *Hyperallergic*, June 24, 2016. http://hyperallergic.com/306932/the-9th-berlin-biennale-a-vast-obsolescent-pageant-of-irrelevance/.

Baumol, William J. "Unnatural Value: Or Art Investment as Floating Crap Game." *The Journal of Arts, Management and Law* 15, no. 3 (Fall 1985): 47–59.

Baur, Dirk. "What Is Co-Movement?" Varese: European Commission, 2003.

Bazzichelli, Tatiana. *Networking Art: The Net as Artwork*. Aarhus: Digital Aesthetics Research Center, 2006.

Bazzichelli, Tatiana, and Geoff Cox, eds. *Disrupting Business: Art & Activism in Times of Financial Crisis*. Brooklyn: Autonomedia, 2013.

Beardsley, Monroe C. *Aesthetics from Classical Greece to the Present*. Tuscaloosa: University Alabama Press, 1975.

Bearman, Joshuah. "The Untold Story of Silk Road, Part 1." *WIRED*, April 28, 2015. http://www.wired.com/2015/04/silk-road-1/.

Berardi, Franco "Bifo." *The Uprising: On Poetry and Finance*. Los Angeles: Semiotext, 2012.

Bernstein, Jake. "The Art of Secrecy." *The International Consortium of Investigative Journalists*, April 7, 2016. https://panamapapers.icij.org/20160407-art-secrecy-offshore.html.

Bessy, Christian, and Pierre-Marie Chauvin. "The Power of Market Intermediaries: From Information to Valuation Processes." *Valuation Studies* 1, no. 1 (April 17, 2013): 83–117.

Biswas Mellamphy, Nandita. "Nietzsche's Political Materialism: Diagram for a Nietzschean Politics." In *Nietzsche as Political Philosopher*, edited by Barry Stocker and Manuel Knoll, 77–90. Berlin: De Gruyter, 2014.

"Bitcoin Charts / Markets API." Accessed July 16, 2016. https://bitcoincharts.com/about/markets-api/.

"Bitnodes." *Bitnodes*, 2016. https://bitnodes.21.co/.

Bjerg, Ole. "How Is Bitcoin Money?" *Theory, Culture & Society* 33, no. 1 (2016): 53–72.

———. *Making Money: The Philosophy of Crisis Capitalism*. London: Verso, 2014.

———. *Parallax of Growth: The Philosophy of Ecology and Economy*. Cambridge: Polity, 2016.

Black, Fischer. "Noise." *The Journal of Finance* 41, no. 3 (July 1986): 529–43.

Black, Fischer, and Myron Scholes. "The Pricing of Options and Corporate Liabilities." *The Journal of Political Economy* 81, no. 3 (1973): 637–54.

Bollier, David. "The Blockchain: A Promising New Infrastructure for Online Commons." *David Bollier: News and Perspectives on the Commons*, April 3, 2015. http://bollier.org/blog/blockchain-promising-new-infrastructure-online-commons.

Bonneau, Joseph, Andrew Miller, Jeremy Clark, Arvind Narayanan, Joshua A. Kroll, and Edward W. Felten. "SoK: Research Perspectives and Challenges for Bitcoin and Cryptocurrencies." *IEEE Security and Privacy*, n.d. http://www.jbonneau.com/doc/BMCNKF15-IEEESP-bitcoin.pdf.

Boyle, Phelim P. "Options: A Monte Carlo Approach." *Journal of Financial Economics* 4, no. 3 (May 1977): 323–38.

Bratton, Benjamin. "The Black Stack." *E-Flux* 3 (2014). http://www.e-flux.com/journal/the-black-stack/.

Brautigan, Richard. *All Watched Over by Machines of Loving Grace*. San Francisco: Communication Company, 1967.

Broeckmann, Andreas. “Postmedia Discourses.” Working paper, 2013. http://www.mikro.in-berlin.de/wiki/tiki-index.php?page=Postmedia+Discourses.

Brown, Ronald, and Tim Porter. “Category Theory: An Abstract Setting for Analogy and Comparison.” In *What Is Category Theory?*, edited by Giandomenico Sica, 257–74. Monza: Polimetrica Scientific Publisher, 2006.

Browning, Lynnley. “The Subprime Loan Machine.” *The New York Times*, March 23, 2007. http://www.nytimes.com/2007/03/23/business/23speed.html.

Brush, Silla, Tom Schoenberg, and Suzi Ring. “How a Mystery Trader with an Algorithm May Have Caused the Flash Crash.” *Bloomberg.com*, April 22, 2015. http://www.bloomberg.com/news/articles/2015-04-22/mystery-trader-armed-with-algorithms-rewrites-flash-crash-story.

Bryan, Dick, and Michael Rafferty. “A Time and a Place for Everything: Foundations of Commodity Money.” In *Money and Calculation. Economic and Sociological Perspectives*, edited by Massimo Amato, Luigi Doria, and Luca Fantacci, 101–21. Houndmills: Palgrave Macmillan, 2010.

———. *Capitalism with Derivatives: A Political Economy of Financial Derivatives, Capital and Class*. Houndmills: Palgrave Macmillan, 2006.

Buck-Morss, Susan. “Envisioning Capital: Political Economy on Display.” *Critical Inquiry* 21, no. 2 (Winter 1995): 434–67.

Burnham, Jack. “Systems Esthetics.” *Artforum*, September 1968.

Buterin, Vitalik. “Critical Update Re: DAO Vulnerability.” *Ethereum Blog*, June 17, 2016. https://blog.ethereum.org/2016/06/17/critical-update-re-dao-vulnerability/.

———. “DAOs, DACs, DAs and More: An Incomplete Terminology Guide.” *Ethereum Blog*, May 6, 2014. https://blog.ethereum.org/2014/05/06/daos-dacs-das-and-more-an-incomplete-terminology-guide/.

———. “State of the Onion Report.” Conference Presentation presented at the Blockchain Workshops, Sydney, December 11, 2015. https://docs.google.com/presentation/d/1CxYZbJCryTM2Jz_b6a9_DRe5oD_51ZMjB8vxtfdA2oA/mobilepresent?slide=id.p&usp=embed_facebook.

Carlson, Mark. “A Brief History of the 1987 Stock Market Crash with a Discussion of the Federal Reserve Response.” Finance and Economics Discussion Series. Washington: Divisions of Research & Statistics and Monetary Affairs, Federal

Reserve Board, November 2006. http://www.federalreserve.gov/pubs/feds/2007/200713/200713pap.pdf.

Carmona, René, Pierre Del Moral, Peng Hu, and Nadia Oudjane. “An Introduction to Particle Methods with Financial Applications.” In *Numerical Methods in Finance*, edited by René A. Carmona, Pierre Del Moral, Peng Hu, and Nadia Oudjane, 3–49. Springer Proceedings in Mathematics 12. Berlin: Springer Berlin Heidelberg, 2012.

Cascone, Sarah. “Panama Papers Reveal Ganz Collection Secret.” *Artnet News*, April 8, 2016. https://news.artnet.com/market/picasso-panama-papers-ganz-collection-469646.

Chabot, Pascal. *La Philosophie de Simondon*. Paris: Librairie Philosophique Vrin, 2003.

Chaitin, Gregory. *Meta Math!: The Quest for Omega*. New York: Vintage Books, 2006.

———. “The Limits of Reason.” *Scientific American* 294, no. 3 (March 2006): 74–81.

Chazelle, Bernard. “Natural Algorithms.” In *SIAM*, 2009. https://people.mpi-inf.mpg.de/~mehlhorn/SeminarEvolvability/ChazelleNaturalAlgorithms.pdf.

———. “Natural Algorithms and Influence Systems.” Research Highlights, CACM 2012. Princeton University, 2012. https://www.cs.princeton.edu/~chazelle/pubs/cacm12-natalg.pdf.

chris4210. “An Open Letter to the DAO and the Ethereum Community.” *Steemit*, June 21, 2016. https://steemit.com/ethereum/@chris4210/an-open-letter-to-the-dao-and-the-ethereum-community.

Combes, Muriel. *Gilbert Simondon and the Philosophy of the Transindividual*. Translated by Thomas LaMarre. Cambridge: The MIT Press, 2013.

Commodity Futures Trading Commission. “CFTC Glossary.” *Commodity Futures Trading Commission*. Accessed August 8, 2016. http://www.cftc.gov/ConsumerProtection/EducationCenter/CFTCGlossary/index.htm.

———. “CFTC Orders Bitcoin Options Trading Platform Operator and Its CEO to Cease Illegally Offering Bitcoin Options and to Cease Operating a Facility for Trading or Processing of Swaps without Registering.” Press Release, September 17, 2015. http://www.cftc.gov/PressRoom/PressReleases/pr7231-15.

———. “Over-the-Counter Derivatives.” *Commodity Futures Trading Commission*, 1998. http://www.cftc.gov/opa/press98/opamntn.htm.

Constine, Josh. “Monegraph Uses Bitcoin Tech So Internet Artists Can Establish ‘Original’ Copies of Their Work.” *TechCrunch*, May 9, 2014. http://social.techcrunch.com/2014/05/09/monegraph/.

Coombs, James H., Allen H. Renear, and Steven J. DeRose. “Markup Systems and the Future of Scholarly Text Processing.” *Communications of the ACM (ACM)* 30, no. 11 (1987): 933–47.

Cooper, Melinda, and Martijn Konings. “Contingency and Foundation: Rethinking Money, Debt, and Finance after the Crisis.” *South Atlantic Quarterly* 114, no. 2 (April 1, 2015): 239–50.

Corkery, Michael, and Jessica Silver-Greenberg. “Overdraft Practices Continue to Gut Bank Accounts and Haunt Customers.” *The New York Times*, February 28, 2016. http://www.nytimes.com/2016/02/29/business/dealbook/overdraft-practices-continue-to-gut-bank-accounts-and-haunt-customers.html.

Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. *Introduction to Algorithms. Third Edition*. Cambridge: The MIT Press, 2009.

Costanza, Robert, Rudolf de Groot, Paul Sutton, Sander Van Der Ploeg, Sharolyn J. Anderson, Ida Kubiszewski, Stephen Farber, and R. Kerry Turner. “Changes in the Global Value of Ecosystem Services.” *Global Environmental Change* 25 (2014): 152–58.

CPSC S101. “Homework #5 Algorithms,” 2011. http://zoo.cs.yale.edu/classes/cs101/current/s11h5.

Croggon, Alison. “The 70% Drop in Australia Council Grants for Individual Artists Is Staggering.” *The Guardian*, May 18, 2016. http://www.theguardian.com/culture/2016/may/19/the-70-drop-australia-council-grants-artists-funding-cuts.

“Crypto-Currency Market Capitalizations.” *Crypto-Currency Market Capitalizations*. Accessed August 18, 2016. http://coinmarketcap.com/currencies/views/all/.

Curme, Chester, Tobias Preis, H. Eugene Stanley, and Helen Susannah Moat. “Quantifying the Semantics of Search Behavior before Stock Market Moves.” *PNAS* 111, no. 32 (August 12, 2014): 11600–605.

Curtis, Adam. *All Watched Over by Machines of Loving Grace*. Documentary, 2011.

Dash, Anil. “A Bitcoin for Digital Art.” *The Message*, May 9, 2014. https://medium.com/message/a-bitcoin-for-digital-art-8c7db719e495.

Davé, Sandeep, Ashwin Shirvaikar, and Greg Baxter. "Digital Money: A Pathway to an Experience Economy." London: Citi, January 2015. http://www.citibank.com/icg/sa/digital_symposium/digital_money_index/pdf/Digital%20money%20A%20pathway%20to%20an%20Experience%20Economy.pdf.

Dawkins, Richard. *The Extended Phenotype: The Long Reach of the Gene*. Revised edition. Oxford: Oxford Paperbacks, 1999.

———. *The Selfish Gene*. Oxford: Oxford University Press, 2006.

De Boever, Arne, Alex Murray, Jon Roffe, and Ashley Woodward, eds. *Gilbert Simondon: Being and Technology*. Edinburgh: Edinburgh University Press, 2012.

De Filippi, Primavera. "Governance by Design." presented at the OuiShare Labs Camp #3, 2015. https://www.youtube.com/watch?v=hpzGy5t4baQ.

Del Castillo, Michael. "The DAO Attacked: Code Issue Leads to $60 Million Ether Theft." *CoinDesk*, June 17, 2016. http://www.coindesk.com/dao-attacked-code-issue-leads-60-million-ether-theft/.

Del Moral, Pierre, Gareth William Peters, and Christelle Vergé. "An Introduction to Particle Integration Methods: With Applications to Risk and Insurance." *arXiv:1210.3851 [Math, Q-Fin, Stat]*, October 14, 2012. http://arxiv.org/abs/1210.3851.

Deleuze, Gilles. *Cinema II: The Time-Image*. Translated by Hugh Tomlinson and Robert Galeta. Minneapolis: University of Minnesota Press, 1997.

———. "Postscript on the Societies of Control." *October* 59 (1992): 3–7.

———. "Review of Gilbert Simondon's L'Individu et Sa Genèse Physico-Biologique (1966)." *PLI* 12 (2001): 43–49.

Deleuze, Gilles, and Félix Guattari. *A Thousand Plateaus: Capitalism and Schizophrenia*. Minneapolis: University of Minnesota Press, 2005.

———. *Anti-Oedipus*. Minneapolis: University of Minnesota Press, 1983.

Deloitte, and ArtTactics. "Art & Finance Report 2014," 2014. http://www2.deloitte.com/content/dam/Deloitte/at/Documents/Tax/art-finance-report.pdf.

Dodd, Randall. "The Structure of OTC Derivatives Markets." *The Financier* 9, no. 1–4 (2002): 1–5.

Dourado, Eli. “Bitcoin Isn’t Money — It’s the Internet of Money.” *The Ümlaut*, January 8, 2014. http://theumlaut.com/2014/01/08/bitcoin-internet-of-money/.

Dowgird, Rafał. “How Does the Banking Transactions Work ‘under the Hood’ - Possibly in Detail.” *Stack Overflow*, 2010. http://stackoverflow.com/questions/4512547/how-does-the-banking-transactions-work-under-the-hood-possibly-in-detail.

Dowling, Emma, Rodrigo Nunes, and Ben Trott. “Immaterial and Affective Labour: Explored.” *Ephemera* 7, no. 1 (2007): 1–7.

Duffield, Evan, and Daniel Diaz. “Dash: A Privacy-Centric Crypto-Currency.” White paper. Dash, 2015. https://www.dash.org/wp-content/uploads/2015/04/Dash-WhitepaperV1.pdf.

Duhem, Ludovic. “Simondon e la Questione Estetica.” *Il Protagora*, no. 12 (December 2008): 369–77.

Dunn, Catherine. “Dirty Little Secrets: Inside the ‘Wikileaks’ of the Ultra-Rich and Ultra-Powerful.” *Fusion*, 2016. http://interactive.fusion.net/dirty-little-secrets/.

Durden, Tyler. “What A Cashless Society Would Look Like.” *Zero Hedge*, January 31, 2016. http://www.zerohedge.com/news/2016-01-31/what-cashless-society-would-look.

During, Elie. “Simondon Au Pied Du Mur.” *Critique*, no. 706 (2006). http://www.ciepfc.fr/spip.php?article41.

Easley, David, and Jon Kleinberg. *Networks, Crowds, and Markets: Reasoning About a Highly Connected World*. New York: Cambridge University Press, 2010.

Eckhardt, Roger. “Stan Ulam, John von Neumann, and the Monte Carlo Method.” *Los Alamos Science*, Special Issue (1987): 131–43.

EDM Council. “EDM Council - Enterprise Data Management.” Accessed August 3, 2016. http://www.edmcouncil.org/.

———. “Financial Industry Business Ontology™.” Accessed July 29, 2016. http://www.edmcouncil.org/financialbusiness.

England, Jeremy. “Dissipative Adaptation in Driven Self-Assembly.” *Nature Nanotechnology* 10 (2015): 919–23.

———. “Statistical Physics of Self-Replication.” *The Journal of Chemical Physics* 139, no. 121923 (2013).

Fantacci, Luca. “The Dual Currency System of Renaissance Europe.” *Financial History Review* 15, no. 1 (April 2008): 55–72.

"FAQ | ArtRank™." Accessed April 8, 2014. http://artrank.com/pages/faq.

Farago, Jason. "Art.sy and the Myth of the Online Art Market." *New Republic*, October 22, 2012. https://newrepublic.com/article/108893/artsy-and-the-myth-the-online-art-market.

———. "Welcome to the LOLhouse: How Berlin's Biennale Became a Slick, Sarcastic Joke." *The Guardian*, June 14, 2016. https://www.theguardian.com/artanddesign/2016/jun/13/berlin-biennale-exhibition-review-new-york-fashion-collective-dis-art.

Fazi, M. Beatrice. "Incomputable Aesthetics: Open Axioms of Contingency." *Computational Culture*, no. 5 (January 15, 2016). http://computationalculture.net/article/incomputable-aesthetics-open-axioms-of-contingency.

FCIC. *The Financial Crisis Inquiry Report*. New York: PublicAffairs, 2011.

Federici, Silvia. *Caliban and the Witch: Women, the Body and Primitive Accumulation*. New York: Autonomedia, 2004.

Feifer, Jason. "Why It's Nearly Impossible to Stop This Amazon and eBay Scheme." *Entrepreneur*, July 27, 2016. https://www.entrepreneur.com/article/278622.

"Financial Products Markup Language (FpML®) XML Schema Documentation." Accessed July 21, 2016. http://schemas.liquid-technologies.com/FpML/5.0/.

Financial Stability Board. "Policy Measures to Address Systemically Important Financial Institutions." Financial Stability Bureau, November 4, 2011. http://www.fsb.org/wp-content/uploads/r_111104bb.pdf?page_moved=1.

Fischer, Douglas. "'Dark Money' Funds Climate Change Denial Effort." *Scientific American*, December 23, 2013. http://www.scientificamerican.com/article/dark-money-funds-climate-change-denial-effort/.

Fisher, Mark. *Capitalist Realism: Is There No Alternative?* Winchester: Zero Books, 2009.

Fletcher, Mal. "Chips Under the Skin - 'Convenient' But Not Wise." *2020Plus*, May 26, 2015. http://2020plus.net/Editorial-362-Mal-Fletcher-Chips-Under-The-Skin-Convenient-But-Not-Wise.aspx.

Fosback, Norman G. *Stock Market Logic*. New Delhi: Vision Books Pvt, 2005.

Foucault, Michel. "Of Other Spaces: Utopias and Heterotopias." Translated by Jay Miskowiec. *Architecture / Mouvement / Continuité*, October 1984.

———. *The Birth of Biopolitics: Lectures at the College De France, 1978-1979*. Translated by Graham Burchell. Basingstoke: Palgrave Macmillan, 2008.

"FpML® @ a Glance." Accessed May 14, 2015. http://www.fpml.org/about/ataglance.html.

"FpML® Information." Accessed May 13, 2015. http://www.fpml.org/about/factsheet.html.

Francis, Hannah. "Chip Implants beneath the Skin Bring a New Meaning to 'Pay Wave.'" *The Sydney Morning Herald*, May 30, 2015. http://www.smh.com.au/digital-life/digital-life-news/chip-implants-beneath-the-skin-bring-a-new-meaning-to-pay-wave-20150528-ghbq71.html.

