Investigating the Potential of Service Oriented Architectures to Realize Dynamic Capabilities

Haresh Luthria[1], Fethi Rabhi[2], Michael Briers[3]
Information Systems, Technology & Management, Australian School of Business, University of New South Wales, Australia
[1]*h.luthria@unsw.edu.au*, [2]*f.rabhi@unsw.edu.au*, [3]*m.briers@sirca.org.au*

Abstract

The paradigm of service-oriented computing (SOC) has emerged as an architectural approach to flexibility and agility, not just in systems development but also in business process management. There is, however, a paucity of critical research assessing the strategic impact of SOA on the competitiveness of organizations. Some research literature in strategic management indicates that firms may gain a competitive advantage in rapidly changing market environments by concentrating on their dynamic capabilities – i.e., product flexibility and agility in organizational transformation in response to rapidly changing market conditions and customer requirements. The intent of this paper is to analyze the conduits through which service-oriented architectures (SOAs) may exert influence on dynamic capabilities within firms. The results could potentially assist in evaluating if and how the adoption of service-oriented architecture may help achieve key dynamic capabilities, giving the enterprise a competitive edge.

1. Introduction

Recent cross-industry surveys of global CEOs, conducted by IBM Business Consulting Services [1], indicate that organizational agility is high on the priority list of business executives looking to establish a competitive advantage. The organizational processes that facilitate this kind of agility are termed "dynamic capabilities" [2] in management literature. In practical terms, there are five dimensions of dynamic capabilities: integration of internal resources, integration of external resources (partners, customers, etc.), rapid product development, learning, and the creation of assets. The ability to use these dynamic capabilities to rapidly build new resource configurations can result in sustained competitive advantage [3].

The challenge then lies in implementing the organization's business processes with information technology solutions that can facilitate these dynamic capabilities thereby building agility [4]. IT infrastructures based on Service Oriented Computing (SOC) principles can provide organizational agility and, consequently, be a source of competitive advantage [5-7]. The SOC paradigm views whole business functions (order placement, for example) as modular, standards-based software services. The associated Service Oriented Architecture (SOA) establishes a defined relationship between such services offering discrete business functions and the consumers of these services, independent of the underlying technology implementation [8].

There is a great deal of enthusiasm in the industry about this concept, but the adoption of SOA by end-user organizations is still in a relatively early stage [9] and there is little critical research on the practical use of SOA. There is, hence, a great dependency on analyst reports and vendor surveys for insights into the strategic value, and the incumbent challenges, of implementing SOA. Some notable analytical literature does exist on the potential strategic value of Web Services [5, 10, 11], and other empirical studies of Web services, and more generally SOA, are emerging [7, 12]. Even as these studies break new ground in the area of competitive advantage using SOA through Web services implementations, this area continues to remain largely unexplored.

The strategic management concept of dynamic capabilities is a widely accepted approach to understanding the competitiveness of organizations. There is, however, no study that links SOA as a technology concept to the "first principles" of dynamic capabilities. Therefore, the attributes of SOA that may make it amenable to creating dynamic capabilities and the channels through which it might be able to influence its creation are not well understood.

This paper builds on previous research efforts in IS and strategic management literature [2, 4, 8] to address the following question:

How does the adoption of service-oriented computing impact a firm's five dynamic capabilities - (1) integration of internal resources, (2) integration with of external

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resources, (3) rapid product development, (4) learning, and (5) creation of assets?

In attempting to answer this question, this paper aims to establish an analytical framework linking the adoption of SOA and dynamic capabilities, thus providing a pragmatic mechanism to examine the strategic impact of SOA on competitive strategy. The framework will be developed by examining the key attributes of SOA, and then relating these attributes to the five dynamic capabilities, with the premise that the use of dynamic capabilities by firms to achieve competitive advantage is well established in management literature. This framework may be extended empirically and analytically to investigate the strategic value of SOA, and may potentially also be used as a communication tool between IT and business teams within organizations.

The following two sections present the concepts of service orientation and dynamic capabilities, respectively. The next section reviews the attributes of SOA and their role in achieving dynamic capabilities. The following section proposes this relationship as a framework to examine the strategic impact of SOA, and discusses its relevance to both, researchers and practitioners. The final section summarizes the contributions of this paper.

