Resistance factors to technology innovation in construction organisations

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Resistance factors to technology innovation in construction organisations

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Effective technology innovation today appears to be all about the push factors that promote comprehensive technology uptake. There are now multiple, well-established and diverse theories on how best to effect technology innovation deployment, adoption and diffusion. In practice, however, for every push factor there is a potential resistance factor. Significantly, resistance factors become increasingly problematic as the technology innovation moves from its early stages and early adopters to wider spread use by the majority. For a construction industry on the cusp of major transformation, effective integration of emerging communication and collaboration technologies is critical.

This study undertakes a comprehensive review of current innovation theory to identify and examine the particular factors that drive user resistance to technology innovation in construction organisations, most specifically user resistance to Online Project Information Management Systems (OPIMS). For the first time, multiple theoretical perspectives drawn from diffusion of innovation theory, technology acceptance models and social network theories are consolidated into a unified analytical framework of potential resistance factors: the Integrated Resistance Factor Model (IRFM). The IRFM is then tested and refined to identify the most significant resistance factors for OPIMS. Knowledge of the most significant resistance factors for OPIMS can then be used strategically to address key barriers to broader utilisation of that technology. It can also be used to better manage the deployment of emerging technology innovations, such as Building Information Modelling (BIM) and Mobile Computing.

The study employs a mixed methods research approach. Data collection and analysis is conducted sequentially using quantitative (survey) and qualitative (interview) methods. Data from the survey is analysed using a novel application of the Partial Least Square (PLS) technique, more generally used in Structural Equation Modelling (SEM). All constructs proposed in the IRFM model are demonstrated to be significant, valid and consistent with the theory. IRFM is verified as an effective and appropriate model of user resistance factors. Specific results demonstrate that the most critical factors to influence technology resistance in this context are: (i) the support provided by leaders and peers; (ii) the complexity of the technology; (iii) how compatible the technology is with key work practices; and (iv) the extent to which potential users are able to pre-trial the technology before it is actually deployed. These findings are confirmed by the interviews. The key limitations of the research are specific to the formative measures used in the analysis technique and the sample size.

This research has implications for innovation theory as well as for construction organisations and software providers seeking to implement new technology innovations. For innovation theory, the IRFM represents a unified analytical framework with particular application later in the innovation cycle where resistance becomes a more particular issue. For strategic management of new technology innovations the study identifies a revised focus for learning and training, more particularly to promote user motivation, and a more active role for management in support networks and communities of practice.

Keywords: User resistance, Online project information management systems, Technology innovation, Diffusion of innovation, Technology acceptance model, Social network

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Abstract

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Research Publications

Ishak, S.S.M. & Newton, S. (2012). *Taking a broader view of user resistance to online project information management system implementation in the construction industry*, in I. Kamardeen, S. Newton, B. Lim and M. Loosemore (eds), Proceedings of 37th AUBEA International Conference, Sydney: UNSW, pp.647-656.

Ishak, S.S.M., Kamardeen, I. & Newton, S. (2009). *An overview of web-based project management systems in construction*, in Proceedings of 2nd Construction Industry Research Achievement International Conference, Kuala Lumpur: Construction Research Institute of Malaysia, pp.1-9.

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Contents

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List of Abbreviations and Glossary of Terms

AGFI	adjusted goodness-of-fit
AMRIT	Attributional Model of Reactions to Information Technologies
AVE	average variance extracted
BEIIC	Built Environment Industry Innovation Council
BIM	Building Information Modelling
BPM	building project management
CAD	Computer-Aided Design
CPD	continuing professional development
CRW	Compliance-Resistance-Workaround
DoI	Diffusion of Innovation
EDI	Electronic Data Interchange
EDM	electronic document management
EIM	Equity Implementation Model
ERP	enterprise resource planning
GFI	Goodness-of-Fit Index
Hypothesis	This term specifically refers to the statistical form of hypotheses (in contrast to the experimental hypothesis), wherein a descriptive statement of the probability distribution/correlations for a certain variable is proposed and tested.
ICT	information and communication technology
IRFM	Integrated Resistance Factor Model
LVs	latent variables
MIS	management information system
ML	maximum likelihood
MMRIT	multilevel model of resistance to information technology
MPCU	Model of Personal Computer Utilisation
MRTOC	Model of Resistance to IT-induced Organizational Change
NFI	normed fit index

OLS	ordinary least square
OPIMS	Online Project Information Management Systems
OVs	observed variables
PLS	Partial Least Square
PRM	Passive Resistance Misuse
RFI	request for information
RMSEA	Root Mean Square Error of Approximation
SAFM	Social Architecture Factor Model
SEM	Structural Equation Modelling
SHT	Structural Holes Theory
SME	small-to-medium-sized enterprises
SNT	social network threshold
SSQ	Social Support Questionnaire
SWTT	Strength of Weak Ties Theory
TAM	technology acceptance model
TLI	Tucker-Lewis Index
TofA	Theory of Actions
TPB	theory of planned behaviour
TRA	theory of reasoned action
UTAUT	unified theory of acceptance and use of technology
VCT	virtual construction technology
VIF	variance inflation factor
VR	virtual reality
WPMS	web-based construction project management systems

Chapter 1: Background to the Research

1.1 Introduction

Building construction is a complex process: technically, it involves a multiplicity of raw/refined, bulk/hi-tech, prefabricated/in-situ, stable/corrosive materials; operationally, it is bespoke, risky, expensive, time-pressured, weather exposed, highly skilled and procedurally interdependent; organisationally, it tends to involve fragmented, casual, disparate, temporal and independent entities. Consistently, over many years now, a strong argument has been made that innovation represents the most significant driver of this complex industry (Egan, 1998; Hampson & Brandon, 2004) and that 'rapid adoption of 21st century technologies is needed to transform this traditionally focussed industry sector' (BEIIC, 2012: 4). Communication and collaboration technologies are often highlighted as the key issues for construction industry innovation and transformation that are not receiving the strategic attention from practice or theory that they warrant (Dainty et al., 2006; Emmitt & Ruikar, 2013).

Innovation generally, innovation specific to communication and collaboration technologies and innovation particular to communication and collaboration technologies within the construction industry have actually received a great deal of attention. Indeed, a comprehensive review of the literature undertaken for this thesis reveals a plethora of eclectic and trans-disciplinary approaches. It follows that the strategic attention that communication and collaboration technologies warrant is contingent on the development of a more unified theoretical framework that effectively integrates the broad palette of otherwise discrete theoretical perspectives into a pragmatic strategic planning tool.

Any integration of multiple perspectives demands a new formulation of the problem. This thesis reconceptualises the issue of communication and collaboration technology innovation in the construction industry in terms of the cycle of innovation diffusion and resistance. The cycle of innovation diffusion (Rogers, 1962) recognises that the nature of innovation changes as it progresses from the earliest stages through to maturity. This thesis will argue that communication and collaboration technologies are mature innovations and that this fundamentally changes the diffusion strategies required.

Resistance is an alternative conceptualisation of how the barriers to innovation are constituted and might usefully be addressed, most especially in the context of a mature technology innovation. The aim of this thesis is to develop and test the capacity of an Integrated Resistance Factor Model (IRFM) to identify those critical aspects that most directly influence effective technology innovation.

This chapter provides the background of the research and discusses in detail the motivation for studying the topic of resistance in the technology implementation process. Section 1.2 describes the motivation of this thesis. It sets the scene by clearly explaining the trends in the research, the gaps and the theory in general. It discusses advances and critiques surrounding the concepts of acceptance, adoption and diffusion linked to technology innovations and the need for a shift in focus towards resistance. Section 1.3 highlights the problem of resistance towards Online Project Information Management Systems (OPIMS) in the construction industry, and sets the scope of the investigation. Section 1.4 briefly introduces the theoretical foundation used in the research. Section 1.5 states the research problem, aims and objectives. Section 1.6 summaries the research methodology. Finally, Section 1.6 introduces the overall structure of this thesis.

1.2 Motivation for the Research

1.2.1 Innovation Theory in General

For more than a decade, innovation theory has been dominated by the notion of 'diffusion', which was first articulated as far back as Rogers (1962). Diffusion of innovation has become the preeminent subject of interest in the innovation literature across information systems, organisational behaviour, marketing and management in general (Williams et al. 2009). This focus on diffusion has resulted in a significant bias in the literature towards the earlier stages of 'adopting' and 'accepting' new technologies. A comprehensive review (of 345 articles across 19 peer-reviewed journals over the period 1985 to 2007) by Williams et al. (2009) found that 'adoption' was considered in over half (51.9 per cent) of the articles reviewed, with 'acceptance' (26.9 per cent) and 'diffusion' (14 per cent) the other standout terminology used. The same review also highlighted the broad variety (nearly 200 in number) of theories and

theoretical constructs being applied to understand innovation, and the range of levels at which innovation might be considered (from an entire economy, through particular industry sectors, to individual households and consumers).

Earlier significant reviews by Legris et al. (2003) and Jeyaraj et al. (2006), across a range of journals (including MIS Quarterly, Decision Sciences, Management Science, Journal of Management Information Systems, Information Science Research, Information and Management, and conference proceedings in ABI/Inform and Science Citation Index databases), also noted the strong bias towards technology acceptance models and diffusion of innovation theory. The conclusions to each of these major reviews challenged the lack of integration between theories (Williams et al., 2009), highlighted the fact that not all innovation is beneficial/desireable (Jeyaraj et al., 2006) and called for a more effective accommodation of broader organisational and social factors within the scope of consideration (Legris et al., 2003). Overall, the need for a shift in focus was emphasised, to move from initial adoption to the longer-term quality of the innovation, its impact on user performance and the actual benefits being derived.

1.2.2 Shifting from Acceptance to Resistance

The lexicon of technology acceptance models and diffusion of innovation theory is strongly positive towards technology innovation. The terminology itself presumes upon the user to adopt and deploy the innovation, and there is a sense in which the technology *per se* is beyond reproach (Jeyaraj et al., 2006). Technology acceptance models in particular are increasingly criticised due to their saturation of the field, creating a limited picture of the problem (Benbasat & Barki, 2007). Technology acceptance models do not address some of the more central characteristics of user sense-making that potentially contribute so significantly to how an innovation is conceptualised and regarded by users (Salovaara & Tamminen, 2009). It is also argued that acceptance models tend to treat user perception as a uniform construct that can be, and therefore is, largely ignored (Salovaara & Tamminen, 2009). To address this failing, calls have been made for the adoption of alternative theoretical frameworks, beyond technology acceptance models (see Alshawi & Goulding, 2012; Aouad et al., 2010; Tookey, 2011). Venkatesh (2006) is more explicit in casting technology acceptance models as part of the problem, calling instead for a focus on the factors influencing resistance.

Resistance refers to the natural tendency or preference of an individual to avoid change. As such, resistance often has negative, destructive and adversarial connotations. However, resistance can also be construed as a positive and necessary response to technological change: necessary because, by observing the presence of resistance (whether passive or aggressive), an organisation is able to identify what has potential to fail. Resistance can thus play an important role in drawing attention to problematic elements and potential technical failure of newly implemented technologies. Resistance also provides important insight into how users are likely to, and actually do, respond to technology innovations. For example, a new technology is less likely to be rejected if the work-practice it is associated with is not being compromised. Unlike the prevailing conceptualisation based on acceptance and diffusion, the introduction of resistance has the potential to set the functional properties of a technology in the immediate context of existing work practices.