Frey, Carl Benedikt, and Michael A. Osborne. "The Future of Employment: How Susceptible Are Jobs to Computerisation?" Oxford: Oxford University Engineering Sciences Department, September 17, 2013. http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

Friedman, Milton. "The Methodology of Positive Economics." In *Essays in Positive Economics*, 3–43. Chicago: University of Chicago Press, 1953.

———. "The Need for Futures Markets in Currencies." *CATO Journal* 31, no. 3 (Fall 2011): 635–41.

———. *There's No Such Thing as a Free Lunch*. La Salle: Open Court Publishing Company, 1977.

Friedman, Milton, and Anna Jacobson Schwartz. *A Monetary History of the United States, 1867-1960*. Princeton: Princeton University Press, 1971.

Frisby, Dominic. *Bitcoin: The Future of Money?* London: Unbound, 2014.

Fuller, Matthew, and Andrew Goffey. *Evil Media*. Cambridge: The MIT Press, 2012.

Gai, Jiading, Chen Yao, and Mao Ye. "The Externalities of High-Frequency Trading," March 15, 2012. https://www.sec.gov/divisions/riskfin/seminar/ye031513.pdf.

Galloway, Alexander R. *Protocol: How Control Exists after Decentralization*. Cambridge: The MIT Press, 2006.

———. "The Poverty of Philosophy: Realism and Post-Fordism." *Critical Inquiry* 39, no. 2 (January 1, 2013): 347–66.

Galloway, Alexander R., Eugene Thacker, and McKenzie Wark. *Excommunication*. Chicago: University of Chicago Press, 2014.

Garcia-Molina, Hector, Jeffrey D. Ullman, and Jennifer Widom. *Database Systems: The Complete Book. Second Edition*. Upper Saddle River: Pearson, 2009.

Genosko, Gary. “A-Signifying Semiotics.” *The Public Journal of Semiotics* II, no. 1 (January 2008): 11–21.

Genosko, Gary, and Andrew Murphie. “Models, Metamodels and Contemporary Media.” *Fibreculture Journal*, no. 12 (2008). http://twelve.fibreculturejournal.org/.

Gibbs, Michael. “Designing Incentive Plans: New Insights from Academic Research.” *WorldatWork Journal* 21, no. 4 (2012): 29–47.

Gibson, William. *Neuromancer*. London: Harper Voyager, 1995.

Goddard Institute for Space Studies. “GLOBAL Station Temperature Index in 0.01 Degrees Celsius.” *National Aeronautics and Space Administration - Goddard Institute for Space Studies*, July 2016. http://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts.txt.

Goguen, Joseph A. “A Categorical Manifesto.” *Mathematical Structures in Computer Science* 1, no. 1 (March 1991): 49–67.

Goldstein, Andrew M. “Art Rank Founder Carlos Rivera on Why He’s Leading the Flipper Revolution—and Why It Can’t Be Stopped.” *Artspace*, June 11, 2015. http://www.artspace.com/magazine/interviews_features/carlos-rivera-art-rank-interview.

Good, Robin. “P2P and Open Infrastructures: The Society of Openness Comes of Age.” *Robin Good’s Master New Media*, October 26, 2010. http://www.masternewmedia.org/p2p-and-open-infrastructures-the-society-of-openness-comes-of-age/.

Goodhart, Charles A. E. *Money, Information and Uncertainty*. Cambridge: The MIT Press, 1989.

———. “The Two Concepts of Money: Implications for the Analysis of Optimal Currency Areas.” *European Journal of Political Economy* 14, no. 3 (August 1998): 407–32.

Goriunova, Olga. *Art Platforms and Cultural Production on the Internet.* London: Routledge, 2013.

Graeber, David. *Debt: The First 5,000 Years*. Brooklyn: Melville House, 2012.

Greenberg, Andy. “The Dread Pirate Roberts: Internet’s Multimillionaire Druglord.” *Forbes India*, September 26, 2013. http://forbesindia.com/article/cross-border/the-dread-pirate-roberts-internets-multimillionaire-druglord/36181/3#ixzz2galPpfe0’.

Greenstein, Shane. “Commercialization of the Internet: The Interaction of Public Policy and Private Choices or Why Introducing the Market Worked So Well.” In *Innovation Policy and the Economy, Volume 1*, edited by Adam B. Jaffe, Josh Lerner, and Scott Stern, 151–86. Cambridge: The MIT Press, 2001.

Gregg, Melissa, and Gregory J. Seigworth, eds. *The Affect Theory Reader*. Durham: Duke University Press Books, 2010.

Grosz, Elizabeth. “Identity and Individuation: Some Feminist Reflections.” In *Simondon: Being and Technology*, edited by Arne De Boever, Alex Murray, Jon Roffe, and Ashley Woodward, 37–56. Edinburgh: Edinburgh University Press, 2012.

Guattari, Félix. *Chaosmosis: An Ethico-Aesthetic Paradigm*. Translated by Paul Bains and Julian Pefanis. Reprint edition. Sydney: Power Institute, 2006.

———. *Schizoanalytic Cartographies*. Translated by Andrew Goffey. New York: Bloomsbury Academic, 2013.

———. *The Three Ecologies*. Translated by Ian Pindar and Paul Sutton. London: The Athlone Press, 2000.

———. “Towards a Post-Media Era.” In *Provocative Alloys: A Post-Media Anthology*, edited by Clemens Apprich, Josephine Berry Slater, Anthony Iles, and Olivier Lerone Schultz, translated by Alya Sebti and Clemens Apprich, 26–27. Lüneburg: Post-Media Lab & Mute Books, 2013.

Haldane, Andrew. “Andrew G Haldane: Managing Global Finance as a System.” Birmingham University, 2014. http://www.bis.org/review/r141030f.pdf.

Hammermeister, Kai. *The German Aesthetic Tradition*. Cambridge: Cambridge University Press, 2002.

Hardt, Michael, and Antonio Negri. *Multitude: War and Democracy in the Age of Empire*. Reprint edition. New York: Penguin Books, 2005.

Harney, Stefano, and Fred Moten. *The Undercommons. Fugitive Planning & Black Study*. New York: Minor Compositions, 2013.

Haugh, Martin. “The Monte Carlo Framework, Examples from Finance and Generating Correlated Random Variables.” New York: Columbia, Fall 2004. http://www.columbia.edu/~mh2078/MCS04/MCS_framework_FEegs.pdf.

Hayek, Friedrich A. *The Sensory Order: An Inquiry into the Foundations of Theoretical Psychology*. Eastford: Martino Fine Books, 2014.

Hayles, N. Katherine. *How We Think: Digital Media and Contemporary Technogenesis*. Chicago: University of Chicago Press, 2012.

Hearn, Mike. "The Resolution of the Bitcoin Experiment." *Medium*, January 14, 2016. https://medium.com/@octskyward/the-resolution-of-the-bitcoin-experiment-dabb30201f7#---262-344.puwe6jpse.

Heideman, M., D. Johnson, and C. Burrus. "Gauss and the History of the Fast Fourier Transform." *IEEE ASSP Magazine* 1, no. 4 (October 1984): 14–21.

Heidenreich, Stefan. "Freeportism as Style and Ideology: Post-Internet and Speculative Realism, Part I." *E-Flux*, no. 71 (March 2016). http://www.e-flux.com/journal/freeportism-as-style-and-ideology-part-i-post-internet-and-speculative-realism/.

Hicks, John R. "Liquidity." *The Economic Journal* 72, no. 288 (1962): 787–802.

Hitzler, Pascal, Markus Krötzsch, Bijan Parsia, Peter F. Patel-Schneider, and Sebastian Rudolph. "OWL 2 Web Ontology Language Primer (Second Edition)." *W3C Recommendation*, December 11, 2012. https://www.w3.org/TR/owl2-primer/.

Holmes, Brian. "Money Unlimited: Consequences of Quantitative Easing." Amsterdam: Institute of Network Cultures, 2014. http://networkcultures.org/moneylab/2014/03/27/brian-holmes-consequences-of-quantitative-easing/.

Honeysett-Watts, Adam. "Calypso Acquires Galapagos." *Reuters*, February 26, 2009. http://www.reuters.com/article/2009/02/26/idUS193198+26-Feb-2009+BW20090226.

Hörl, Erich. "A Thousand Ecologies." In *The Whole Earth: California and the Disappearance of the Outside*, edited by Diedrich Diederichsen and Anselm Franke. Berlin: Sternberg Press, 2013.

Howard, Emma. "Humans Have Already Used up 2015's Supply of Earth's Resources – Analysis." *The Guardian*, August 13, 2015. http://www.theguardian.com/environment/2015/aug/12/humans-have-already-used-up-2015s-supply-of-earths-resources-analysis.

Hui, Yuk. "Algorithmic Catastrophe: The Revenge of Contingency." *Parrhesia* 23 (2015): 122–43.

———. “Form and Relation. Materialism on an Uncanny Stage.” *Intellectica* 1, no. 61 (2014): 105–21.

———. “Induction, Deduction and Transduction: On the Aesthetics and Logic of Digital Objects.” *Networking Knowledge: Journal of the MeCCSA Postgraduate Network* 8, no. 3 (June 3, 2015). http://ojs.meccsa.org.uk/index.php/netknow/article/view/376.

———. “Modulation after Control.” *New Formations: A Journal of Culture/Theory/Politics* 84, no. 84 (2015): 74–91.

———. *On the Existence of Digital Objects*. Minneapolis: University of Minnesota Press, 2016.

Hui, Yuk, and Andreas Broeckmann. *30 Years After Les Immatériaux: Art, Science and Theory*. Lüneburg: meson press by Hybrid Publishing Lab, 2015.

Hui, Yuk, and Harry Halpin. “Collective Individuation: The Future of the Social Web.” In *Unlike Us Reader: Social Media Monopolies and Their Alternatives*, edited by Geert Lovink and Miriam Rasch, 103–16. Amsterdam: Institute of Network Cultures, 2013.