2. Service Oriented Computing

As organizations have evolved with ever-changing technology, and natural organic and acquisition-based growth, the complexity of their infrastructures has increased dramatically, requiring more innovative distributed computing techniques to address their needs [13]. With the increasing diversity of platforms, protocols, and development environments, the need for a higher level of abstraction was recognized as being imperative for the efficient use of existing heterogeneous and/or geographically distributed resources [14]. This need was compounded by the growing business need for communications across diverse domains – for example, across partner or customer systems - for increased business value through strategic partnerships [15]. This gave rise to the concept of *services*, functional entities whose location and implementation are abstracted from the client or user, to allow the integration and communication of diverse and distributed technology domains.

2.1. What Constitutes a Service?

A service is a business function implemented in software, wrapped with a formal, documented interface that is well known, does not depend on the internal workings of other services, and can be located and accessed by any software agent using standards-based communication mechanisms [8]. These services could be *simple* services performing basic granular functions such as order tracking or *composite* services that assemble simple or other composite services to accomplish a broader modular business task such as a specialized product billing application. As an example, a business flow, such as an online book retail service, could be built using services across multiple service providers pulling together, say, billing services from a partner, and warehousing services from another partner. At a lower level, this could also potentially work for an individual business application say, the ordering of a book being built from tying together simple services such as a book search feature and customer verification.

2.2. Service Oriented Architecture (SOA)

While services manifest business functionality in the service-based computing model, a Service-Oriented Architecture (SOA) provides a framework for the infrastructure to facilitate the interactions and communications between services [8]. An SOA is as an interconnected set of services which in its basic form is a message-based interaction between software agents, each accessible through standard interfaces and messaging protocols. These agents can be service providers or service requesters (clients) interacting with service discovery agencies, and the services in the SOA should be technology neutral, loosely coupled (not tightly integrated into the requester's process), and support location transparency. .

SOAs can be thought of as both an architecture and a programming model, more a way of thinking about building software than a software development technique [13]. According to widely accepted definitions of services (W3C 2004; Papazoglou 2003), SOA-compliant architectures exhibit the following four properties:

- ***Modularity.*** The services in the architecture are developed as independent modules of functionality, offering well-defined interfaces to their users. The services represent a logical view of discrete business level operations (e.g., customer verification) and are relatively granular or coarse-grained in scope.
- ***Loose Coupling.*** This is facilitated by encapsulation of the underlying functionality so that the implementation is logically decoupled from the invoking entity. Services may encapsulate functionality at various levels – from components within an application to components or sub-systems communicating across enterprises – as long as they represent discrete meaningful business functions. This facilitates the composition of these services into complex services and applications.
- ***Technology neutrality***. Services are universally usable by any requester, and communication between services is message based, with the message format being standards-based and platform-neutral.

- ***Location transparency.*** The services are self-describing in that they have formal documented interfaces that are well known, and they are easily locatable and accessible over a network. According to Papazoglou (2003), the service interface is "known where to be found not only by agents who designed the services but also by agents who do not know about how the service has been designed and yet want to access and use it".

In the business world, SOAs may be viewed as application architectures "within which all functions are defined as independent services with well-defined invokable interfaces, which can be called in defined sequences to form business processes" [13]. Decomposing this definition, services can represent simple business capabilities (e.g., address validation), complex business transactions built from simple business capabilities (e.g., placing purchase orders), or broader system functions (e.g., user authentication). In addition to this essential attribute of granularity, services are "independent" in that they meet the requested need but their internal implementations are irrelevant to the business process. Services are "invokable" in that they can be used from within or across enterprise boundaries by users across diverse platforms.

Service consumers can, ostensibly, weave together business services, with no knowledge of the underlying technical service implementations, changing existing business models where the business process are invariably tightly tied to specific technology solutions [16] . The pulling together of simple, basic, core services to form a complex business process in the SOA world is called *service composition* [17]. To achieve this seemingly easy equilibrium of the composition of services into higher level applications, however, the underlying technical infrastructure needs to provide stateless or context independent technical services with relevant metadata that describes what the service does and how to interact with it. These stateless technical services can then be bound together on demand to form business services, using generic communications infrastructure and the contextual metadata [18-20].

2.3. Technology Implementations of SOA

SOAs may be implemented using any appropriate technology as long as the services in the SOA framework support the basic principles of service-oriented computing - modularity, loose coupling, technology neutrality, and location transparency.