1.2.3 Innovation Theory Applied to Construction

There is a substantial literature specific to innovation theory applied to construction. A review of this literature undertaken for the purposes of this thesis is summarised in Appendix A. Each study is characterised in terms of its identified barriers and factors for successful technology implementation and adoption (e.g. technological, process, individual, social, structural, organisational and other consequences); the level of investigation (industry, organisational, individual); and the research design and methods used (e.g. survey, interview, case study).

An analysis of Appendix A shows that, in line with innovation theory in general, the large majority of innovation studies in construction relate to the early process of technology implementation and identifying the factors that most influence adoption. The same rich variety of factors present in the general field of innovation studies is evident in construction innovation studies. However, three aspects of the previous studies specific to technology innovation in construction stand out: the specific factors that constitute the various influences being considered; the missing levels of investigation; and the total dominance of discrete research methods.

1.2.3.1 Specific Factors

A vast array of, often disparate, factors has been identified in the literature. A study by Croker and Rowlinson (2007) identified four categories of critical factors that influence information and communication technology (ICT) implementation decisions within project teams over time: external forces, internal forces, situational factors and organisational factors. More specifically, the factors identified by Croker and Rowlinson (2007) included: external requirements, competitive advantage, technology opportunity, information exchange standards, organisational structure, culture and technology champions, project readiness, corporate strategy, project size, people and skills. While these have been identified as very significant factors, they indicate that a major reason for not adopting new ICT is the lack of prospect of continuing use of such technology. This is the most relevant factor in the current context and supports the direction taken by the thesis. Other studies targeted the impact of technology characteristics, user attitudes, social and organisational factors (Alshawi & Ingirige, 2003; Hjelt & Björk, 2007; Laage-Hellman & Gadde, 1996; Mitropoulos & Tatum, 2000; Nitithamyong & Skibniewski, 2004; Ruikar et al., 2005; Wong & Zhang, 2013; Wong & Lam, 2010). According to Laage-Hellman and Gadde (1996), the implementation process is most particularly hindered by the quality of communication, information exchange, poor integration with other software and hardware, lack of information technology (IT) skills among staff and top management support, a reluctance to change business processes and poor partnerships.

Mitropoulos and Tatum (2000) focus on externalities such as the competitive advantage of core technologies adopted by competitors and responding to the demands of clients and collaborators. Wong and Lam (2010) highlight self-discipline and self-awareness as key to the cultural and behavioural adjustments of ten required to accommodate technological change. In contrast, for Hjelt and Björk (2007), the same issue of behavioural change calls for outward-looking, interpersonal skills and the support and guidance of top management.

Technical issues are also multifarious and often conflicting. Alshawi and Ingirige (2003) identified security of project information, technical integration, compatibility with existing work practices, technical staff and cost constraints as of central

importance. Ruikar et al. (2005) included online connectivity, software interactivity, storage and access and legal issues, while Marsh and Finch (1998) focussed on cost issues and return on investment. For Marsh and Flanagan (2000), the major issue is a general lack of technical awareness, coupled with uncertainty on how to identify potential benefits and measure financial return explicitly. Specifically, they identified three sets of factors: improved business effectiveness, productivity, reduced operational and labour costs (automation); increased capacity to collect, store, process and disseminate information, improved decision making, employee empowerment, enhanced work procedure and better quality processes (information); and increased business value, facilitating and supporting new business processes and implementing technology change (transformation).

According to Love et al. (2001), factors such as risk, uncertainty, change and knowledge are fundamentally critical. For Zou and Seo (2006), the challenges are mainly caused by reluctance on the part of sub-contractors and suppliers, pointing to a need for greater clarity in the objectives that drive technology innovation, more user-friendly systems, continuous learning and more extensive training and knowledge sharing. According to Aranda-Mena et al. (2006), while formal training and learning activities are useful, most learning happens informally within the user's spare time and through informal interaction with peers, junior staff and trainees. For Lou and Alshawi (2009), technology adoption is a matter of motivation, interest in IT, job satisfaction, prior experience and so on.

There is such a preponderance of relatively incommensurate and conflicting factors identified specific to construction innovation that almost any aspect or influence could be considered and/or justified. This broad and confusing array of potential factors and the lack of clarity this creates around strategic planning for technology innovation is most recently evidenced in the slow rate of adoption of building information modelling (BIM) (Arayici et al., 2011; Gajendran & Brewer, 2012; Gu & London, 2010; Khosrowshahi & Arayici, 2012; Rowlinson et al., 2009). Khosrowshahi and Arayici (2012) have sought to tailor strategic and implementation planning for BIM according to different stages of BIM maturity. Stage 1 is largely related to a transition process from 2D to 3D and object-based modelling; at Stage 2, model-based collaboration and

interoperability are used more extensively to improve communication and data sharing; and at Stage 3, network-based integration is implemented and whole project lifecycle, business intelligence, lean practice and green policy benefits are realised. Khosrowshahi and Arayici's (2012) study showed that the drivers and barriers to BIM adoption are different at each stage. For example, at Stages 1 and 2, the implementation problems are more directly related to a lack of awareness of BIM, its use and potential benefits, a reluctance to initiate new workflow, staff training and concern over the cost of implementation, and inherent resistance to change. At Stage 3, where the technology has already demonstrated its potential for collaboration and process improvement, the critical issues are training, education and understanding.

The useful separation of factors across different stages of maturity adopted by Khosrowshahi and Arayici (2012) suggests that an equivalent separation of how all potential factors are considered might also prove valuable more generally.

1.2.3.2 Level of Investigation

A clear majority of the studies reviewed in Appendix A are concerned with innovation at the overall industry and/or organisational levels. At most, only seven of the 37 studies reviewed are concerned with technology implementation at the individual and/or work-group level. Croker and Rowlinson (2007) focusses on the work group or team, and an attempt is made to shift the level of analysis towards the individual by Mohamed and Stewart (2003), Ruikar et al. (2005), Hjelt and Björk (2007), Lou and Alshawi (2009), Wong and Lam (2010) and Son et al. (2012). The broader literature on innovation reflects a similar focus on the contribution at the organisation level, and the body of findings in this regard is now substantial.

However, the nature of construction practice is governed substantially by group-based activities and characterised by often *ad hoc* and multidisciplinary project team structures. Relevant findings on the implementation of innovations at a team and individual level would be particularly useful in construction and contribute more directly to practical outcomes.

1.2.3.3 Research Methods

A further key feature of the analysis provided in Appendix A is the propensity of studies to employ a case study or qualitative interview research method. Fewer studies use a quantitative and/or mixed-method approach. Of course, the different research methods have different qualities, strengths and weaknesses when applied in different problem contexts. Qualitative methods tend to focus on providing richness to the data, where quantitative methods tend to focus more on structure. A mixture of methods is often proposed to overcome the key limitations of both the quantitative and qualitative approaches. Nevertheless, it is apparent that a strong preference for qualitative methods, most especially the case study method, is manifest in previous construction innovation research.

The high prevalence of qualitative approaches in the innovation literature may simply indicate a consistent and particular characterisation of the problem context. However, it does represent a potential bias in how the issues are revealed. If appropriate, the use of a mixed methods approach would help to allay some of the concerns associated with such extensive application of a particular method.

1.3 Scope of the Research

The development and application of ICT is at the forefront of innovation in the Australian construction industry (BEIIC, 2010). Of particular interest at the current time are developments in BIM. However, BIM is an emerging technology and is still at an early stage of the innovation cycle. As such, it falls within the same bias previously identified in the literature towards the earlier stages of 'adopting' and 'accepting' new technologies. It is also the case that the majority of current users and those currently engaging with BIM are practitioners from design-based consultancies, such as architects and engineers (Arayici et al., 2011; CRCCI, 2009; Khosrowshahi & Arayici, 2012; Rowlinson et al., 2009). A focus on BIM at this time would be both premature and more difficult to link directly with construction professions.

1.3.1 Online Project Information Management Systems

OPIMS is a collective term for web-based project management systems, web-enabled project management, project extranets, online project management technologies, online collaboration and electronic document management systems and similar technology innovations (Alshawi & Ingirige, 2003; Andresen et al., 2003; Björk, 2003; Ilich et al., 2006; Nitithamyong & Skibniewski, 2004; Ruikar et al., 2005). As such, OPIMS are a relatively mature and robust technology innovation, the technical background and functionality of which is well understood by the construction industry. Nevertheless, the pace and extent of uptake by the industry remains slow and relatively limited in Australia (Kajewski et al., 2004; Nitithamyong & Skibniewski, 2011; Peansupap & Walker, 2005; Stewart et al., 2004). Understanding the resistance factors associated with OPIMS will not only improve how that innovation is managed in Australia, but may also inform how maturing technology innovations (such as BIM) are managed in the future.

The principal features and basic functionality of OPIMS are provided by Nitithamyong (2003) and Ishak et al. (2009). In general, OPIMS enable individuals involved in a construction project to collaborate, share documents and communicate online more effectively. The technology is used to manage each phase of a project, from planning and development, through design, bidding and negotiating, construction, operation and occupancy, either individually or as a whole (Alshawi & Ingirige, 2003). OPIMS are also intended to refer to any web-enabled software package or system able to manage and support communication and information exchange in a construction project. Such information might include project details, project team contacts, an e mail directory, Computer-Aided Design (CAD) drawings, specifications, requests for information, contract administration information, contract status, project time and schedule, safety information, cost estimations or cash flow data. Basic OPIMS are used to support project collaboration and information sharing, while advanced OPIMS enhance information search capabilities and enable business transactions such as contract bidding and tendering to be conducted online. Examples of such software include, but are not limited to, ProjectCentre (http://www.projectcentre.net/), Aconex

(http://www.aconex.com/), e-Builder (http://www.e-builder.net/) and Basecamp (http://basecamp.com/).

1.3.2 A Mature and Robust Technology Context

OPIMS were first introduced to the construction industry in the mid-1990s (Becerik, 2004; Samuelson, 2008; Wilkinson, 2005). The idea arrived alongside the emergence onto the market of key internet, intranet and extranet hosting technologies. The rapid development of these host technologies enabled the development of OPIMS. By 2000, the use of OPIMS was booming; however, just as rapidly, deployment peaked and then slowed significantly. This slowdown was in large part a response to the growing capabilities of technologies focussed on the integration of generic application software. The OPIMS software was subsequently developed to integrate seamlessly with generic software applications, and uptake accelerated once more. OPIMS have now gone through several rounds of starts, stops, spins-offs, acquisition, re-acquisition, progress and failures.