ICIJ. “The Panama Papers.” *The International Consortium of Investigative Journalists*, 2016. https://panamapapers.icij.org/.

Iliadis, Andrew. “Mechanology: Machine Typologies and the Birth of Philosophy of Technology in France (1932-1958).” *Systema* 3, no. 1 (2015): 131–44.

International Swaps and Derivatives Association. “Product Summary.” *FpML.org*, 2015. http://www.fpml.org/spec/index.html.

Ivanova, Victoria. “Art’s Values: A Détente, a Grand Plié.” *Parse*, no. 2 (November 2015): 91–105.

Jackson, Allison, and Jason Margolis. “So What’s the Deal with Negative Interest Rates?” *Public Radio International*, February 12, 2016. http://www.pri.org/stories/2016-02-12/so-whats-deal-negative-interest-rates.

Jameson, Fredric. *Postmodernism, Or, The Cultural Logic of Late Capitalism*. Durham: Duke University Press, 1991.

Jeftovic, Mark. “Trapped inside the Zero Bound: What It Means Now That We’ve Crossed the Economic Event Horizon.” *Rebooting Capitalism*, January 14, 2016. http://rebootingcapitalism.com/2016/01/14/trapped-inside-the-zero-bound-what-it-means-now-that-weve-crossed-the-economic-event-horizon/.

Jones, Claire. “European Banks Uneasy over Deeper Negative Interest Rates.” *Financial Times*, February 9, 2016. http://www.ft.com/cms/s/0/2ed4d1ae-cf48-11e5-831d-09f7778e7377.html?siteedition=intl#axzz4HMQeDXAi.

Kantchev, Georgi, Christopher Whittall, and Miho Inada. “Are Negative Rates Backfiring? Here’s Some Early Evidence.” *Wall Street Journal*, August 8, 2016. http://www.wsj.com/articles/are-negative-rates-backfiring-heres-some-early-evidence-1470677642.

Karppi, Tero, and Kate Crawford. “Social Media, Financial Algorithms and the Hack Crash.” *Theory, Culture & Society* 33, no. 1 (January 2016): 73–92.

Kawa, Luke. “HSBC: Sweden’s Experience Shows Negative Rates Haven’t Worked.” *Bloomberg.com*, February 10, 2016. http://www.bloomberg.com/news/articles/2016-02-09/hsbc-sweden-s-experience-shows-negative-rates-haven-t-worked.

Kerslake, Christian. “Marxism and Money in Deleuze and Guattari’s Capitalism and Schizophrenia: On the Conflict Between the Theories of Suzanne de Brunhoff and Bernard Schmitt.” *Parrhesia*, no. 22 (2015): 38–78.

Keynes, John Maynard. *A Treatise on Money in Two Volumes. 1 The Pure Theory of Money*. The Collected Writings of John Maynard Keynes. Volume V. Cambridge: Cambridge University Press, 2013.

———. *A Treatise on Money in Two Volumes. 2 The Applied Theory of Money*. The Collected Writings of John Maynard Keynes. Volume VI. Cambridge: Cambridge University Press, 2013.

———. *The General Theory of Employment, Interest and Money*. New York: Harvest/HBJ, 1964.

Kinsella, Eileen. “What Does TEFAF 2016 Art Market Report Tell Us About the Global Art Trade?” *Artnet News*, March 9, 2016. https://news.artnet.com/market/tefaf-2016-art-market-report-443615.

Klossowski, Pierre. *La Monnaie Vivante*, 1970. https://www.scribd.com/doc/102285892/Klossowski-Pierre-La-Monnaie-Vivante.

Knuth, Donald E. *The Art of Computer Programming: Volume 3: Sorting and Searching. Second Edition*. Reading: Addison-Wesley Professional, 1998.

———. “Von Neumann’s First Computer Program.” *ACM Computing Surveys* 2, no. 4 (December 1970): 247–260.

Kostakis, Vasilis, and Michel Bauwens. *Network Society and Future Scenarios for a Collaborative Economy*. Ebook. Basingstoke: Palgrave Pivot, 2014.

Kraus, Christina S. “Divide and Conquer: Caesar, De Bello Gallico 7.” In *Ancient Historiography and Its Contexts: Studies in Honour of A. J. Woodman*, edited by Christina S. Kraus, John Marincola, and Christopher Pelling, 40–59. Oxford: Oxford University Press, 2010.

Krämer, Sybille. *Medium, Messenger, Transmission: An Approach to Media Philosophy*. Translated by Anthony Enns. Amsterdam: Amsterdam University Press, 2015.

Kristof, Kathy. “Nearly Half of Banks Still ‘Reorder’ Checks, Boosting Overdraft Fees.” *CBS Money Watch*, April 9, 2014. http://www.cbsnews.com/news/nearly-half-of-banks-still-reorder-checks-boosting-overdraft-fees/.

Laboria Cuboniks. “Xenofeminism. A Politics for Alienation,” 2015. http://laboriacuboniks.net/.

Lambert, Léopold. “For an Allagmatic Architecture: Introduction to the Work of Gilbert Simondon.” *The Funambulist*, November 25, 2013. http://thefunambulist.net/2013/11/25/simondon-episode-01-for-an-allagmatic-architecture-introduction-to-the-work-of-gilbert-simondon/.

Lanchester, John. “Scalpers Inc.” *London Review of Books*, June 5, 2014. http://www.lrb.co.uk/v36/n11/john-lanchester/scalpers-inc.

Land, Nick. “Bitcoin and Philosophy.” The New Centre for Research & Practice, 2015.

———. “Quote Note (#211).” *Outside in*, January 14, 2016. http://www.xenosystems.net/quote-note-211/.

Larimer, Stan. “Bitcoin and the Three Laws of Robotics.” *Let’s Talk Bitcoin*, September 14, 2013. http://letstalkbitcoin.com/bitcoin-and-the-three-laws-of-robotics/.

Laruelle, François. *Au-delà du Principe de Pouvoir*. Paris: Payot, 1978.

———. “Économie Générale des Effets d’Ệtre.” Doctoral Thesis, Université Paris X Nanterre, 1975.

———. “Le Concept d’une ‘Technologie Première.’” In *Gilbert Simondon: Une Pensée de L’Individuation et de La Technique*. Ebook. Paris: Albin Michel, 1994.

———. “What Can Non-Philosophy Do?” Translated by Ray Brassier. *Angelaki* 8, no. 2 (2003): 169–89.

“Law of Diminishing Marginal Utility Definition.” *Investopedia*, January 6, 2004. http://www.investopedia.com/terms/l/lawofdiminishingutility.asp.

Lee, Edmund. “AP Twitter Account Hacked in Market-Moving Attack.” *Bloomberg Business*, April 24, 2013. http://www.bloomberg.com/news/articles/2013-04-23/dow-jones-drops-recovers-after-false-report-on-ap-twitter-page.

“Legality of Bitcoin by Country.” *Wikipedia, the Free Encyclopedia*, last modified July 23, 2016. https://en.wikipedia.org/wiki/Legality_of_bitcoin_by_country.

Leising, Matthew. “Virtu Never Loses (Well, Almost Never).” *Bloomberg.com*, August 11, 2016. http://www.bloomberg.com/news/features/2016-08-11/virtu-never-loses-well-almost-never-in-quest-to-upend-markets.

Leising, Matthew, and Edward Robinson. “Blythe Masters Tells Banks the Blockchain Changes Everything.” *Bloomberg.com*, September 1, 2015. http://www.bloomberg.com/news/features/2015-09-01/blythe-masters-tells-banks-the-blockchain-changes-everything.

Lerner, Sophea. “E-Money.” Unpublished manuscript, 1995. PDF file.

Lessig, Lawrence. *Code. Version 2.0*. New York: Basic Books, 2006.

Levine, Matt. “EBay Arbitrage and Airline Competition.” *Bloomberg View*, July 29, 2016. http://www.bloomberg.com/view/articles/2016-07-29/ebay-arbitrage-and-airline-competition.

Levy, Steven. *Crypto: How the Code Rebels Beat the Government Saving Privacy in the Digital Age*. New York: Viking, 2002.

Lewis, Michael. *Flash Boys*. New York: W. W. Norton & Company, 2014.

“LifeWiki.” ConwayLife.com, March 7, 2016. http://www.conwaylife.com/wiki/Main_Page.

Lin, Li, Longbing Cao, Jiaqi Wang, and Chengqi Zhang. “The Applications of Genetic Algorithms in Stock Market Data Mining Optimisation.” Sydney: Faculty of Information Technology, University of Technology and Capital Market CRC, 2009.

Longo, Giuseppe. “The Difference between Clocks and Turing Machines.” Rome, 1994. http://www.di.ens.fr/users/longo/files/PhilosophyAndCognition/clocksVSturingM.pdf.

Lukács, Georg. *History and Class Consciousness: Studies in Marxist Dialectics*. Translated by Rodney Livingstone. Cambridge: The MIT Press, 1972.

Luo, Yuan, Kecheng Liu, and Darryl N. Davis. “A Multi-Agent Decision Support System for Stock Trading.” *IEEE Network* 16, no. 1 (January 2002): 20–27.

Lury, Celia, Luciana Parisi, and Tiziana Terranova. “Introduction: The Becoming Topological of Culture.” *Theory, Culture & Society* 29, no. 4/5 (2012): 3–35.

Macao. “A Proposal for a Currency Design.” *M^C^O*. Accessed May 19, 2016. http://www.macaomilano.org/spip.php?article47.

Machiavelli, Niccolò. *The Art of War.* Translated by Christopher Lynch. Chicago: Chicago University Press, 2003.

Mackenzie, Adrian. *Cutting Code: Software and Sociality*. New York: Peter Lang, 2006.

———. *Transductions: Bodies and Machines at Speed*. London: Continuum, 2002.