Hub-centric message driven systems used by enterprises today are widely viewed as precursors to what is now called SOA [21]. Message oriented middleware (MOM) allowed systems to build modules that communicated over a messaging infrastructure, forming a loosely coupled system and allowing for a level of abstraction. Component based software programming models, such as DCOM, CORBA, and Enterprise Java Beans (EJB), are also earlier attempts at building loosely-coupled object-based systems [10]. These system models that were precursors to the service concept continue to be viable options of implementing SOA in certain situations [22]. When it comes to wider use across organizational boundaries, however, the use of these models are hampered by the lack of uniform standards and support from major software vendors [23].

The next step on the implementation chain was made possible by the ubiquitous information channel - the Internet. Web services are essentially the deployment of a service-based computing model over the Internet, and unlike other earlier technology implementations, leverage open Internet standards to facilitate diverse inter-enterprise communication [8], garnering relatively unanimous industry vendor support [10].

2.4. Current State of Industry Adoption

There are a variety of statistics available from various trade magazines and technology analysts relating to the adoption of SOA in the industry, all generally indicating the widespread acceptance of SOA. As early as 2003, Gartner [24] had predicted that over time lack of SOA would become a competitive disadvantage for most enterprises. A recent survey of 1356 IT professionals worldwide [9], indicates that knowledge and awareness of SOA amongst the IT professional community was "significant", extrapolating from the results that indicated that about a third of the respondents had looked at SOA "in-depth" and an additional third of them had a high-level knowledge. The conclusion of this report, that the spread of SOA is "almost inevitable", mirrors the general optimism in trade journals and magazines, indicating that SOA, and specifically Web Services, is the popular choice for businesses looking for flexible systems development.

The major technology vendors appear to have invested significant effort in promoting SOA, building supporting products and tools, and even publishing related research, with IBM seemingly in the forefront. Its research initiative (Service Science, Engineering, and Management or SSME for short) is a collaborative effort with various universities worldwide to promote multi-disciplinary research in service-oriented computing. HP has recently introduced the Business Technology Optimization (BTO) for SOA, a set of software and services for service management. Microsoft and BEA are also updating their product suites and infrastructures to include service-oriented concepts. In addition to specific products and solutions, software vendors, large and small, have thrown their support behind SOA, working on various cross-vendor initiatives to promote the growth of SOA adoption. The efforts are too numerous to list here, but industry trade journals have an abundance of information

on vendor products, and ongoing collaboration efforts across various vendors to promote standards and interoperability for enterprise service infrastructures.

3. Dynamic Capabilities

Research literature in the field of strategic management has focused on sources of competitive advantage, especially in rapidly changing market environments [25]. In dynamic markets, the strategic advantage appears to lie in the ability to change repeatedly to meet customer needs and stay ahead of the competition.

Seminal work by Teece and Pisano (1994) in this area analyses the competencies or capabilities of firms that could result in potential competitive advantage. Corporations that have been able to succeed in the global marketplace have been those with (a) product flexibility and (b) the managerial ability to harness internal and external resources, resulting in the ability to respond in a timely manner to a rapidly changing competitive environment. The concept of a firm's *dynamic capabilities* is introduced in this context of competition as those competencies or capabilities which facilitate the rapid creation of new products and processes by the agile coordination of "internal and external organizational skills, resources, and functional competences" in response to dynamic market conditions. Teece *et al* identify a firm's dynamic capabilities as primarily its organizational processes, its market positions, and its possible expansion paths. The processes are explained to be the managerial and organizational routines for accomplishing tasks within the firm – coordination or integration (both of internal resources and with external partners for enhanced value products and services), learning by doing (both individual and organizational), and transformation (the reconfiguration of resources to respond to a changing customer environment). Positions, in the context of dynamic capabilities, refer to a firm's assets – both tangible (e.g., financial assets) and intangible (e.g., reputation). The authors also include as dynamic capabilities, the organization-wide decision paths taken in the past, and those decision paths available to the organization going forward.

In concrete terms, the following dynamic capabilities are identified to be potential sources of competitive advantage – (1) internal coordination and integration of business processes, (2) integration with strategic partners, (3) rapid product development, (4) learning by doing, and (5) creation or acquisition of assets (technological, complementary, financial, reputational, structural, institutional, and/or market assets).