OPIMS are now recognised as a critical technology for the effective management of construction and improved productivity performance (Eric et al., 2012; Stewart, 2007). OPIMS provide a gateway for clients, architects, engineers, contractors and all trusted team members on a particular project to utilise common software tools and access consistent project data. OPIMS are a required technology for many projects, bringing a range of advantages. In terms of communication, OPIMS provide the technology to combine multiple forms of communication (such as memo, telephone, email, chat messenger, video conference, application sharing and mark-up tools) within a single software interface. From an information perspective, OPIMS include processes for transferring and exchanging documents and completing activities and procedures over electronic networks, where the software is able to collect, organise, store, manage and share information associated with the delivery of a project. Finally, from a project management perspective, OPIMS offer clients the potential to reduce the cost of a project, while improving the delivery time, processes, trust and risk sharing.

Despite the OPIMS software's obvious benefits and potential for many areas of practice, uptake remains disappointing (Andresen et al., 2003; Gustavsso et al., 2012;

Nitithamyong & Skibniewski, 2011; Samuelson, 2008, 2012). Use of OPIMS is largely limited to the exchange of drawings (Andresen et al., 2003) and even though usage has increased considerably over the past decade, a majority of practitioners still only report using the technology occasionally (Samuelson (2008). Usage levels do vary across the industry, with the level of usage by architects reported to be as high as 90 per cent (Samuelson, 2012) and the usage level among contractors increasing from 35 per cent in 2007 to a current level of 75 per cent (Gustavsso et al., 2012).

1.3.3 A Focus on the Individual Level

Understanding the factors that influence resistance to OPIMS requires acknowledgement of the various levels from which the problem can be viewed: individual, organisation and industry or economy more broadly. As highlighted by several studies (e.g. Davis, 2004; Hartmann & Fischer, 2009; Joshi, 2005; Prasad & Prasad, 2000), resistance to technology manifests differently at different levels. Relatively little research has focussed on the individual level. The individual level is also the preferred level of consideration for this thesis because current technology innovation strategies tend to over-emphasise the technology and discount the people factors. People are the core element in any organisation. Where a technology innovation is implemented as a mandated requirement of the organisation, the attitude of the individual can be critical. Individual attitudes are influenced by a range of factors, and a better understanding of those factors will significantly affect the implementation of any technology innovation. Moreover, the organisational aspects of technology innovation specific to the construction industry have already been researched extensively (see for example Brewer & Gajendran, 2009; Goulding & Lou, 2013; Lou & Alshawi, 2009; Love et al., 2005; Marsh & Flanagan, 2000; Mitropoulos & Tatum, 2000; Peansupap & Walker, 2005; Stewart et al., 2002). There is every indication that resistance at an organisational level is largely driven by resistance at the individual level (Backblöm & Björk, 2002; Nitithamyong & Skibniewski, 2004; O'Brien, 2000; Villeneuve & Fayek, 2003), but little has been done to explore the reasons for this individual or end-user level resistance.

1.4 Theoretical Foundations to the Research

It is generally claimed that resistance itself has no theories. Specific to information technologies, resistance is beginning to be considered in terms of its nature (Marakas & Hornik, 1996; Rivard & Lapointe, 2012), causes (Joshi, 2005; Kim & Kankanhalli, 2009; Laumer & Eckhardt, 2012; Martinko et al., 1996; Meissonier & Houze, 2010) and management (Legare, 1995; Shang, 2011). In these terms, resistance consists of a diverse set of factors including the attributes of the technology, process and work expectations, individual belief, perception and attitude, social influences and relationships throughout the organisation. These studies have focussed on resistance *per se*, but effectively none has sought to examine or test the factors influencing resistance at an individual level.

In change management, resistance is generally regarded as a primary reason for the failure of organisation change. Resistance to change in that context is conceived of as an irrational reaction that managers must strive to overcome. However, the main attributes of resistance to technology in any organisation are rarely considered purely technical in origin. More typically, resistance in an organisation is related to the 'soft issues' that underpin the capacity of an individual to adapt technology into existing work practices successfully. According to Bagozzi and Dholakia (1999), cited in Bagozzi (2007a), adoption, acceptance and even resistance is the natural consequence of striving towards a particular goal, which involves mental effort, self-efficacy, expectations, effect of function and motivation.

Given that soft issues are likely to influence resistance significantly, it is important to accommodate individual attitudes, social networking and key technical factors within the broad theoretical framework of the research. Consequently, the theoretical foundations for the research are drawn from three distinct sources: diffusion of innovation theory, technology acceptance models and social network perspectives.

1.4.1 Diffusion of Innovation Theory

Diffusion of Innovation (DoI) by Rogers (1962) is well-regarded and has been shown to generalise across multiple fields. This theory is particularly concerned with understanding how ideas and technologies spread among potential adopters (people).

DoI is relevant to any innovation, be it an object, idea, technology, product, service or practice. The innovation can be tangible (a new device, piece of equipment or new material) or intangible (a novel system configuration, procedure or pedagogical approach). An important contribution of this theory is to articulate the decision-making process through which an individual comes to adopt, reject or ignore an innovation. Further detail and discussion of this theory is provided in Sections 2.3 and 3.5.

1.4.2 Technology Acceptance Model

The technology acceptance model (TAM) is closely connected to, but different from, DoI. TAM is relevant to the current research because there is a close connection between the concepts of adoption and acceptance. TAM first focusses on the attitude of an individual towards a technology and only then on their intention to use it. Intention to use a new technology is driven by the perceived usefulness and ease of use of the technology. TAM has a basis in psychological research: the underlying theories of TAM include the theory of reasoned action (TRA) and theory of planned behaviour (TPB). A unified theory of acceptance and use of technology (UTAUT) extended the original TAM and added four new constructs: performance expectancy, effort expectancy, social influence and facilitating condition (Venkatesh et al., 2003). TAM is employed in this study to recognise the 'soft issues' and the way in which attitudes and behaviours affect user resistance. Further detail and discussion of this theory is provided in Sections 2.4 and 3.4.

1.4.3 Social Network Perspective

DoI and TAM both recognise that the context of the social system, social structure and associated networks can all affect the decisions of individuals and the adoption of a technology. A given technology may be entirely satisfactory when used in private, but concerns about compatibility and appearance may discourage its use in public. The more a person engages with others, the less potential there is for such disparities to arise. Seeking and receiving help with a technology from workplace colleagues (supervisors, peers and technical staff) can increase exposure to, and promote the adoption of, a technology. The social network threshold (SNT) model by Valente (1996b) proposes that effective diffusion of information occurs most effectively when

individuals have sufficient information (exposure) to fulfil their personal threshold requirements. The same framework is applied here in terms of personal exposure to innovation: exposure is gained from a range of people included in the adoption network of an individual, using the communication links that connect people within that network. This concept of personal exposure is explained in terms of a personal support network, and is discussed in more detail in Sections 2.5 and 3.3.

1.4.4 Interrelationships between the Frameworks

The three theoretical foundations identified above are coherent within themselves and distinctive. However, they can also be interrelated in various ways. DoI and TAM in particular are well-established theories in the context of innovation and have previously been independently applied to analyse acceptance, adoption, diffusion and resistance. The focus of both perspectives is to achieve effective adoption and implementation. Technology attributes such as advantage, complexity and compatibility are the key considerations of DoI; and these are similar to the usefulness and ease of use factors in TAM. DoI and TAM both include aspects of social networks, although TAM adopts a more behavioural, intentions and motivational perspective.

While clearly interrelated, DoI and TAM are rarely applied to innovation in concert. The addition of a social network perspective to create an IRFM is unique to this research. The justification and proposed integration of the three theoretical foundations are described and discussed in detail in Chapters 2 and 3. Four key elements are proposed for the IRFM: (1) resistance indicators, (2) support network factors, (3) experience and disposition factors and (4) integration and accessibility factors. The IRFM proposes that resistance can usefully be indicated by two factors: the time adoption of technology and the level of usage. These two indicators are then used to test the significance of the support network (which links users with Leaders, Peers and Affiliates), experience and disposition factors (Knowledge of ICTs, Use of ICTs, Motivation, Efficacy, Anxiety, Interpersonal Power) and integration and accessibility factors (Perceived Advantage, Compatibility, Complexity, Learning, Trialling, Visibility).

1.5 Research Problem, Aim and Objectives

Having considered the motivation for the research, its scope and the theoretical foundations, the research problem can now be stated as follows.

Effective technology innovation is a key driver of transformation for the construction industry, which is complex and traditionally focussed. Previous studies of innovation have focussed on early adoption and initial diffusion to the detriment of more mature innovation technologies. The focus has been such that TAMs now dominate the literature and criticism is growing that so much emphasis on a single paradigm is tending to promote bias and place limitations on our understanding of the problem. A shift from acceptance and diffusion concepts to consideration of resistance factors is proposed as a means to break the impasse.

A change in perspective is also necessary to force some simplifying structure on the plethora of factors associated with technology innovation in the construction industry. This change is articulated around the move to a later stage of the innovation cycle, a recalibration towards the individual level and a shift in the research method used. To facilitate the change in perspective, the particular technology innovation to be considered will be OPIMS. OPIMS represent a mature and robust technology with a demonstrated potential for the construction industry that is yet to be fully realised.

While previous research has examined DoI and TAMs in isolation, there is an important deficiency in how the two theoretical frameworks might be considered in concert and extended with a social network perspective. The addition of a social network perspective is significant because it more explicitly recognises the influence that others exercise on individuals' attitudes and behaviours towards innovation. The development and testing of an IRFM would represent a major contribution to innovation theory. A viable IRFM would also translate more directly into strategic initiatives to provide practical help in addressing the barriers and issues that challenge technology innovation in the construction industry.

Based on the problem statement provided, the objectives of this research are as follows:

i. To develop a comprehensive model of the key resistance factors identified in the literature.
ii. To test and evaluate the significance of the variables/constructs in influencing the development of resistance.
iii. To verify the critical resistance factors using a mixture of quantitative and qualitative methods.
iv. To consider the potential training and technology deployment strategies that could overcome individual resistance.

The overall aim of the research is to establish a viable IRFM that incorporates a range of theoretical foundations and provides a simplified structure/lens to improve the effectiveness of mature technology innovation. Most specifically, the model should identify the critical factors that influence individual resistance to the effective use of OPIMS.

1.6 Overview of Research Strategy and Methodology

The research presented in this thesis is exploratory in nature. A mixed-method research approach is used, with data collected using two methods: survey and interviews.

The survey instrument is compiled from the literature and trialled. The pilot trial is used to test the adequacy of the survey instrument and the feasibility of a full-scale survey. The pilot study also helped to avoid the use of misleading, inappropriate and/or redundant questions.

The aim of the full-scale survey is to test the research model (IRFM) and a series of explicit research hypotheses. Industry practitioners are invited to participate in the survey using convenience sampling. Data collected from the survey are analysed using a partial least square (PLS) technique, derived from structural equation modelling (SEM). PLS is particularly useful at this stage because the research seeks to evaluate and predict a very large set of variables from a relatively small sample.

The final interviews are intended to verify and complement the survey results. The selection of interview participants is determined by participation in the survey: survey respondents are asked to indicate whether they are willing to participate in the

subsequent interviews. The interview participants were varied in terms of their professional and management functions. They included project managers, construction managers, architects, engineers, document controllers, cadets and graduate students.

1.7 Structure of the Thesis

The thesis is organised into seven chapters.