———. *Wirelessness. Radical Empiricism in Network Cultures*. Cambridge: The MIT Press, 2010.

MacKenzie, Donald. *An Engine, Not a Camera: How Financial Models Shape Markets*. Cambridge: The MIT Press, 2008.

———. “Be Grateful for Drizzle.” *London Review of Books*, September 11, 2014. http://www.lrb.co.uk/v36/n17/donald-mackenzie/be-grateful-for-drizzle.

———. “Dark Markets.” *London Review of Books*, June 4, 2015. http://www.lrb.co.uk/v37/n11/donald-mackenzie/dark-markets.

———. “How to Make Money in Microseconds.” *London Review of Books*, May 19, 2011. http://www.lrb.co.uk/v33/n10/donald-mackenzie/how-to-make-money-in-microseconds.

———. “On ‘Spoofing.’” *London Review of Books*, May 21, 2015. http://www.lrb.co.uk/v37/n10/donald-mackenzie/on-spoofing.

MacSweeney, Greg. “Calypso Acquires Galapagos Portfolio Platform.” *Wall Street & Technology*, February 26, 2009. http://www.wallstreetandtech.com/trading-technology/calypso-acquires-galapagos-portfolio-pla/214600176.

madeleine. “Artsy/the-Art-Genome-Project.” *GitHub*, March 18, 2016. https://github.com/artsy/the-art-genome-project.

Madigan, Peter. “Fix and FpML: A Friendly War.” *Www.risk.net*, August 22, 2014. http://www.risk.net/risk-magazine/feature/2361155/fix-and-fpml-a-friendly-war.

Malik, Suhail. *On the Necessity of Art’s Exit from Contemporary Art*. Falmouth: Urbanomic, 2016.

———. “The Value of Everything.” *Texte Zur Kunst*, no. 93 (March 2014): 66–79.

Malik, Suhail, and Andrea Phillips. “Tainted Love: Art’s Ethos and Capitalization.” In *Art and Its Commercial Markets: A Report on Current Changes and with*

Scenarios for the Future, edited by Maria Lind and Olav Velthuis, 209–40. Berlin: Sternberg Press, 2012.

Manning, Erin. *Always More than One: Individuation's Dance*. Durham: Duke University Press, 2013.

———. "Artfulness." In *The Nonhuman Turn*, edited by Richard Grusin, 45–78. Minneapolis: Minnesota Press, 2015.

Manning, Erin, and Brian Massumi. *Thought in the Act: Passages in the Ecology of Experience*. Minneapolis: University of Minnesota Press, 2014.

Manola, Frank, and Eric Miller. "RDF Primer." *W3C Recommendation*, 2004. https://www.w3.org/TR/2004/REC-rdf-primer-20040210/#intro.

Mao, Huina, Scott Counts, and Johan Bollen. "Predicting Financial Markets: Comparing Survey, News, Twitter and Search Engine Data." *arXiv:1112.1051v1 [Q-fin.ST]*, December 5, 2011. http://arxiv.org/pdf/1112.1051.pdf.

Marr, Bernard. "Are We Headed for 'Automated Luxury Communism'?" *Forbes*, June 30, 2016. http://www.forbes.com/sites/bernardmarr/2016/06/30/are-we-headed-for-automated-luxury-communism/#66309bc43dcb.

Martin, John. *Key Concepts in Human Resource Management*. London: SAGE, 2010.

Martin, Randy. *An Empire of Indifference: American War and the Financial Logic of Risk Management*. Durham: Duke University Press, 2007.

———. "Dance and Finance—Social Kinesthetics and Derivative Logics." Experimental Media and Performing Arts Center (EMPAC), October 9, 2013. https://vimeo.com/95306125.

Mason, Paul. *Postcapitalism: A Guide to Our Future*. New York: Farrar, Straus and Giroux, 2016.

Massumi, Brian. "National Enterprise Emergency: Steps Toward an Ecology of Powers." *Theory, Culture & Society* 26, no. 6 (November 1, 2009): 153–85.

———. *Parables for the Virtual: Movement, Affect, Sensation*. Durham: Duke University Press, 2002.

———. "'Technical Mentality' revisited: Brian Massumi on Gilbert Simondon." *Parrhesia* 7 (2009): 36–45.

———. *The Power at the End of the Economy*. Durham: Duke University Press, 2015.

Maturana, Humberto R., and Francisco J. Varela. *Autopoiesis and Cognition: The Realization of the Living*. Dordrecht: D. Reidel Publishing Company, 1980.

Maurer, Bill, Taylor C. Nelms, and Lana Swartz. "'When Perhaps the Real Problem is Money Itself!': The Practical Materiality of Bitcoin." *Social Semiotics* 23, no. 2 (2013): 261–77.

May, Timothy C. "The Crypto Anarchist Manifesto." *Activism: Cypherpunks*, November 22, 1992. http://www.activism.net/cypherpunk/crypto-anarchy.html.

Marx, Karl. *Capital: A Critique of Political Economy. Volume 1*. Translated by Ben Fowkes. Reprint edition. London: Penguin Classics, 1992.

McAndrew, Clare, "An Introduction to Art and Finance." In *Fine Art and High Finance: Expert Advice on the Economics of Ownership*, edited by Clare McAndrew, 32–81. Ebook. New York: Bloomberg Press, 2010.

McArdle, Megan. "It's All Fun and Games Until Somebody Loses a Bank Account." *Bloomberg View*, March 15, 2016. https://www.bloomberg.com/view/articles/2016-03-15/the-end-of-cash-and-the-rise-of-government-power.

McCombie, Charlie. "Negative Rates, Cash Blocks Help Adopt Cryptocurrencies." *CoinTelegraph*, February 26, 2016. http://cointelegraph.com/news/negative-rates-cash-blocks-help-adopt-cryptocurrencies.

McKim, Joel. "Of Microperception and Micropolitics: An Interview with Brian Massumi, 15 August 2008." *Inflexions: A Journal for Research-Creation*, no. 3 (October 2009): 1–20.

McLuhan, Marshall. *Understanding Media: The Extensions of Man*. Reprint edition. Cambridge: The MIT Press, 1994.

Medina, Eden. *Cybernetic Revolutionaries: Technology and Politics in Allende's Chile*. Cambridge: The MIT Press, 2014.

Meillassoux, Quentin. *After Finitude: An Essay on the Necessity of Contingency*. Translated by Ray Brassier. London: Bloomsbury Academic, 2010.

Mellamphy, Dan. "The Birth of Technology from the Spirit of Alchemy." *Platform: Journal of Media and Communication* 6 (2015): 108–16.

Mellamphy, Dan, and Nandita Biswas Mellamphy. "Welcome to the Electrocene, an Algorithmic Agartha." *Culture Machine* 16 (2015): 1–27.

Merchant, Brian. "Fully Automated Luxury Communism." *The Guardian*, March 18, 2015. http://www.theguardian.com/sustainable-business/2015/mar/18/fully-automated-luxury-communism-robots-employment.

"Messaging and Standards." *SWIFT*, August 24, 2015. https://www.swift.com/about-us/discover-swift/messaging-standards.

Metropolis, Nicholas. "The Beginning of the Monte Carlo Method." *Los Alamos Science*, no. Special Issue (1987): 125–30.

Michaud, Yves. "The Aesthetics of Gilbert Simondon: Anticipation of the Contemporary Aesthetic Experience." In *Gilbert Simondon: Being and Technology*, edited by Arne De Boever, Alex Murray, Jon Roffe, and Ashley Woodward, translated by Justin Clemens, 121–32. Edinburgh: Edinburgh University Press, 2012.

Mirowski, Philip. "Inherent Vice: Minsky, Markomata, and the Tendency of Markets to Undermine Themselves." *Journal of Institutional Economics* 6, no. 4 (2010): 415–43.

———. *Machine Dreams: Economics Becomes a Cyborg Science*. Cambridge: Cambridge University Press, 2002.

———. "Markets Come to Bits: Evolution, Computation and Markomata in Economic Science." *Journal of Economic Behavior & Organization*, Markets as Evolving Algorithms, 63, no. 2 (June 2007): 209–42.

———. *More Heat than Light: Economics as Social Physics, Physics as Nature's Economics*. Cambridge: Cambridge University Press, 1991.

———. *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown*. London: Verso, 2014.

Mirowski, Philip, and Dieter Plehwe, eds. *The Road from Mont Pelerin: The Making of the Neoliberal Thought Collective*. Cambridge: Harvard University Press, 2009.

"Monegraph." *NEW INC*. Accessed January 2, 2016. http://www.newinc.org/monegraph/.

"Money." *Online Etymology Dictionary*. Accessed February 28, 2015. http://www.etymonline.com/index.php?term=money.

Money & Speed: Inside the Black Box (Marije Meerman, VPRO), 2012. http://www.youtube.com/watch?v=aq1Ln1UCoEU&feature=youtube_gdata_player.

Montague, Brian William. "Basic Hamiltonian Mechanics." Geneva: CERN Accelerator School, 1995. https://cds.cern.ch/record/399399/files/p1.pdf.

"Monte Carlo Simulation of Correlated Asset Returns - MATLAB Portsim." *MathWorks*, 2016.

http://au.mathworks.com/help/finance/portsim.html?requestedDomain=au.mathworks.com.

Moore, Heidi, and Dan Roberts. “AP Twitter Hack Causes Panic on Wall Street and Sends Dow Plunging.” *The Guardian*. April 23, 2013. http://www.theguardian.com/business/2013/apr/23/ap-tweet-hack-wall-street-freefall.

Moore, Jason W. “The End of Cheap Nature. Or How I Learned to Stop Worrying about ‘The’ Environment and Love the Crisis of Capitalism.” In *Structures of the World Political Economy and the Future of Global Conflict and Cooperation*, edited by Christian Suter and Christopher Chase-Dunn, 285–314. Berlin: LIT Verlag, 2014.