Dynamic capabilities, as thus defined, appear to provide a suitable framework for looking at the potential strategic technology initiatives being pursued by corporations in the current market environment. In the much researched area of how information technology can be used to influence a firm's performance, an oft cited study theorizes that information technology can be used to enable key organizational capabilities and strategic processes, thus positively impacting the firm's performance [4] The authors indicate that their analysis is a stage-setter for potential future research, both analytical and empirical, in the bid to study the complex relationship of investments in information technology and organizational agility. A further review of the literature in this area indicates that, of the studies that have taken this approach further, few have linked service-oriented computing with the building of dynamic capabilities in management or information systems research literature. Those that have examined the strategic positioning of service-oriented computing have focused specifically on the impact of Web services on a single generic organizational capability (such as application integration or business process flexibility). Exploring this relationship further could provide additional insight into the strategic value of service oriented computing.

4. SOA as an Enabler of Dynamic Capabilities

We can now examine the five dynamic capabilities – integration of internal resources, integration of external resources, rapid product development, learning, and creation of assets – and analyze how the fundamental properties of an SOA-compliant architecture can help achieve these dynamic capabilities. Let us consider this analysis in the context of the mortgage services business of Company X, a fictitious financial institution. The business functions supporting the mortgage processes may potentially include the evaluation of risk, underwriting of loans, support for the processing and closing of loans, and post-closing servicing of loans, as in a typical mortgage provider's process.

4.1. Integration of Internal Resources

Moving to a service based approach allows existing and proven legacy system functions to be encapsulated as services on a new standards based integration platform. The services can encapsulate single functions, or be composed of several smaller services, representing legacy functions on a diverse set of hardware and software platforms [13, 15, 26] thus allowing for the integration of internal resources that may be implemented across disparate platforms and infrastructures [22, 23]. Although the argument for location transparency could be made for geographically disparate resources, the properties of encapsulation, along with technology neutrality, are sufficient conditions to address basic intra-enterprise integration of diverse resources. In the case of Company X, compute-intensive credit scoring models typically

implemented on mainframes could be converted to services with clearly defined interfaces and service-level agreements, and potentially be integrated with Internet-based loan request applications for a robust underwriting process. These scoring models could be constantly updated based on evolving knowledge and market conditions without impacting the broader underwriting application as long as the service interface requirements are complied with.

4.2. Integration of External Resources

The transformation of an enterprise's business processes to services, along with standards-based communication protocols, opens up new avenues of strategic partnerships with suppliers, partners, and customers [27]. Primarily, encapsulation allows services from external service providers to be included as part of the system [28] without having to understand the underlying implementation of the service. The inter-enterprise communication required for such cross-domain business flows may then be facilitated by the technology neutrality property of SOAs, i.e., a messaging infrastructure based on open standards. Arguably, the most significant advantage of a service-based business model in the context of inter-enterprise integration is that services have interfaces that are location transparent. This means that the services are reachable independent of whether they are implemented within the boundaries of the same business process, in another business process within the organization, or in a business process in an external (partner or customer) domain. This attribute of accessibility independent of location is a key enabler of the critical strategic transformation facing corporations today – extending the enterprise to establish strategic partnerships beyond organizational boundaries [29]. Company X could potentially incorporate additional risk evaluation models available in the market into their underwriting service, partner with vendors (for services such as property appraisals, flood certifications, etc.) to provide customers with an end-to-end automated loan processing service, or even replace in-house servicing of loans with more cost effective loan servicing offered by partners.

4.3. Rapid Product Development

Modularity, encapsulation, and location transparency allow for rapid development in that existing components implemented within and across varying platforms may be encapsulated and then assembled to form new business applications [22]. This could potentially reduce the time to pull together well-design tested functionality to meet new market needs [5]. The reuse of existing modular components also reduces risk in more ways than one [13, 26] in that the enhanced business process incurs no new potential points of failure, and the maintenance of the supporting infrastructure continues to remain unaltered. Company X could potentially leverage its credit scoring models to provide a variety of loan products based on evolving customer demands.

4.4. Learning

A considerable amount of critical literature exists on the link between learning and product modularity, with critical analyses of how modular product design and architectures can positively impact learning at the individual and organizational level. While component modularity helps in individual learning of system components insulated from disruptions at the architecture level, modular architectures help organizations learn about markets by enabling rapid product variations due to modularity of the architectural components [30].