Chapter 1 provides a background to the research and introduces the key elements of the research.

Chapter 2 presents a comprehensive review of the existing literature to inform the theoretical model. The review also examines the findings of other studies specific to innovation and ICT implementation in construction.

Chapter 3 develops the conceptual model from an initial theoretical model, and explains and justifies the choice of resistance factors. The final conceptual model is presented and a measurement scale is developed.

Chapter 4 presents and justifies the research methodology. Each stage of the research is described in terms of the approach taken, the methods of data collection and the screening process. The testing and administration of the pilot study, questionnaire and interviews are described in detail. The key statistical and non-statistical methods used to examine and verify relationships between the constructs of the research model are explained. The specific approach to sampling is also described and justified.

Chapter 5 presents the results and analysis of the data collected from the survey. The PLS technique is explained and the conduct of the survey is described. Employees of various architectural, engineering and construction organisations and current users of OPIMS are included in the survey.

Chapter 6 presents the results and analysis of the data obtained by interviews. Interviews are conducted with those respondents to the survey who agreed to be interviewed later.

Chapter 7 includes the conclusions and recommendations based on the findings of the survey data and interviews. It provides conclusions from the results of the PLS analysis and interviews, and discusses their implications related to practice and the contribution they make to the body of knowledge and innovation theory. The limitations of the study and suggestions for future research are also considered.

Chapter 2: Literature Review

2.1 Introduction

This chapter provides a comprehensive review of the literature specific to resistance. Resistance is considered in broad respect to the introduction of new digital technologies to an organisation and the changing work practices this engenders. Such resistance requires consideration from various theoretical perspectives. This review focusses specifically on the DoI theory originally proposed by Rogers (1962), the TAM first introduced by Davis (1986) and the broad perspective offered by the social network threshold. The background knowledge is used to inform and justify the research.

The chapter begins with a review of resistance as a concept, its definition, its source and the broad issues that influence it. Building on this foundation, a framework of the key theories and models that have been used to examine and explain resistance previously are discussed and evaluated. This review is wide-ranging, and draws from the literature on information systems, organisational and management science, and social and behavioural research. The existence and consequences of individual psychological, behavioural and organisational elements in resistance have been comprehensively studied. The dynamics of resistance from an individual psychological and behavioural perspective is also reasonably well understood. One stream of literature examines the significance of the social and organisational aspects of resistance specific to technology. Fewer investigations report studies that consider individual capabilities and their influence on resistance in a social and technical context. No previous studies have linked all three aspects of human psychology, attitude and behaviour; organisation support and social connection in the workplace; and the appropriateness of a technology, its usability and its relevance to the particular work activity. In bringing together DoI, TAM and SNT, a fundamentally different theoretical framework is proposed.

2.2 Resistance to Technology Use

2.2.1 Definitions of Resistance

The organisational change and behaviour literature originally defined resistance in a broad sense as 'behaviour intended to protect an individual from the effects of real or imagined change' (Zander, 1950: 9, cited in Dent and Goldberg, 1999: 34). Since that early introduction, however, resistance has been considered from three principal perspectives: as a cognitive state, an emotional state and/or as behaviour. Consequently, resistance is now variously defined as both a natural tendency and an individual preference (Marakas & Hornik, 1996; Martinko et al., 1996; Rivard & Lapointe, 2012). The tendency or preference may be to maintain what is well known and familiar; or to accept new practices, ideas, innovations, technology or the like. Thus, the definition of resistance now depends on the theoretical perspective and ranges from an organisational consideration—'the forces against change in work organisations' (Mullins, 1999: 824)—to a more individual consideration—'an inability, or an unwillingness, to discuss or to accept organisational changes that are perceived in some way to be damaging or threatening to the individual (or group)' (Huczynski and Buchanan, 2001: 887, cited in Price and Chahal, 2006: 243).

Resistance is typically viewed as something that is negative and potentially adversarial. It is discussed in terms of that which must be overcome by an organisation to ensure that a given change is successfully achieved (Waddell & Sohal, 1998). It is positioned as something that could increase costs and cause delays in the change processes of an organisation (Ansoff & McDonnell, 1990). However, a significant body of researchers have found that resistance is better perceived as something positive. They argue that there are significant benefits to be gained from resistance (Bauer, 1995; Hartmann & Fischer, 2009; Hirschheim & Newman, 1988; Lapointe & Rivard, 2005; Martinko et al., 1996; Val & Fuentes, 2003; Waddell & Sohal, 1998). These researchers claim that some degree of resistance is a necessary, and possibly unavoidable, part of every technology implementation process. They point out that there may be good organisational reasons for resisting poorly designed or implemented systems. Such 'positive resistance' can be used by developers to improve future implementations (Hirschheim & Newman, 1988). The evidence of resistance can provide clues that perhaps more evaluation and

improvements are needed (Bauer, 1995). User resistance has been found to increase process awareness (Hartmann & Fischer, 2009. In doing so, it provides a readymade warning system about user expectations and potential implementation issues. Resistance has also been used to highlight incidents of technical failure or where implementations include unnecessary or problematic elements (Bauer, 1995).

Resistance can play a significant role in drawing attention to aspects of an newly implemented technology that may be less than ideal, not well thought through or just plain wrong. Resistance can be taken as an important mechanism to better understand how users actually and are likely to respond to new technology innovations. Organisational and work-practice change can be promoted when users perceive the technology as necessary and/or they accept that without the technology the work-practice may be compromised. For these reasons, it is not the intention of this thesis to distinguish in any substantive way between positive resistance and negative resistance.

For the purposes of this thesis, resistance is defined as: the actions of a potential user of a new technology implementation that reflect his or her concern or opposition to particular aspects of that technology relative to a given work-practice context.

2.2.2 Key Sources of Resistance

Resistance is a complex phenomenon. It can occur at various stages of a technology development cycle (design, implementation or operational) and can manifest at different levels of the organisation (Hirschheim & Newman, 1988; Meissonier & Houzé, 2010). According to Hirschheim and Newman (1988), resistance during the design stage or early phase of the technology development may take the form of users refusing to participate fully or constructively in the specification of requirements. During implementation, users may take no role or interest in the introduction of the technology and/or any associated induction programs. Throughout the operational stage, they may refuse to employ the system or aspects of the system to make effective use of the technology.

User resistance during the early stages of a deployment can be relatively unobtrusive. Through the operational stage, however, a lack of user commitment is more obvious.

According to Meissonier and Houzé (2010), user resistance can result in reduced productivity, ineffectiveness, high staff turnover, disputes, absenteeism and employee aggression. The impact can be observed at all levels of the organisation, from technical workers and administration staff through to supervisors and managers.

Lapointe and Rivard (2005), Klaus et al. (2010), Prasad and Prasad (2000) and Joshi (1991) have all developed models of user resistance. One common element is that resistance has been found to occur differently at the individual, group and organisation levels. Joshi (1991) suggests that users will resist if they perceive an inequity at or across any of these levels. Klaus et al. (2010) show that distinct forms of resistance exist across characteristic groups within an organisation, and that each group has a different set of reasons for their resistance: for some groups, the lack of an opportunity to provide input to the process was important; for others, it was the level of uncertainty. Prasad and Prasad (2000) propose that resistance can take place throughout the organisation, but is generally only manifest at a relatively low level of the organisation. Lapointe and Rivard (2005) also highlight the distinction between passive, active and/or aggressive resistance.

2.2.3 Key Causes of Resistance

A number of authors conclude that resistance can be caused by multiple factors. In an examination of employee resistance to IT in the workplace, Martinko et al. (1996) found three reasons that people have negative reactions to a computer system: the personal attributes of an individual; the quality of the system design; and the interaction between the system design and the attributes of its users. Shang (2011) focussed on the individuals themselves, and those aspects of change that directly affect the user. Actual or perceived loss of power and status, job insecurity, loss of autonomy and skills can all be described as having a negative impact on the potential user due to the system implementation decreasing the status (outcomes) of the user. In addition, the actual or perceived increase in the level of effort required to perform standard work tasks in new technology contexts, the possible need for up skilling and temporary or permanent increases in the time required to perform tasks can all be described as having a negative impact because they increase the demands on (inputs by) the user. According to Bhattacherjee and Hikmet (2007), people may not be appropriately trained to use new

technology in their current jobs, even when they have extensive work experience in every other regard. Training often requires time and can bring additional workload.

Klaus et al. (2010) identifies 12 determinants that affect the level of user resistance behaviour. These are grouped into four broad categories: individual, system, organisational and process issues. Individual issues reflect the potential uncertainty about the future, or potential loss of control or power in an organisation. System issues capture technical problems or the complexity of system integration. Organisational issues refer to the facilitating environment, including the communication activities that attend any change project and the training required during an implementation phase. Process issues include broad user reactions to job or work-skill changes, the workload and the potential lack of fit between process and technology.

Waddell and Sohal (1998) believe that resistance to change is a complex phenomenon, beyond a unifying theory, and not simply driven by the psychology or self-interest of the individual. From that perspective, resistance can be associated with a variety of social factors, including:

i. Rational factors—resistance occurs because the rational assessment of the outcomes of the proposed change by the employee differs from the outcome envisaged by management. Such differences of opinion can cast doubt in the mind of an employee as to the merit or worth of the changes. The employee might thus elect to stand in opposition to change or voice their concern.
ii. Non-rational factors—the reaction of an individual to a proposed change is always, to some extent, a function of their predispositions and preferences. Such bias is not necessarily based on a rational assessment of the situation. It may simply be a reluctance to change, move offices or lose contact with a particular colleague. It may be the consequence of discomfort or uncertainty at the prospect of implementing something new and unfamiliar.
iii. Political factors—resistance is also influenced by political factors, such as perceived favouritism or animosity towards those responsible for the change effort.
iv. Management factors—inappropriate or poor management style also contributes to resistance.

In a study specific to change management, Val and Fuentes (2003) distinguish the reasons for resistance into five broad categories:

i. Vague strategic priorities, including distorted perception and interpretation barriers. This category includes
    a. Myopia and the inability of the company to look into the future with clarity
    b. Denial and refusal to accept information that is not expected or desired
    c. Perpetuation ideas and the tendency to go on with present thoughts even when the situation has changed
    d. Implicit assumptions
    e. Communication barriers
    f. Organisation silence, which limits the information flow available to individuals about why the change is taking place.
ii. Low motivation resulting from the direct cost of change, cross subsidy distortions, past failures, different levels of interest between employees and management, and the lack of motivation for employees who value the change results less than do management.
iii. Lack of creative response due to rapid and complex environmental changes that do not allow for a comprehensive situation analysis; a reactive mind-set or tendency to believe that obstacles are inevitable; inadequate strategic vision or a lack of clear commitment to the changes from top management.
iv. Political and cultural deadlock, comprising
    a. The implementation climate and the relationship between change values and organisational values. A strong implementation climate coupled with a negative value relationship relative to the organisational values will lead to resistance and opposition to change
    b. Departmental politics and resistance from those departments that might suffer because of the change implementation
    c. Incommensurate beliefs or strong and definitive disagreement among groups about the nature of the problem and, consequently, about the relative merits of alternative solutions
    d. Deep-rooted values and emotional loyalty

e. Failure to recognise and accommodate the social dimensions of change.