Morris, Jeremy Wade. “Curation by Code: Infomediaries and the Data Mining of Taste.” *European Journal of Cultural Studies* 18, no. 4–5 (August 1, 2015): 446–63.

Moss, Ceci. “Expanded Internet Art and the Informational Milieu.” *Rhizome.org*, December 19, 2013. http://rhizome.org/editorial/2013/dec/19/expanded-internet-art-and-informational-milieu/.

Mumford, Lewis. *Pentagon of Power: The Myth of the Machine, Vol. II*. New York: Harcourt, Brace Jovanovich, 1974.

Naftalin, Maurice, and Philip Wadler. *Java Generics and Collections*. Sebastopol: O’Reilly Media, 2006.

Nakamoto, Satoshi. “Bitcoin: A Peer-to-Peer Electronic Cash System.” Paper, 2008. https://bitcoin.org/bitcoin.pdf.

———. “Bitcoin Minting Is Thermodynamically Perverse.” *Bitcoin Talk*, August 7, 2010. https://bitcointalk.org/index.php?topic=721.msg8114#msg8114.

Neapolitan, Richard E., and Kumarss Naimipour. *Foundations of Algorithms Using Java Pseudocode*. Sudbury: Jones and Bartlett Publishers, 2004.

Nitzan, Jonathan, and Shimshon Bichler. *Capital as Power: A Study of Order and Creorder*. London: Rutledge, 2009.

Nugent, Helen. “Is the Cashless Society a Good Thing? Definitely Not.” *The Spectator*, May 24, 2016. http://blogs.spectator.co.uk/2016/05/cashless-contactless-cards/.

O’Dwyer, Rachel. *Blockchain Workshop #1 Governance by Design*. Ireland, 2015. https://www.youtube.com/watch?v=yq6KgauDd88.

———. “Commons Governance and Law with Primavera De Filippi.” *Commons Transition*, July 31, 2015. http://commonstransition.org/commons-centric-law-and-governance-with-primavera-de-filippi/.

Office of the Comptroller of the Currency. “OCC’s Quarterly Report on Bank Derivatives Activities. Third Quarter 2007.” Washington: U.S. Department of the Treasury, 2007. http://www.occ.treas.gov/topics/capital-markets/financial-markets/trading/derivatives/dq307.pdf.

O’Hagan, Andrew. “The Satoshi Affair.” *London Review of Books*, June 30, 2016. http://www.lrb.co.uk/v38/n13/andrew-ohagan/the-satoshi-affair.

Okhaos. “Plantoid.” Accessed December 10, 2015. http://okhaos.com/plantoid/.

Pack, Spencer J. *Aristotle, Adam Smith and Karl Marx: On Some Fundamental Issues in 21st Century Political Economy*. Cheltenham: Edward Elgar Publishing, 2010.

Parisi, Luciana. *Contagious Architecture: Computation, Aesthetics, and Space*. Cambridge: The MIT Press, 2013.

———. “Digital Design and Topological Control.” *Theory, Culture & Society* 29, no. 4/5 (2012): 165–92.

Pasquale, Frank. *The Black Box Society: The Secret Algorithms That Control Money and Information*. Cambridge: Harvard University Press, 2015.

Pasquinelli, Matteo. “Capital Thinks Too: The Idea of the Common in the Age of Machine Intelligence.” *Open! Platform for Art, Culture & the Public Domain*, December 11, 2015. http://onlineopen.org/capital-thinks-too.

———. “Google’s PageRank Algorithm: A Diagram of the Cognitive Capitalism and the Rentier of the Common Intellect.” In *Deep Search: The Politics of Search Beyond Google*, edited by Konrad Becker and Felix Stalder. New Jersey: Transaction Publishers, 2009.

Patterson, Scott. *Dark Pools: The Rise of the Machine Traders and the Rigging of the U.S. Stock Market*. New York: Crown Business, 2013.

Peachey, Kevin. “Cashless Payments Overtake the Use of Notes and Coins.” *BBC News*, May 21, 2015. http://www.bbc.com/news/business-32778196.

Pelbart, Peter Pál. *Cartography of Exhaustion: Nihilism Inside out*. Translated by Hortencia Santos Lencastre. Helsinki: n-1 publications, 2013.

Piironen, Pekka, and Akseli Virtanen. “Democratizing the Power of Finance: A Discussion About Robin Hood Asset Management Cooperative with Founder Akseli Virtanen.” In *MoneyLab Reader: An Intervention in Digital Economy*, edited by Geert Lovink, Nathaniel Tkacz, and Patricia De Vries. Amsterdam: Institute of Network Cultures, 2015.

Plant, Sadie. *Zeroes + Ones: Digital Women + the New Technoculture*. New York: Doubleday, 1997.

Popper, Nathaniel. “A Venture Fund with Plenty of Virtual Capital, but No Capitalist.” *The New York Times*, May 21, 2016. http://www.nytimes.com/2016/05/22/business/dealbook/crypto-ether-bitcoin-currency.html.

———. *Digital Gold: Bitcoin and the Inside Story of the Misfits and Millionaires Trying to Reinvent Money*. New York: Harper, 2015.

———. “Knight Capital Says Trading Glitch Cost It $440 Million.” *The New York Times*. August 2, 2012. http://dealbook.nytimes.com/2012/08/02/knight-capital-says-trading-mishap-cost-it-440-million/.

———. “The Robots Are Coming for Wall Street.” *The New York Times*, February 25, 2016. http://www.nytimes.com/2016/02/28/magazine/the-robots-are-coming-for-wall-street.html.

Posner, Eric A., Kathryn E. Spier, and Adrian Vermeule. “Divide and Conquer.” Discussion Paper No. 639. Cambridge: Harvard Law School, 2009. http://www.law.harvard.edu/programs/olin_center/papers/pdf/Vermeule_639.pdf.

Potts, Jason. “Do Plantoids Dream of Electric Arts Council Grants?” *The Conversation*, December 14, 2015. http://theconversation.com/do-plantoids-dream-of-electric-arts-council-grants-52263.

Pötzsch, Holger, and N. Katherine Hayles. “FCJ-172 Posthumanism, Technogenesis, and Digital Technologies: A Conversation with Katherine N. Hayles.” *The Fibreculture Journal*, no. 23 (2014). http://twentythree.fibreculturejournal.org/fcj-172-posthumanism-technogenesis-and-digital-technologies-a-conversation-with-katherine-n-hayles/.

Powers, Shelley. *Practical RDF*. Sebastopol: O’Reilly Media, 2003.

Preis, Tobias, Helen Susannah Moat, and H. Eugene Stanley. “Quantifying Trading Behavior in Financial Markets Using Google Trends.” *Scientific Reports* 3 (April 25, 2013). http://www.nature.com/srep/2013/130425/srep01684/full/srep01684.html.

Press, Larry. “Commercialization of the Internet.” *Communications of the ACM* 37, no. 11 (1994): 17–21.

Prigogine, Ilya, and Isabelle Stengers. *Order Out of Chaos: Man’s New Dialogue with Nature*. New York: Bantam Books, 1984.

Randow, Jana, and Simon Kennedy. “Negative Interest Rates.” *Bloomberg View*, June 6, 2016. http://www.bloomberg.com/view/quicktake/negative-interest-rates.

Raschid, Louiqa. “BMGT 499B Next Generation Financial Cyberinfrastructure -- Data Science for Finance.” University of Maryland, April 2, 2013. http://www.umiacs.umd.edu/~louiqa/2014/BMGT499B/RESOURCES/Lecture1.pdf.

Readfearn, Graham. “Doubt over Climate Science Is a Product with an Industry behind It.” *The Guardian*, March 5, 2015. https://www.theguardian.com/environment/planet-oz/2015/mar/05/doubt-over-climate-science-is-a-product-with-an-industry-behind-it.

Richardson, George P. *Feedback Thought in Social Science and Systems Theory*. Waltham: Pegasus Communications, 1999.

———. “The Feedback Concept in American Social Science, With Implications for System Dynamics.” Chestnut Hill, Massachusetts, 1983. http://www.systemdynamics.org/conferences/1983/proceed/plenary/richa001.pdf.

riemannzetajones. “Dear Reddit, Wells Fargo Took Approx $1400 of My Girlfriend’s Money in Fees over 1 Month. She Can’t Afford This, Help! • /r/AskReddit.” *Reddit*, 2010. https://www.reddit.com/r/AskReddit/comments/a50px/dear_reddit_wells_fargo_took_approx_1400_of_my/.

Rizzo, Pete. “CFTC Defines Bitcoin and Digital Currencies as Commodities.” *CoinDesk*, September 17, 2015. http://www.coindesk.com/cftc-ruling-defines-bitcoin-and-digital-currencies-as-commodities/.

Robin Hood Cooperative. “Equity, Options, Assemblage: Robin Hood 2.0.” Grey Paper. Milan, May 1, 2015. https://speculativematerialism.files.wordpress.com/2015/06/robin-hood-grey-paper-april-2015.pdf.

Roffe, Jon. *Abstract Market Theory*. Houndmills: Palgrave Macmillan, 2015.

Roio, Denis. “Bitcoin, the End of the Taboo on Money,” April 6, 2013. http://www.dyndy.net/2013/04/bitcoin-ends-the-taboo-on-money/.

Roio, Denis, Marco Sachy, Stefano Lucarelli, Bernard Lietaer, and Francesca Bria. “Design of Social Digital Currency.” London: Nesta, 2015. http://dcentproject.eu/wp-content/uploads/2015/10/design_of_social_digital_currency_publication.pdf.

Rosenblatt, Joel, and Karen Gullo. “Wells Fargo Seeks Reversal of $203 Million Overdraft Damages.” *Bloomberg.com*, May 16, 2012. http://www.bloomberg.com/news/articles/2012-05-15/wells-fargo-seeks-reversal-of-203-million-damages-in-appeal-1-.