From a systems perspective, component modularity may contribute to the reduction over time of the learning curve of the development or assembly team due to familiarity with existing modular services [5, 13, 31, 32]. From a business process perspective, existing architecture frameworks tend to be program-centric with business flow or process knowledge often spread across individual system components, hampering the consolidation of information relevant to clearly understanding business flows. Effective SOAs tend to be well-defined process-centric architectures, allowing for better process design and knowledge, monitoring, and rapid transformation of these processes from a business perspective rather than systems perspective [5, 13, 16]. This flexibility of service-based business process architectures is enabled by modularity, loose coupling, and technology independence, allowing rapidly assembled variations to be tested against changing market requirements, potentially building a better awareness or knowledge of markets. This is applicable for simple business functions such as customer validation, relevant across the entire business process for Company X, or for the end-to-end mortgage process defined as discrete services for loan requests, underwriting, processing, closing, and servicing.

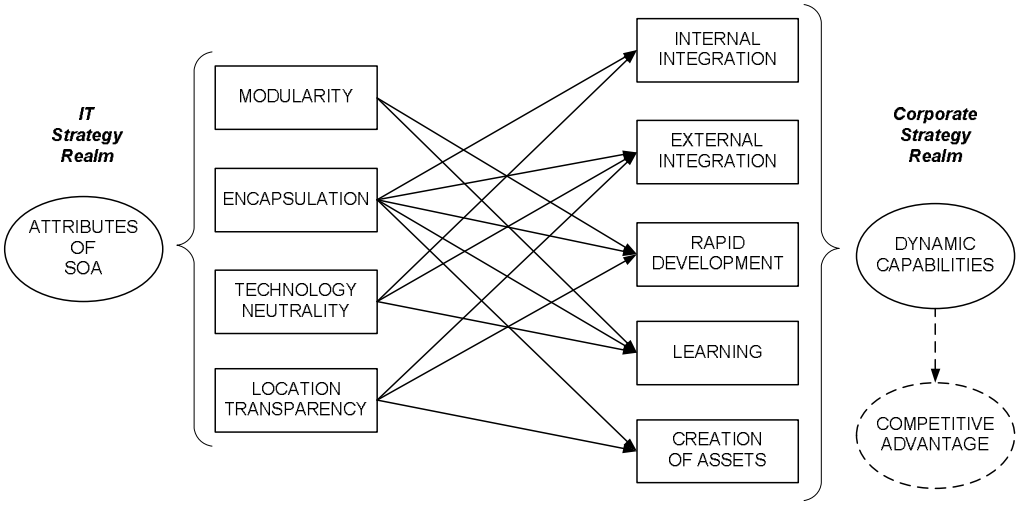

Figure 1 - The SOA-DC Framework

4.5. Creation of Assets

While the concept of software as a service is not new, the packaging of discrete business functions as services appears to provide new business opportunities for organizations. The clear representation of business flows as services, allows for the identification of business services that are the core competence of the organization, allowing for the non-core services to be substituted by those provided by vendors with the relevant expertise [13]. As a result, service based architectures enable corporations to offer their core competencies as services to other companies [5, 19, 27], focusing on areas of comparative advantage while buying or leasing services in which they lack superior expertise from other service providers [15]. As time progresses, the developed services become a core asset of the organization – a library of tested, ready to use, compatible components [13], encapsulated as services to be made available to external entities, independent of location, as products. This concept can also be extended to key data repositories, making them available to partners as services [28]. Technology neutrality can add to increasing the market-base but is not a necessary condition to make internal business functions available as marketable service assets. Company X's in-house credit scoring model, closing service, or servicing applications are typical examples of services that could potentially be marketed as independent products.

5. Discussion

In reviewing the growing body of literature on SOA, there is a lot of analytical information on the potential value of a service-oriented approach. There are few, if any, formal mechanisms to align SOA as a technology strategy with a firm's corporate strategy for competitiveness. When viewed through the lens of the five dimensions of dynamic capabilities, a key school of thought in competitive strategy, SOAs appear to conceptually match the technology infrastructure required to implement a firm's dynamic capabilities. This similarity in these disparate concepts from the disciplines of information systems and strategic management provides the motivation for the development of an analytical framework mapping the attributes of SOA to the dimensions of dynamic capabilities thus providing a bridge between the realms of IT strategy and a firm's corporate strategy.

The proposed framework mapping the linkages between the attributes of SOA to the five dimensions of dynamic capabilities (the SOA-DC framework), depicted in Figure 1, provides the basis for a formal examination of the relevance of SOA to corporate strategy.