Other problems also exist, including: leadership inaction, where leaders may be afraid of uncertainty or fear changing the status quo; embedded routines; collective action problems, such as having to decide on who is affected first or how free-riders are to be dealt with; capabilities gap, where management lack the necessary capabilities to implement change; and cynicism. Val and Fuentes (2003) undertook a comprehensive test for all of these factors or sources of resistance. The tests allowed each source of resistance to be ranked in order of importance. Val and Fuentes (2003) found that the most powerful factor was the existence of deep-rooted values. Deep-rooted values also represent the most significant difference between evolutionary and strategic changes. Indeed, the majority of the overall top-ranked resistance factors vary significantly between evolutionary and strategic change management contexts. It follows, according to Val and Fuentes (2003), that deep-rooted values, different interests, communication barriers, organisation silence and the capabilities gap represent the most significant issues that managers leading strategic change processes should take into consideration.

2.2.4 Managing User Resistance

Using a change management approach, Val and Fuentes (2003) argue that some degree of resistance is part of any process of organisational change, and before the change process begins, management must take the potential for such resistance into account. They argue that special attention needs to be paid to the particular reasons that lead employees to resist and avoid such change. A key element of Val and Fuentes' (2003) work is the extent to which the existing organisational culture fits with the change objectives, and how that fit can be improved before the change process begins. Consideration of organisational culture was also recommended, because of the assistance such consideration can provide in bringing the understanding and expectations of employees and management into closer alignment.

Dunphy and Stace (1988) are strong advocates for a strategic approach to organisational change. Dunphy and Stace (1993) and Dunford et al. (1990) advocate a multi-strategy approach, involving directive, participative, consultative and coercive strategies. The directive approach to managing change refers to the use of managerial authority to

affect change. Managers inform employees about change by describing explicitly the overall picture of the new system flow, and visually showing end users where the components they use are located in the organisation system. They argue that where the system does not fit directly with existing work practices, which is likely, job reassignment and modification need to be considered at an early stage.

According to Dunphy and Stace (1988), participation is a key requirement to encourage a sense of interest. In this sense, participation involves providing employees with information regarding the change, and opening specific communication channels to allow for negotiation and clarification of the change process itself. Given adequate participation, it has been shown that the motivation of employees to support change is greatly enhanced. At the same time, the commitment and involvement of the organisation itself has been shown to play a key role in the acceptance of change by employees. The so-called consultative approach focusses on the morale of employees during the change process. According to Dunphy and Stace (1993), supports such as training and orientation sessions are useful tactics in helping to motivate employees to adjust to change. Finally, the coercive approach is a 'last resort'. This strategy may be suitable for managing resistance that is deemed irreconcilable. Examples of the coercive approach would include firing or transferring people who resist change, or implicitly threatening the loss of job and/or promotion possibilities.

Jiang et al. (2000) and Shang (2011) argue that different systems and technologies bring different causes of user resistance. Therefore, to overcome resistance, a variety of strategies should be considered. These they divided into two categories: participative and directive. Participative strategies include training in the use of the new system, establishing user support, allowing time, trialling system use, encouraging open communication between management and employees, and user participation during the design process. Directive strategies include new job provisions and roles, incentives and top management support. The best strategies to use to overcome resistance further depend on the type of user; that is, operational or managerial (Shang, 2011). Operational users typically resist new technology due to self-interest, or because of poor communication. In this case, directive strategies are effective. In contrast, managerial

users resist new technology due to concerns about the overall benefits of the technology to the organisation. Hence, for them, participative strategies are more useful.

Importantly, there is no one best approach to minimise user resistance for all types of user in all situations. Top management needs to recognise, understand and respond to a range of human emotions, attitudes and resources. Depending on the circumstances, different strategies for managing resistance are required. For example, if employees resist adopting new technology because they lack knowledge or skills, managers should be encouraged to search for alternative methods of training the technology and to communicate and consult regularly with their employees. Conversely, if employees resist adopting new technology because they lack awareness of the usefulness of the technology to their job, managers should involve them in the implementation process and discuss the system's benefits with them.

2.2.5 Resistance Theory and Models

More specific to information systems, a number of studies focus on 'cognitive', personal characteristics (Marakas & Hornik, 1996) and human attitudes (Cenfetelli, 2004; Lapointe & Rivard, 2005; Martinko et al., 1996). Marakas and Hornik (1996) propose a Passive Resistance Misuse (PRM) model, which aims to understand covert resistance, where resistance is motivated more by individual personal gain or the desire to sabotage the change effort itself. PRM assumes that resistance to change is an observable behaviour that manifests as covert action. The theoretical foundation for PRM is a combination of passive-aggressive behaviour theory (Fine et al., 1992), espoused theory and theory-in-use (Argryis et al., 1985). The passive-aggressive behaviour theory is used to understand the human aspects of how a user responds to the real or perceived personal threats or stresses that the user associates with an new technology. The theory is derived from the psychology literature. Another theoretical foundation originates from the Theory of Actions (TofA), first proposed by Argyris and Schön (1974). TofA includes a notion of espoused theory (which refers to how the user claims he or she would act) and theory-in-use (which refers to how the user actually acts). For example, to minimise resistance to a new technology, managers first need to make explicit their espoused theory and demonstrate the theory in use. In other words,

they must provide clear explanations for their actions and be frequently seen as using the technology accordingly.

Cenfetelli (2004) proposed a model called the 'dual-factor model of IT usage'. This model offers a conceptualisation of perceived threats that will lead to resistance behaviour. The core argument for this model is that the TAM, which has been studied extensively (Davis et al., 1989; Venkatesh & Davis, 2000; Venkatesh et al., 2003), successfully fosters positive user attitudes and encourages system use. However, the factors that influence user resistance are different from the factors that encourage use. For Cenfetelli (2004), the perceived usefulness and ease of use of IT introduced in TAM were taken as enabling factors. These enabling factors are not quite the opposite of resistance factors (inhibitors). However, they are qualitatively distinct constructs that are independent of enablers. Cenfetelli (2004) proposed a set of enabler and inhibitor factors that predict the usage intentions for a particular technology. The enabler factors are derived directly from TAM. The inhibitor factors are based on the work of DeLone and McLean (1992, 2003) relative to information and system quality measures. In the Cenfetelli (2004) model, information quality refers to a user's evaluation of the system's delivery of semantic meaning and/or communication of knowledge. System quality refers to the technical capabilities of the system and its usability.

Other studies focus on the influence of individual personal gains and social factors on resistance (Joshi, 1991; Kim & Kankanhalli, 2009; Prasad & Prasad, 2000). Joshi (1991) introduced the Equity-Implementation (E-I) model. The E-I model is based upon equity theory in the social sciences. It assumes that in every exchange relationship, people are concerned with differentiating their inputs, outcomes and the fairness of the exchange with others in the same group. The issue of fairness is particularly significant. Indeed, the sense of fairness can be the critical resistance factor among employees. Joshi (1991) contends that if one user feels that other users have benefited more than they have from a new system, that user is more likely to resist the change.

Prasad and Prasad (2000) studied managerial control and employee resistance in the workplace using 'Iron Cage' theory. The term iron cage is derived from Weber (1958) and refers to the oppressive bureaucracy or rules within an organisation that constrain employee action. The focus of the model in Prasad and Prasad (2000) is on the more

informal aspects of workplace resistance, or what they called 'routine resistance'. Prasad and Prasad (2000) believe that routine resistance is complex and can develop in a situation that is planned or unplanned, often as a consequence of multiple actors in an organisation. Routine resistance is often repetitive on the part of particular employees, as a means to prevent any form of change in an organisation. Prasad and Prasad (2000) found that routine resistance does not create the Iron Cage, but rather makes use of it as a kind of holding space from which to wait out/delay the change.

Another study addressing the social aspects of resistance is that of Kim and Kankanhalli (2009). Kim and Kankanhalli (2009) integrated the TAM (Davis 1989; Venkatesh & Davis, 2000) and resistance literatures (Hirschheim & Newman, 1988; Joshi, 1991; Lapointe & Rivard, 2005; Marakas & Hornik, 1996; Markus, 1983) with the Status Quo Bias theory (Samuelson & Zeckhauser, 1988). The Status Quo Bias model recognises that resistance can be influenced by a user's preference to stay with the current situation. Based on the Status Quo Bias theory, Kim and Kankanhalli (2009) proposed two key responses to resistance factors: switching benefits and switching costs. Switching benefits requires outcomes to be increased relative to the same or reduced level of inputs; for example, where the new technology can be shown to increase the quality of work and/or productivity of the employee relative to the current situation. Switching costs refers to a reduction in the effort/resources required to achieve the same outcomes.

Meissonier and Houzé (2010) proposed the IT Conflict-Resistance Theory (IT-CRT). IT-CRT is based on theories from psychology and sociology. The principal theory is the TRA of Ajzen and Fishbein (1980). TRA assumes that resistance is a behavioural dimension of conflict or the way in which a person expresses a conflict. In this sense, resistance is the consequent behaviour arising from conflict. Conflict is a form of attitudinal belief and corresponds to the affective or evaluative judgement of a person about the likely consequences of an action. IT-CRT proposes that task-oriented conflicts expressed towards the implementation of IT may be hiding broader socio-political conflict. It also notes that an avoidance management style can be particularly effective in addressing socio-politically-oriented conflict. Under the IT-CRT rubric, resistance ought to be interpreted as a form of appeal for managerial rectification, such as restoring

trust or the professional recognition of employees. IT-CRT promotes greater account of socio-political issues in the design of the IT implementation.

Few studies have considered how the different aspects and foci of different theories (i.e. human, social, technical and organisational) are related to each other and/or might be integrated to address resistance collectively (see, however, Davis, 2004; Ferneley & Sobreperez, 2006; Klaus et al., 2010; Laumer & Eckhardt, 2010). Klaus et al. (2010), rather than proposing a model of resistance, studied the type of user that resists technology. According to Klaus et al. (2010), resistance is driven by the characteristics of resisting users, and the shared communication and beliefs that exist within user groups.

Davis (2004) proposed a Social Architecture Factor Model (SAFM), which encompasses three different perspectives from the change management literature, TRA (Fishbein & Ajzen, 1975) and TPB (Ajzen, 1991). Davis (2004) believed that resistance to IT change can be effectively measured by integrating a wide variety of factors, such as type and scope of change; method and speed of technology introduction; demographic of individual; attitudes, beliefs and fears; and demographic features of organisation.

Ferneley and Sobreperez (2006) proposed a 'Compliance-Resistance-Workaround' (CRW) model. The CRW model, as the name indicates, integrates three different resistance behaviours specific to information systems: compliance, resistance and workaround. Based on this combination, Ferneley and Sobreperez (2006) argued that the concept of resistance may be better understood as a consequence of compliance and prescribed use. Potential impacts of compliance are positive and/or negative resistance, and workaround behaviour (e.g. non-use, sabotage and avoidance of work).