Rossiter, Ned. “Coded Vanilla: Logistical Media and the Determination of Action.” *South Atlantic Quarterly* 114, no. 1 (January 1, 2015): 135–52.

Rotman, Brian. *Signifying Nothing: The Semiotics of Zero*. Stanford: Stanford University Press, 1993.

Rouvroy, Antoinette. “The End(s) of Critique: Data-Behaviourism vs. Due-Process.” In *Privacy, Due Process and the Computational Turn. Philosophers of Law Meet Philosophers of Technology.*, edited by Mireille Hildebrandt and Ekatarina De Vries, 288–331. London: Routledge, 2012.

Rouvroy, Antoinette, and Thomas Berns. “Gouvernementalité Algorithmique et Perspectives d’Émancipation.” *Réseaux* n° 177, no. 1 (April 1, 2013): 163–96.

Ruggiero, Murray A. *Cybernetic Trading Strategies: Developing a Profitable Trading System with State-of-the-Art Technologies*. New York: Wiley, 1997.

Ryzik, Melena. “Art.sy is Mapping the World of Art on the Web.” *The New York Times*, October 8, 2012. http://www.nytimes.com/2012/10/09/arts/design/artsy-is-mapping-the-world-of-art-on-the-web.html.

Salmon, Felix. “Recipe for Disaster: The Formula That Killed Wall Street.” *WIRED*, February 23, 2009. http://archive.wired.com/techbiz/it/magazine/17-03/wp_quant?currentPage=all.

Schneider, Nathan. “After the Bitcoin Gold Rush.” *The New Republic*, February 24, 2015. http://www.newrepublic.com/article/121089/how-small-bitcoin-miners-lose-crypto-currency-boom-bust-cycle.

Schumacher, E. F. *Small Is Beautiful: Economics as If People Mattered*. London: Blond & Briggs, 1973.

Scott, Brett. “Algorithmic Surrealism: A Slow-Motion Guide to High-Frequency Trading.” *The Heretic’s Guide to Global Finance*, June 17, 2015. http://suitpossum.blogspot.com.au/2015/06/high-frequency-trading-guide.html.

———. “The War on Cash.” *The Long and Short*, August 19, 2016. http://thelongandshort.org/society/war-on-cash.

———. “Visions of a Techno-Leviathan: The Politics of the Bitcoin Blockchain.” *E-International Relations*, June 1, 2014. http://www.e-ir.info/2014/06/01/visions-of-a-techno-leviathan-the-politics-of-the-bitcoin-blockchain/.

Scott, David. *Gilbert Simondon’s Psychic and Collective Individuation: A Critical Introduction and Guide*. Edinburgh: Edinburgh University Press, 2014.

Securities and Exchange Commission. “Findings Regarding the Market Events of May 6, 2010.” Securities and Exchange Commission, September 30, 2010. https://www.sec.gov/news/studies/2010/marketevents-report.pdf.

“Semantic Web - W3C.” Accessed May 15, 2015. http://www.w3.org/standards/semanticweb/.

Sentance, Brian. “FpML—The Building Blocks for Trade Automation?” *WILMOTT Magazine*, March 2008.

Simmel, Georg. *The Philosophy of Money*. Edited by David Frisby. Translated by Tom Bottomore and David Frisby. New York: Routledge, 2004.

Simon, Herbert A., and Allen Newell. “Heuristic Problem Solving: The Next Advance in Operations Research.” *Operations Research* 6, no. 1 (February 1, 1958): 1.

Simondon, Gilbert. *Communication et Information: Cours et Conférences*. Edited by Nathalie Simondon and Jean-Yves Chateau. Chatou: Éditions de la Transparence, 2010.

———. *Du Mode d’Existence des Objets Techniques*. Paris: Aubier, 1989.

———. “Entretien Sur La Mécanologie: Gilbert Simondon et Jean Le Moyne (1968).” In *Sur La Technique: 1953-1983*, 405–45. Paris: Presses Universitaires de France, 2014.

———. *Imagination et Invention (1965-1966)*. Chatou: Éditions de la Transparence, 2008.

———. “La Mentalité Technique.” In *Sur La Technique: 1953-1983*, 295–313. Paris: Presses Universitaires de France, 2014.

———. *L’Individuation à la Lumière des Notions de Forme et d’Information*. Grenoble: Millon, 2013.

———. *L'Invention Dans les Techniques: Cours et Conférences*. Edited by Jean-Yves Chateau. Paris: Seuil, 2005.

———. "Naissance de La Technologie (1970)." In *Sur La Technique: 1953-1983*, 131–78. Paris: Presses Universitaires de France, 2014.

———. "On Techno-Aesthetics." Translated by Arne De Boever. *Parrhesia* 14 (2012): 1–8.

———. "Sauver l'Objet Technique (1983)." In *Sur La Technique: 1953-1983*, 447–54. Paris: Presses Universitaires de France, 2014.

———. *Sur la Technique: 1953-1983*. Paris: Presses Universitaires de France, 2014.

Singer, Natasha. "Acxiom, the Quiet Giant of Consumer Database Marketing." *The New York Times*, June 16, 2012. http://www.nytimes.com/2012/06/17/technology/acxiom-the-quiet-giant-of-consumer-database-marketing.html.

———. "Your Online Attention, Bought in an Instant by Advertisers." *The New York Times*, November 17, 2012. http://www.nytimes.com/2012/11/18/technology/your-online-attention-bought-in-an-instant-by-advertisers.html.

Sipser, Michael. *Introduction to the Theory of Computation. Third Edition*. Boston: Cengage Learning, 2013.

Skabar, Andrew, and Ian Cloete. "Neural Networks, Financial Trading and the Efficient Markets Hypothesis." Melbourne, 2001. http://crpit.com/confpapers/CRPITV4Skabar.pdf.

Skyrms, Brian. *The Stag Hunt and the Evolution of Social Structure*. Cambridge: Cambridge University Press, 2003.

Slezak, Michael. "July 2016 Was World's Hottest Month since Records Began, Says Nasa." *The Guardian*, August 16, 2016. https://www.theguardian.com/environment/2016/aug/16/july-2016-was-worlds-hottest-month-since-records-began-says-nasa.

Smiley, Lana. "Money Earning Blockchain-Based Iron Sunflower to Change Future of MLM Business." *CoinTelegraph*, January 16, 2016. http://cointelegraph.com/news/116068/money-earning-blockchain-based-iron-sunflower-to-change-future-of-mlm-business.

"SNTMNT - Social Sentiment Analysis for Financial Markets." Accessed November 11, 2015. http://www.sntmnt.com/.

Sommer, Jeff. “In the Bizarro World of Negative Interest Rates, Saving Will Cost You.” *The New York Times*, March 5, 2016. http://www.nytimes.com/2016/03/06/your-money/in-the-bizarro-world-of-negative-interest-rates-saving-will-cost-you.html.

Son, Hugh, and Margaret Collins. “The Rich Are Already Using Robo-Advisers, and That Scares Banks.” *Bloomberg.com*, February 5, 2016. http://www.bloomberg.com/news/articles/2016-02-05/the-rich-are-already-using-robo-advisers-and-that-scares-banks.

Sorin, Andrei. *Software and Mind: The Mechanistic Myth and Its Consequences*. Toronto: Andsor Books, 2013.

Srnicek, Nick. “Navigating Neoliberalism: Political Aesthetics in an Age of Crisis.” *After Us*, September 2015. http://www.aft3r.us/navigating-neoliberalism/.

Srnicek, Nick, and Alex Williams. *Inventing the Future: Postcapitalism and a World Without Work*. Brooklyn: Verso, 2015.

———. “On Cunning Automata: Financial Acceleration at the Limits of the Dromological.” In *Collapse: Casino Real*, edited by Robin Mackay, 463–506. Falmouth: Urbanomic, 2014.

Stengers, Isabelle. “Pour Une Mise a l’Aventure de La Transduction.” In *Simondon*, edited by Pascal Chabot, 137–59. Annales de l’Institut de Philosophie de l’Université de Bruxelles. Paris: Vrin, 2002.

Steyerl, Hito. “Too Much World: Is the Internet Dead?” In *Too Much World: The Films of Hito Steyerl*, edited by Nick Aikens, 29–40. Berlin: Sternberg Press, 2014.

Stiegler, Bernard. “Anamnesis and Hypomnesis: The Memories of Desire.” In *Technicity*, edited by Arthur Bradley and Louis Armand, 15–41. Prague: Litteraria Pragensia, 2006.

———. *Technics and Time, 1: The Fault of Epimetheus*. Translated by Richard Beardsworth and George Collins. Stanford: Stanford University Press, 1998.

Stone, Oliver. *Wall Street*, 1987.

Stross, Charles. *Accelerando*. New York: Ace, 2006.

Suchanek, Fabian M., Aparna S. Varde, Richi Nayak, and Pierre Senallart. “The Hidden Web, XML and the Semantic Web: Scientific Data Management Perspectives,” 2011. http://suchanek.name/work/publications/edbt2011tut.htm.

Šurda, Peter. “Economics of Bitcoin: Is Bitcoin an Alternative to Fiat Currencies and Gold?” Master Thesis, WU Vienna University of Economics and Business,

2012. http://dev.economicsofbitcoin.com/mastersthesis/mastersthesis-surda-2012-11-19b.pdf.

Sutherland, Thomas. “Liquid Networks and the Metaphysics of Flux: Ontologies of Flow in an Age of Speed and Mobility.” *Theory, Culture & Society* 30, no. 5 (September 2013): 3–23.

Sutton, Benjamin, and Claire Voon. “Panama Papers Shed Light on the Shadowy Art Market.” *Hyperallergic*, April 12, 2016. http://hyperallergic.com/289250/panama-papers-shed-light-on-the-shadowy-art-market/.