5.1. Relevance to Researchers

Earlier studies have articulated analytical frameworks for Web Services, most notably a discussion by Iyer *et al* (2003) that uses Zachman's stakeholder model for systems architecture to examine the factors to be considered when building a Web service based architecture, and an analysis by Huang and Hu (2004) that investigates the link between Web services and competitive strategy using a popular strategic management tool, the Balanced Scorecard [33]. Emerging empirical studies include an assessment of the implementation of Web services by two banks[12], and a cross-sector examination of the impact of Web services on business process flexibility and, hence, organizational adaptation [7]. All of these studies provide valuable contributions to the body of knowledge, by focusing on an implementation of SOA (Web services), specific management tools, or specific dimensions of agility. What

the SOA-DC framework does is link SOA to a set of fundamental strategic management principles, thus providing a means for a rigorous analysis of the strategic value of SOA.

The SOA-DC framework could potentially be extended to examine (a) the dimensions of the relationship between SOA and dynamic capabilities empirically, (b) the implementation challenges (technical business, organizational, and strategic), (c) the planned benefits versus actual benefits observed, and/or (d) the suitability of various implementation models along each of the relationship links.

As research along these lines progresses, it is also possible that the results may show other links between SOA attributes and the dimensions of dynamic capabilities, replace some of the links with new ones, identify relative weights for each link, and maybe even identify new dimensions of value.

While this framework looks at the impact of SOA on achieving dynamic capabilities, another extension of this concept could be relevant to examine the impact of dynamic capabilities on the adoption of SOA – key dynamic capabilities needed for the effective adoption of SOA, the building of dynamic capabilities within a SOA environment, or even the evolution of dynamic capabilities in a SOA environment. This analysis thereby sets a rich agenda for future research

5.2. Relevance to Practitioners

Even as SOA is now widely accepted as having the potential to improve the responsiveness of both business and IT organizations, it seems that most organizations that are adopting SOA do not fully understand the business potential of SOA, focusing on technical implementation issues instead of the broader business service view [16].

The business opportunity created by SOA revolves around the reorganization of enterprise information resources as independent, reusable services [16], moving away from viewing corporations as a building block of process flows, and re-inventing the corporation to be more a collection of services focused on comparative advantage [27, 34]. The automation of these services creates a new kind of business model, facilitating an integrated process across the enterprise ecosystem to include partners, suppliers, and customers [16]. Not many business people, however, are familiar with the term 'SOA' [35].

There is a considerable body of research on the business impact of IT, specifically the influence of IT-related capabilities on a firm's performance, but there is still ongoing work to be done to clarify how and why these technologies and capabilities may shape a firm's performance and competitiveness [4, 36]. The SOA-DC framework adds to the body of knowledge in this area, and provides a mechanism for IT staff to communicate the impact (positive or negative) of their SOA strategy. This is relevant because the initial adoption of SOA across enterprises appears to be driven by the technology teams rather than the business units. Relating the attributes of SOA to dimensions of competitive strategy can also help in identifying opportunities or challenges at the enterprise level, providing a framework to strengthen the accountability of IT strategy vis-a-vis the corporate strategy.

6. Conclusion

Research scholars indicate that firms may gain competitive advantage in rapidly changing market environments by achieving key *dynamic capabilities*. Recent surveys of CEOs reflect this in practice, indicating that companies with superior financial performance are pursuing this kind of agility in their quest for a competitive edge. Current thinking indicates that IT infrastructures can enable agility. The paradigm of service-oriented computing appears to provide avenues for flexibility and agility in business process transformation and systems development.

This paper adds to an emerging body of knowledge about this new computing paradigm and provides a platform to investigate the applicability of service-oriented computing in today's competitive markets by proposing an analytical framework linking the adoption of SOA to the strategic management concept of dynamic capabilities.

For IS researchers looking to investigate the value of SOA, this analysis acts as an agenda-setting tool, providing the groundwork for future empirical research along the five dimensions of dynamic capabilities – some options being, but not limited to, the examination of technology implementations best suited for each of these dimensions, the actual benefits realized, and the challenges faced along these dimensions. For management researchers, the framework provides a platform to evaluate the link of a strategic management theory with a technology concept of growing popularity.

For IS practitioners, this framework provides a tool to communicate with the business and corporate teams. In discussing the value or cost of SOA as an enterprise strategy, positioning SOA in the dynamic capabilities framework may give business people, who may not have heard of SOA, some perspective and understanding of the potential and impact of the technology.

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