Laumer and Eckhardt (2010) proposed the Model of Resistance to IT-induced Organizational Change (MRTOC). MRTOC identified a wide range of drivers of user resistance, and it includes perspectives of technology acceptance, organisation sciences and managerial psychology. This model considers resistance as a multidimensional problem and believes that outcome factors and process factors are interrelated. Thus, these are included in the model. This model posits that work-, technology- and process-

related outcomes are determined by process factors such as technology perceptions, resistance to change, and process and working routine perceptions. Resistance to change is influence by individual differences and personality (e.g. attitude, age, gender, tenure and educational background) and contextual background (e.g. social influence from superiors, colleagues and IT staff). Appendix B provides a tabulated summary of the theories and models outlined in this section.

2.2.6 A New Theoretical Lens Addressing Resistance

Resistance has been recognised as a genuinely complex, multi-faceted phenomenon caused by a variety of factors. A consensus has emerged that resistance is not necessarily the enemy of change. Indeed, resistance can play a useful role in an organisational change effort if an adversarial approach can be avoided.

The available models of user resistance all share a common basis: on the one side, user resistance is expressed in different forms of human psychological and behavioural outcomes; while on the other, user resistance results from several antecedents (technical, social, organisational and managerial). Laumer and Eckhardt (2010), Klaus et al. (2010) Kim and Kankanhalli (2009), Davis (2004) and Cenfetelli (2004) show how the basic resistance theory model can usefully be incorporated with the TAM. They argue that, by consolidating resistance factors specific to the technology itself with those factors arising from behavioural and psychological issues particular to workplace change, the combined model will provide greater effective insight into why individuals resist using technologies. Demonstrably, from the literature, the TAM offers a critical basis for the prediction of specific user attitudes and personality traits relevant to resistance. Further discussion on the TAM is provided in Section 2.4.

It also seems clear that to consider resistance from the individual's perspective, it is necessary to understand how individuals identify/position themselves relative to the technology over time. Perspectives are known to change over the course of a technology diffusion process (Cenfetelli, 2004; Davis, 2004). Therefore, it is important to consider the impact that changing perspectives over the course of a diffusion process might have in terms of modifications and adjustments to the TAM predictions. The most widely accepted theory of technology diffusion is the DoI theory proposed by Rogers (1962).

This is now a relatively advanced theory and literature, and it will be reviewed and discussed in relation to the TAM in Section 2.3.

An obvious failing of the current resistance literature is in terms of the social factors that contribute to resistance. It appears that social factors have rarely been considered or included in previous studies specific to resistance. Social influence and social network factors have been considered more directly in terms of the innovation diffusion process and TAM. According to Orlikowski (2000), use of technology in organisations is strongly shaped by users' understandings of the conditions and functionalities of a technology, actions (e.g. to achieve collaboration or process-support) and consequences of actions. Based on this view, the understanding of how and why people engage with resistance towards technology can be associated with human action and choices, and conditions of technology, and has evolved form of social interaction. Orlikowski (2000) believes that social interactions can be viewed as support mechanisms in using technology. If supports are embedded within social groups, technology use is stabilised. Consequently, people may choose to enact and adjust their behaviour towards the technology based on a desire to share files with co-workers, or due to having become more knowledgeable about using that technology through attending training and/or watching co-workers' demonstrations. To address the lack of social influence and social network factors in the current resistance literature, the social network perspective will be reviewed, and its potential specific to resistance theory considered in Section 2.5.

2.3 Diffusion of Innovation Theory

2.3.1 Core Elements of Theory

Rogers' (1962) DoI theory is one of the most widely used theories in the technology implementation literature (Kale & Arditi, 2005; Larsen & Ballal, 2005; Mitropoulos & Tatum, 2000; Moore & Benbasat, 1991; Panuwatwanich et al., 2009; Peansupap & Walker, 2005b; Ruikar et al., 2005). The DoI theory not only defines the idea of technology diffusion in terms of stages, but also describes in detail the factors that influence the scope of the diffusion and the speed with which technology is adopted. DoI is concerned with the manner in which an entirely new technology, idea or practice (or the new use of an existing one) spreads from one person to another, or from one

organisation throughout society. According to Rogers (2003, p. 5), diffusion is 'the process in which an innovation is communicated through certain channels over time among the members of a social system'. The definition implies the four core components of the DoI theory, namely: the innovation, communication channels, time and a social system.

i. The innovation can be 'an idea, practice, or object that is perceived as new by an individual or other unit of adoption' (Rogers, 2003, p. 12). Thus, an innovation could have been invented some time previously, but if a given group perceive it as being new, then it may be considered as an innovation for that group. The novelty of innovation is determined by the specific knowledge and persuasiveness of the group in question, and at what point they decide to engage more actively with the innovation. For example, the OPIMS technology was adopted relatively early by large construction companies, but not by small-sized companies. The technology was considered too expensive for small-sized companies at the time, and they thus opted out of the technology. Over time, as perceived benefits to costs render the technology more attractive to small-sized companies, they may begin the innovation adoption process. For larger companies, the technology is no longer innovative.

ii. Communication channels include mass media and interpersonal communication channels. Communication is a process through which people create and share information with one another to convey meaning and understanding. A communication medium or channel can be mass media–based or face-to-face. Mass media channels include TV, radio, newspapers and the internet. Mass media has an immediate, broad reach. Interpersonal channels comprise the two-way, direct communications between individuals. Word-of-mouth selling campaigns can have a broad reach, but they are not as immediate as mass media. Interpersonal communication is more intimate.

iii. Time is an important factor in DoI. It determines the pace of adoption and the extent to which a particular innovation is absorbed into the mainstream. The impact of time has relevance for the diffusion process in the sense that it provides a measure of progress towards total diffusion and the adoption of

the innovation by the market at large. Time also helps to determine the changing pace of adoption over the course of a diffusion process. DoI theory classifies consumers/adopters across different segments of the overall diffusion process. There are five categories, as follows: innovators, early adopters, early majority, late majority and laggards.

a. Innovators are those consumers who are the first to seek, buy and use a new product or service offering. They typically buy the new product or service not because of a particular need, but simply due to desiring all new ideas, and being eager and willing to try out new things.
b. Early adopters are consumers who purchase and use the new product or service to satisfy a particular need. They have usually considered the product or service in detail before purchase, making them good opinion leaders. Other adopters tend to look to them for advice on new products or services and as a source of innovation ideas.
c. Early majority are similar to early adopters. They buy the product or service offering because they have a particular need. However, the adoption process takes longer than for the early adopters because they have less interest in the novelty of a product, and prefer to evaluate alternatives and the value proposition carefully.
d. Late majority also have a need to buy or adopt the new product, but they are sceptical by nature. Late majority will not adopt until they are thoroughly convinced by others in the social system that the innovation is safe and realistic to adopt. The late majority are risk averse.
e. Laggards are the last group to buy or adopt a new product or service. They are very slow in adopting because they tend not to accumulate much information about the innovation, are unfamiliar with it and tend not to be influenced by others. Laggards are extremely cautious in adopting anything new or different.

iv. The social system refers to the social setting in which diffusion takes place. It refers to the market segments or target consumers. Rogers (2003, p. 23) defines the social system as 'a set of interrelated units engaged in joint problem solving to accomplish a common goal'. Diffusion can occur within

a particular community, group or organisation, and it is influenced by the social structure within that social system. In research, the definition and scope of a social system depends on the product or service in question, its usefulness and the basis for its existence. In a way, it reflects the target users for whom the product/service is designed and the segment within which it is to be diffused. For instance, if new modelling software is to be implemented in an organisation, the social system could include employees such as architects and engineers who are working in the design team. The software would be first discussed and evaluated by other members of the social system, such as directors or managers, through word-of-mouth communication and advice from the software provider. Often, implementation of new software in an organisation is largely dependent on how the top management comes to a decision, long before its use is imposed on employees.

Links between all elements described above can be illustrated as in Figure 2.1. The characteristic curve of adoption is s-shaped when plotted over time against the percentage of users adopting the technology (or number of users using the technology). The percentage of adoption rises slowly at first, when there are only a few adopters in each period. The slope of the curve then accelerates to a maximum, until a critical proportion of the users in the system have adopted the technology. This s-shaped curve is considered typical because there are multiple human traits that influence users to adopt or reject an innovation (Bass, 1969; Rogers, 2003). In addition, user decisions regarding whether to adopt or reject an innovation can be influenced greatly by the 'lifecycle' of the innovation (Bass, 1969; Geoffrey A., 1991; Mahajan et al., 1990; Norman, 1998). The lifecycle is a metaphor of human progression taken from biology. The stages include conception or birth, infancy, childhood, adolescence, maturity, senescence and death. These similar stages can also be identified in the evolution of other entities, such as technologies, products, services or an industry.

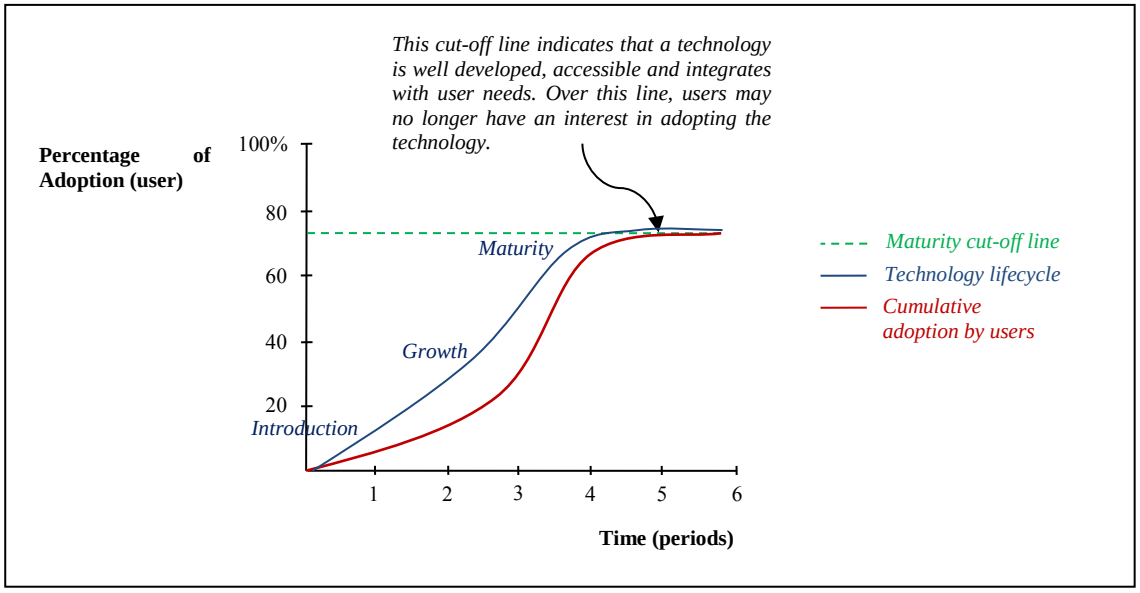

Figure 2.1: Diffusion process and adoption *(adapted from Moore, 1991; Norman, 1998; Rogers, 2003)*

In addition to the product lifecycle concept, a technology introduced to the market can be characterised in terms of its progression through different stages or turning points: (1) take-off, (2) saddle, (3) commercialisation, (4) slowdown and (5) substitution (Bass, 1969; Peres et al., 2010). Take-off is the time at which an increase in product sales occurs between the initial introduction and the genuine growth stages of the product lifecycle. The saddle follows take-off. This refers to the phenomenon of a strong growth in sales up to the peak level of growth, after which sales can suffer a sudden decrease. The saddle is equivalent to a minor recession situation, where the adoption rate temporarily decreases, influenced by weak changes in technology or microeconomic events. After the saddle period, and after the first generation of technology has changed to meet customer needs, an advanced generation will appear on the market. Commercialisation accelerates growth and adoption to the final state, which is maturity. At this final state, the technology is well developed and gains broader consumer acceptance. The development of technology then goes into the slowdown and substitutes phases, with newer technologies with more advance attributes superseding the original.