Swan, Melanie. “Digital Simondon: The Collective Individuation of Man and Machine.” *Platform: Journal of Media and Communication* 6 (2015): 46–58.

Swartz, Aaron. *Aaron Swartz’s A Programmable Web - An Unfinished Work*. Synthesis Lectures on The Semantic Web: Theory and Technology. San Rafael: Morgan & Claypool, 2013. http://commons.wikimedia.org/wiki/File:Aaron_Swartz_s_A_Programmable_Web_An_Unfinished_Work.pdf.

Szabo, Nick. “Shelling Out - The Origins of Money,” 2002. http://szabo.best.vwh.net/shell.html.

Talwalkar, Presh. “In What Order Does Your Bank Post Transactions? Why This Matters for Overdraft Fees.” *Mind Your Decisions*, November 14, 2012. http://mindyourdecisions.com/blog/2012/11/14/in-what-order-does-your-bank-post-transactions-why-this-matters-for-overdraft-fees/.

Tapscott, Don, and Alex Tapscott. *Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World*. New York: Portfolio, 2016.

Tauberer, Joshua. “What Is RDF.” *XML.com*, July 26, 2006. http://www.xml.com/pub/a/2001/01/24/rdf.html.

Terranova, Tiziana. *Network Culture: Politics for the Information Age*. Ann Arbor: Pluto Press, 2004.

The Editors. “Bring On the Cashless Future.” *Bloomberg View*, January 31, 2016. https://www.bloomberg.com/view/articles/2016-01-31/bring-on-the-cashless-future.

The Invisible Committee. *To Our Friends*. Translated by Robert Hurley. South Pasadena: Semiotext, 2015.

“The Moniac.” *The Reserve Bank Museum*. Accessed July 22, 2016. http://www.rbnzmuseum.govt.nz/activities/moniac/introduction.aspx.

The Pew Charitable Trust. “Checks and Balances.” The Pew Charitable Trust, 2015. http://www.pewtrusts.org/~/media/assets/2015/05/checks_and_balances_report_final.pdf.

The World Counts. “Number of Planet Earths We Need - to Provide Resources and Absorb Our Waste.” *The World Counts*. Accessed June 4, 2016. http://www.theworldcounts.com/counters/shocking_environmental_facts_and_statistics/what_is_the_environmental_footprint.

Torque, and Furtherfield. “Artists Re:Thinking the Blockchain,” 2016. http://www.crowdfunder.co.uk/artists-rethinking-the-blockchain?tk=208334da9b174c4145e1fec75e784e1b261ff238.

Toscano, Alberto. “Technical Culture and the Limits of Interaction: A Note on Simondon.” In *Interact or Die!*, edited by Joke Brouwer and Arjen Mulder. Rotterdam: V2 Pub./NAi Publishers, 2007.

———. “The Disparate: Ontology and Politics in Simondon.” University of Sussex, 2007. http://www.after1968.org/app/webroot/uploads/Toscano_Ontology_Politics_Simondon.pdf.

Totaro, Paolo, and Domenico Ninno. “The Concept of Algorithm as an Interpretative Key of Modern Rationality.” *Theory, Culture & Society* 31, no. 4 (March 2014): 29–49.

Touryalai, Halah. “Yes, Banks are Reordering Your Transactions and Charging Overdraft Fees.” *Forbes*, June 11, 2013. http://www.forbes.com/sites/halahtouryalai/2013/06/11/yes-banks-are-reordering-your-transactions-and-charging-overdraft-fees/.

Troemel, Brad. “Athletic Aesthetics.” *The New Inquiry*, May 10, 2013. http://thenewinquiry.com/essays/athletic-aesthetics/.

Troemel, Brad, Artie Vierkant, and Ben Vickers. “Club Kids: The Social Life of Artists on Facebook.” *DIS Magazine*, 2012. http://dismagazine.com/discussion/29786/club-kids-the-social-life-of-artists-on-facebook/.

Tuwiner, Jordan. “Bitcoin Mining Centralization.” *Bitcoin Mining*, May 12, 2016. https://www.bitcoinmining.com/bitcoin-mining-centralization/.

Universities Australia. “Uni Funding Cuts No Answer to Higher Education Financial Sustainability,” April 7, 2016. https://www.universitiesaustralia.edu.au/Media-and-Events/media-releases/Uni-funding-cuts-no-answer-to-higher-education-financial-sustainability#.V0k7opN96cY.

Vaccari, Andrés. “Unweaving the Program: Stiegler and the Hegemony of Technics.” *Transformations*, no. 17 (2009).

Vadén, Tere. “FAQ on Robin Hood Services.” *Robin Hood Coop Forums*, September 6, 2015. http://discourse.robinhoodcoop.org/t/faq-on-robin-hood-services/145.

———. “FAQ on the Relationships between Robin Hood Coop, Robin Hood Unlimited and Robin Hood Services.” *Robin Hood Coop Forums*, September 2015. http://discourse.robinhoodcoop.org/t/faq-on-the-relationships-between-robin-hood-coop-robin-hood-unlimited-and-robin-hood-services/149.

Valdes, Ray, David Furlonger, and Fabio Chesini. “The Bitcoin Blockchain: The Magic and the Myths.” Gartner, April 8, 2016.

Valdes, Ray, and Neil MacDonald. “Maverick* Research: In a Post-Bitcoin World, Metacoin Platforms Enable the Programmable Economy.” Gartner, October 28, 2014.

Varoufakis, Yanis. “State of Power 2016: Democracy, Sovereignty and Resistance.” In *Democracy, Power, and Sovereignty in Today’s Europe*, edited by Nick Buxton and Deborah Eade, 17–35. Amsterdam: Transnational Institute, 2016. https://www.tni.org/files/publication-downloads/state-of-power-2016.pdf.

Vidokle, Anton. “Art Without Artists?” *E-Flux*, no. 16 (May 2010). http://www.e-flux.com/journal/art-without-artists/.

Vierkant, Artie. *The Image-Object Post-Internet*, 2010. http://jstchillin.org/artie/pdf/The_Image_Object_Post-Internet_a4.pdf.

Vilar, Pierre. *A History of Gold and Money: 1450-1920*. Translated by Judith White. London: Verso, 2011.

“Virtu Financial Form S-1.” Washington: Securities and Exchange Commission, March 10, 2014. https://www.sec.gov/Archives/edgar/data/1592386/000104746914002070/a2218589zs-1.htm.

Vogl, Joseph. “Taming Time: Media of Financialization.” Translated by Christopher Reid. *Grey Room* (January 1, 2012): 72–83.

Von Mises, Ludwig. *Human Action: A Treatise on Economics*. San Francisco: Fox & Wilkes, 1996.

W., C. “Why Negative Interest Rates Have Arrived—and Why They Won’t Save the Global Economy.” *The Economist*, February 18, 2015. http://www.economist.com/blogs/economist-explains/2015/02/economist-explains-15.

W3C. “Initial Proposal - Financial Industry Business Ontology Community Group,” May 4, 2015. https://www.w3.org/community/fibo/wiki/Initial_Proposal.

Wark, McKenzie. “On Scrooge and His Art Collection: A Little Xmas Offering.” *Public Seminar*, December 3, 2013. http://www.publicseminar.org/2013/12/on-scrooge-and-his-art-collection-a-little-xmas-offering/.

———. *Telesthesia. Communication, Culture and Class*. Cambridge: Polity, 2012.

Weinstein, Jack Russell. “Adam Smith (1723 - 1790).” *Internet Encyclopedia of Philosophy*. Accessed July 21, 2016. http://www.iep.utm.edu/smith/.

Wen, Zikai Alex, and Andrew Miller. “Scanning Live Ethereum Contracts for the ‘Unchecked-Send’ Bug.” *Hacking Distributed*, June 16, 2016. http://hackingdistributed.com/2016/06/16/scanning-live-ethereum-contracts-for-bugs/.

Whitehead, Alfred North. *The Function of Reason*. Boston: Beacon Press, 1958.

Wiener, Norbert. *Cybernetics: Or, Control and Communication in the Animal and the Machine*. Cambridge: The MIT Press, 1965.

———. *The Human Use of Human Beings: Cybernetics and Society*. New York: Avon Books, 1967.

Wigglesworth, Robin. “Artificial Intelligence-Focused Numerai Raises $1.5m.” *Financial Times*, April 18, 2016. http://www.ft.com/intl/cms/s/0/b743fa8e-034a-11e6-af1d-c47326021344.html?ftcamp=engage%2Femail%2Femailthis_link%2Fft_articles_share%2Fshare_link_article_email%2Feditorial#axzz46CEjwy8G.

———. “Fintech: Search for a Super-Algo.” *Financial Times*, January 20, 2016. http://www.ft.com/intl/cms/s/0/5eb91614-bee5-11e5-846f-79b0e3d20eaf.html#axzz44sCMEouu.

Willemse, Tinus. “Contactless Technology Overview.” *MWR InfoSecurity*, August 8, 2013. https://www.mwrinfosecurity.com/our-thinking/contactless-technology-overview/.

Winograd, Terry, and Fernando Flores. *Understanding Computers and Cognition: A New Foundation for Design*. Reprint edition. Norwood: Ablex Publishing Corporation, 1990.

Wirth, Niklaus. *Algorithms + Data Structures = Programs*. Englewood Cliffs: Prentice Hall, 1976.

Wolchover, Natalie. "A New Physics Theory of Life." *Quanta Magazine*, January 22, 2014. https://www.simonsfoundation.org/quanta/20140122-a-new-physics-theory-of-life/.

Zalamea, Fernando. "Peirce and Latin American 'Razonabilidad': Forerunners of Transmodernity." *European Journal of Pragmatism and American Philosophy* 1, no. 1 (2009).

———. *Synthetic Philosophy of Contemporary Mathematics*. Falmouth: Urbanomic, 2012.