As shown in Figure 2.1, a technology lifecycle curve that follows the cumulative adoption curve can also be drawn. A technology lifecycle curve appears in three stages:

(1) introduction, (2) growth and (3) maturity. In the first stage, a new technology is introduced and implemented by management for use by employees. At this stage, it can be assumed that the new technology will be used by a small minority (perhaps 5 per cent) of the targeted users or employees in less than one year's time. As the technology grows and becomes better known (possibly due to satisfying users' needs), the adoption rate gradually increases. At the maturity stage, the technology has been adopted by the majority of targeted users. A technology can be considered successful when it is used by around 80 per cent of the targeted users within a period of four years. However, in the maturity stage, the technology can no longer generate the same excitement and claim further acceptance among targeted users. If improvement or re-invention of the technology does not occur at this point, then the technology becomes stagnant. At this point, a new technology will most likely replace the original technology. Further, the organisation may not be able to rely solely on the advantages (features and functions) of the technology to encourage employees to accept and use it. To sustain technological investment, the organisation may need to seek new strategies to encourage employees to maintain maximum utilisation of the technology. The central argument in this regard is that the speed with which a new technology can be introduced and accepted by users is crucial to understanding both the organisational capabilities and technical characteristics required to exploit a technology opportunity successfully (Peres et al., 2010).

2.3.2 Attributes of Innovation

In assessing the merits of a technology, Rogers (2003) suggested five attributes, termed the characteristics of innovations: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability and (5) observability. Rogers (2003) stated that individual perceptions of these characteristics both influence and predict the take up of innovation. For instance, if a user finds that innovation is of value and is well integrated into the work process, then there is stronger potential that the technology will be used and users will seek to persuade others to use it also. To increase adoption and relative advantage, financial and non-financial incentives may then be used to support users and others within the social system (e.g. organisation, group or project team) in adopting the innovation. Incentives are a support and motivation factor. Another motivation factor is

the complexity attribute. The characteristics of innovation described by Rogers (2003) are as follows:

i. Relative advantage is 'the degree to which an innovation is perceived as better than the idea it supersedes' (p. 229). This is the extent to which an individual perceives the technology as advantageous. The greater the advantages, the faster will be the rate of adoption. For instance, 3D CAD software is broadly considered a critical technology for the architect, but not for the construction project management consultant. For the architect, that software provides significant functionality related to the design model, sketches and drawing details. However, the core functionality for a construction project management consultant is more to do with electronic data interchange. Thus, the necessity for 3D CAD leads the architect to adopt such technology faster than the project management consultant.

ii. Compatibility is 'the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of potential adopters' (p. 240). The technology may be seen as incompatible if it does not suit the socio-cultural values, beliefs or 'job-fit' of the individual. Judgement from experience could weaken acceptance of newly introduced technology. For example, for the project manager, handling digital drawings through a computer tablet or smart phone while working onsite may not be favourable, especially on a large-scale project. Instead, they might prefer to continue using conventional paper-based drawings, perhaps using a smart phone as a backup.

iii. Complexity is 'the degree to which an innovation is perceived as difficult to understand and use' (p. 257). Some technologies may be readily understood by most potential adopters. New ideas that are simpler to understand and learn are adopted faster than are innovations that require users to develop new skills and change their understanding of the processes and functions they undertake.

iv. Trialability is 'the degree to which an innovation may be experimented with on a limited basis' (p. 258). If the implementation of a new technology begins with a trial period, it will generally be more quickly adopted than a technology that is not testable by a user before full implementation. A trial period can be used to

promote the popularity of a technology and encourage learning experiences for potential new adopters.

v. Observability is 'the degree to which the results of an innovation are visible to others' (p. 258). People are more likely to use a technology if they have seen the technology-evaluation results. This is especially the case when the evaluation comes from someone that is relatively close to them, such as peers discussing the new technology implemented in an organisation, or friends and neighbours showing the information or physical use of the technology.

2.3.3 The Dimensions of Theory and the Attributes of Innovation in Previous Studies

Dillon and Morris (1996) examined and extended the attributes of innovation introduced by Roger (2003) in a context specific to IT. Moore and Benbasat (1991) undertook an extensive development of the survey instrument used to evaluate user perceptions of IT innovations. Their study shows that the most important perceived characteristics of an IT innovation affecting a user's decision regarding use of technology are voluntariness of use, image, relative advantage, compatibility, ease of use, trialability, result demonstrability and visibility. Moore and Benbasat's instruments provided an extension to Rogers's attributes of innovation and added an important emphasis on variables related to image and voluntariness. Voluntariness is a state in which the user develops some interest in the technology offering; that is, he or she believes that the decision to adopt the technology is supposed to be made willingly. The image factor relates to what the user considers the technology will highlight in terms of their status in the organisation.

In construction management, Mitropoulos and Tatum (2000) adapted the DoI theory and attributes of the innovation concept in explaining their research model. Mitropoulos and Tatum (2000) investigated factors that drive construction firms to adopt new IT, in particular, CAD software and electronic data interchange technology. They suggested four attributes or factors that drive technology implementation, namely: (1) competitive advantage, (2) process problems, (3) technological opportunity and (4) institutional requirements. Based on these factors and the findings of their study, Mitropoulos and Tatum (2000) suggest:

i. At the early stages of technology diffusion, the primary reasons for adoption are competitive advantage or the identification of an important process problem.
ii. Technological opportunity is low in the early phases. The costs of the technology may be high and the required skills may not be available. In the early phases, the cost of the technology may be higher than the saving potential, meaning that the force of this particular factor has a negative value.
iii. Process problems are assumed to increase over time as companies grow, project characteristics change and performance requirements increase.
iv. External requirements typically do not exist in the early phases but increase later as more competitors use the technology and more customers demand its use.

In fact, DoI theory deals with numerous variables, ranging from social to organisational aspects. Indeed, DoI theory was not just used for addressing factors related to technical aspects in technology; it has also been used for cumulating factors relating to technical, social and organisation aspects (Kale & Arditi, 2005; Larsen & Ballal, 2005; Panuwatwanich et al., 2009; Peansupap & Walker, 2005b; Ruikar et al., 2005). In a study to identify factors affecting adoption and implementation of ICTs by construction organisations, Peansupap and Walker (2005b) proposed 46 factors (see Table 2 in Peansupap & Walker, 2005b). They categorised these 46 factors into: (1) individual motivation, (2) training and technical support, (3) technology characteristics, (4) workplace environment for support and (5) knowledge sharing. All factors were tested and analysed. Results from the analysis show that 11 factors (out of the 46 that were established within these four categories) were significant to the case sample (Peansupap & Walker, 2005a). For example, the supporting environment category originally had 10 variables. After analysis using statistics, two variables (help from co-workers and open discussion environments) were verified as significant. Peansupap and Walker (2005a) suggested that this result shows that respondents in their study perceived high levels of support from co-workers and felt comfortable taking part in an open discussion if they faced difficulties when using ICT.

Kale and Arditi (2005) proposed three models for DoI. These were named the external influence model, internal influence model and mixed influence model. Each model is formulated by mathematical equations. Estimation of the models includes three

parameters: (1) the coefficient of internal influence, (2) the coefficient of external influence and (3) the total number of potential adopters in the social system. Taking CAD technology as a case in point, the study found internal influence (i.e. copying behaviours of others) and external influence (i.e. complying with clients' requirements, changes in government regulations, demand conditions and consulting firms' suggestions) can drive the diffusion of an innovation. The study empirically tested all the proposed models. Test results highlighted that a mixed influence model had the greatest explanatory power for innovation diffusion research. The study also claimed that the diffusion of CAD technology in an architectural design practice was primarily driven by internal rather than external influence factors.

A case study investigation by Ruikar et al. (2005) explored the key drivers of project extranet technology adoption in construction. Using DoI concepts, the study highlighted the complexity, compatibility and perceived advantage factors as those aspects having most effect as barriers to technology implementation. They suggested that the perceived complexity of the technology could be reduced by fully understanding the construction process and ensuring the involvement of construction experts during the technology design phase. Technology works well in practice where it has minimal impact on existing practice. Regardless, however, the majority of users remained unconvinced of the advantages of that particular technology, and it was evident that most users were not making full use of it.

Using a sociology perspective as the underlying framework within DoI theory, Larsen and Ballal (2005) extended the diffusion framework to the theory and concepts of cohesion, structural equivalence and thresholds. They justified the relevance of each theory in the United Kingdom construction industry context and concluded that each of these concepts was dominant in a particular stage of the diffusion process over time. For instance, cohesion has an important role in the early stage of diffusion, while structure equivalence and threshold are more important during the later stages of diffusion. They also introduced the 'personal awareness threshold'. This is the number of externalities that might influence and become the source of initial awareness of an innovation. Similarly, focussing on the social aspect of innovation diffusion within architectural and engineering design firms, Panuwatwanich et al. (2009) developed a model named

'climate for innovation' that includes concepts of leadership, team climate and organisation culture.

Most studies related to DoI theory have focussed on the technical aspects of innovation, and have dealt with conceptual and classification issues. In the process, some researchers have drawn attention in their models to the social and traditional organisation perspectives. Including additional categories of resistance factors is strongly noted as a means to provide valuable insights into the theoretical framework for this thesis. It provides a starting point for the research to reflect on and consider different categories of factors of resistance. The attributes of the innovation concept (e.g. relative advantage, compatibility and complexity) suggest a potential alignment with more technical sources of resistance. Certainly, one of the core elements of DoI theory is the social system. This points towards the necessary inclusion of important additional perspectives, including the social network, social support and social exposure perspectives. This is a critical issue for this thesis (see Section 2.5).

2.4 Technology Acceptance Model

2.4.1 Development of Constructs and Measures

The technology acceptance literature has generated many different models. Each model has a set of determinants that are theoretical constructs, and they have been extended by many researchers (King & He, 2006; Legris et al., 2003). A significant theme in the TAM is the understanding of adopter opinions, attitudes and concerns when implementing new technology. The elements of attitude and behaviour are important considerations for this thesis.

TAM was first introduced by Davis (1986) in his doctoral thesis. Soon after, the model was revised in Davis et al. (1989). The initial model, as well as its revision, was developed based on the TRA of Fishbein and Ajzen (1975). Figure 2.2 illustrates this theory. TRA is a psychological theory concerned with the determinants that predict actual individual behaviour in a specific situation. TRA assumes that an individual's actual behaviour is a direct consequence of his or her intention. Intention can be measured by two major factors: (1) attitude towards behaviour and (2) the subjective

norm. Attitude towards behaviour is influenced by external variables including the individual's beliefs and their evolution over time (e.g. an individual's positive or negative feelings about performing a specific behaviour). The subjective norm of an individual includes normative belief, perceptions that have been established by their social group (e.g. cultural belief and organisational belief) and individual motivation to comply with the overall norm.

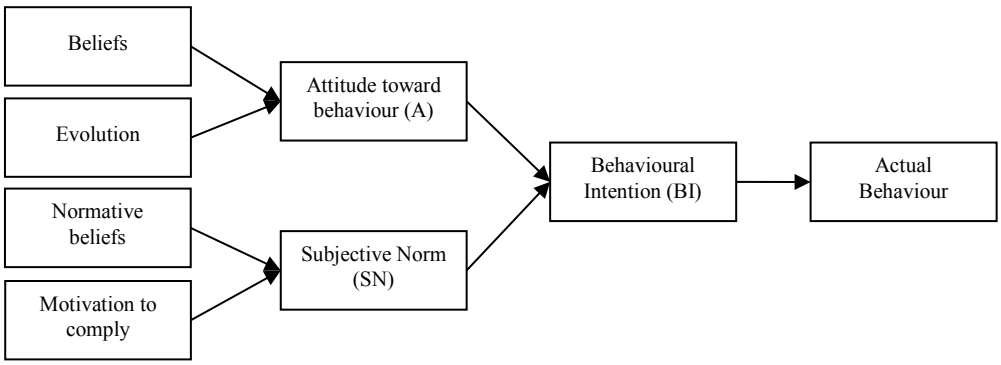

Figure 2.2: Theory of Reasoned Action *(adapted from Fishbein & Ajzen, 1975).*

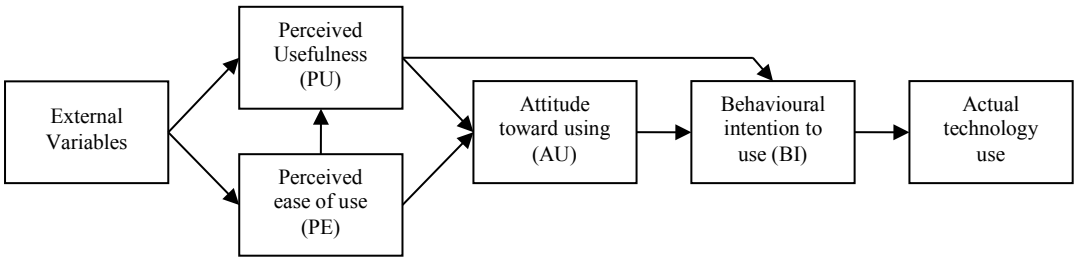

Figure 2.3: Revised version of TAM *(adapted from Davis et al., 1989).*

Figure 2.3 shows that the 'attitude towards using' and 'behavioural intention to use' components of TRA are also part of TAM. However, Davis (1986) and Davis et al. (1989) omitted the variable 'subjective norm' on the basis that it has an insignificant effect on behavioural intention. TAM postulates that actual technology usage is determined by behavioural intention, which is directly predicted by the individual's attitude towards using the technology. Attitude towards using the technology is indicated by two important factors: perceived usefulness and perceived ease of use. Perceived usefulness is 'the degree to which the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context' (Davis, 1989, p. 290). Perceived ease of

use is 'the degree to which the prospective user expects the target system to be free of effort' (Davis, 1989, p. 290). Moreover, the model suggests that behavioural intention could be indirectly measured by perceived usefulness. Based on these theoretical constructs, it appears that the focus of TAM and the key factor governing acceptance or rejection of a new technology is determined by the user attitude (Yang & Yoo, 2004). User attitude could (indirectly) be influenced by external variables/factors such as technical characteristics, user training, user experience and the technology experience.

Subsequent to the work by Davis (1986) and Davis et al. (1989), several studies have applied modifications to TAM. Other than the significant relationship and the direct or indirect link between constructs, modifications and improvements of TAM include the extension of external variables in Venkatesh and Davis (2000) and Venkatesh et al. (2003). Improvements to TAM are in line with the significant improvement to the TRA and TPB by Ajzen (1991). According to TPB, individuals' intentions to perform certain behaviour might also indirectly depend on perceived behavioural control as a third core construct. Perceived behavioural control is the belief that a person has the ability and suitable resources or condition to facilitate particular behaviours (Ajzen, 1991).

A modification proposed by Venkatesh and Davis (2000), called TAM2, incorporates additional theoretical constructs across social influence processes and cognitive instrumental processes (see Figure 2.4). TAM2 proposes three interrelated social processes as persuading an individual to adopt or reject a new system: subjective norm, voluntariness and image. Compared to the original model, in TAM2 subjective norm is also included. The model also proposed four cognitive instrumental determinants of perceived usefulness: job relevance, output quality, result demonstrability and perceived ease of use. Further, the model posited two moderating variables, named experience and voluntariness. These moderating variables influence the subjective norm's impact on the intention to use. Variable experience moderates the effect on perceived usefulness. Venkatesh and Davis (2000) tested TAM2 in a field study with 156 workers, who used four different systems, two of which were voluntary, while the other two were mandatory. The results indicated that TAM2 performs well in both the voluntary and mandatory settings. Subjective norm still had little to no effect on the overall model in terms of voluntary use, but did have an impact in the mandatory setting.

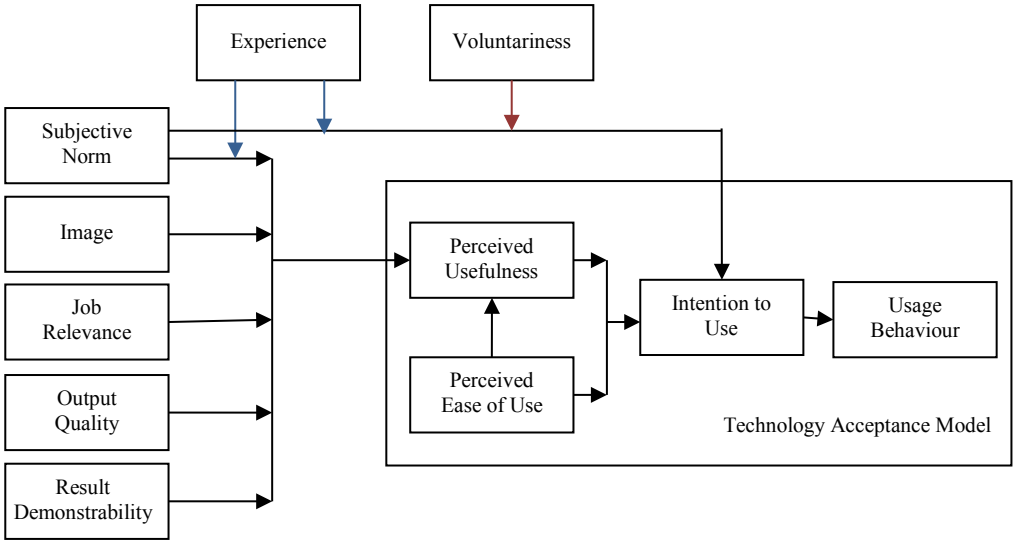

Figure 2.4: TAM2 *(adapted from Venkatesh & Davis, 2000).*

In another version of the model, the UTAUT by Venkatesh et al. (2003), elements of extant TAMs are integrated with elements developed in diffusion theory and social cognitive theory. Table 2.1 summarises the eight theories and models underlying UTAUT. It can be seen from Table 2.1 that some of the constructs underlying UTAUT are familiar to the TAMs, TRA and TPB. Other constructs are developed based on the Model of Personal Computer Utilisation, Motivational Model, DoI and Social Cognitive Theory, which are in turn largely based on social and human behavioural theory.

Table 2.1: Summary of the theory, model and constructs underlying UTAUT *(adapted from Venkatesh et al., 2003).*

Name of Models and Theories	Core constructs
Theory Reasoned Action (TRA) TRA, developed by Fishbein and Ajzen (1975) and drawn from social psychology, is regarded as one of the most fundamental and influential theories of human behaviour.	Attitude towards Behaviour Subjective Norm
Technology Acceptance Model (TAM) Adapted from TRA, Davis (1986) proposed TAM. It was designed to help to predict IT acceptance and usage on the job.	Perceived Usefulness Perceived Ease of Use
Theory of Planned Behaviour (TPB) TBP (by Ajzen, 1991) is an extension of TRA.	Attitude Towards Behaviour Subjective Norm Perceived Behavioural Control
Model of Personal Computer Utilisation (MPCU) MPCU is derived from the theory of interpersonal behaviour by Triandis (1977). The theory exists as a competing perspective to that of the TRA and TPB. Thompson et al. (1991) developed MPCU to predict usage behaviour rather than intention.	Job-fit (technology enhances job performance) Complexity (technology is difficult to understand and use) Long-Term Consequences (payoff in the future) Affect towards Use (feeling joy, elation pleasure or displeasure) Social Factors (e.g. culture) Facilitating Conditions (e.g. technical support)
Motivational Model (MM) Another theory used for behavioural explanation comes from psychology research performed across a range disciplines. It has been applied to the adoption and use of new technology by Davis et al. (1992)**,** who built two core constructs.	Extrinsic Motivation (i.e. user perceptions of valued outcomes from the activity itself, for example pay or promotion) Intrinsic Motivation (i.e. user willingness to perform an activity simply to complete it or enjoyment)
Combined TAM and TPB (C-TAM-TPB) This model, developed by Taylor and Todd (1995a), combines the predictors of TRA/TPB with perceived usefulness from TAM.	Attitude towards Behaviour Subjective Norm Perceived Behavioural Control Perceived Usefulness
Technology Acceptance Model 2 (TAM2) TAM2 (by Venkatesh & Davis, 2000) is an extension of TAM (adapting TRA and TPB), which includes subjective norm as an additional predictor of intention of use, specifically in the case of mandatory use of the technology.	Perceived Usefulness Perceived Ease of Use Subjective Norm
Diffusion of Innovation This theory, introduced by Rogers (1962)**,** incorporates attributes of innovation. The theory has been used to study a variety of innovations (e.g. agricultural tools, medical and organisational technology). Moore and Benbasat (1991) refined and verified a set of attributes of innovation.	Relative Advantage Ease Of Use Image Visibility Compatibility Result Demonstrability Voluntariness of Use
Social Cognitive Theory (SCT) SCT holds that peoples' behaviour is based on dynamic interaction between the person (personal factors), the behaviour and the environment in which the behaviour is performed. This theory has been applied to the context of computer utilisation (see Compeau & Higgins, 1995a, 1995b; Compeau et al., 1999)	Outcome Expectations—Performance Outcome Expectations—Personal Self-efficacy Affect Anxiety

Figure 2.5 is based on Table 2.1. The UTAUT model developed four new constructs to predict user intention and behaviour using technology: (1) performance expectancy, (2) effort expectancy, (3) social influence and (4) facilitating conditions.

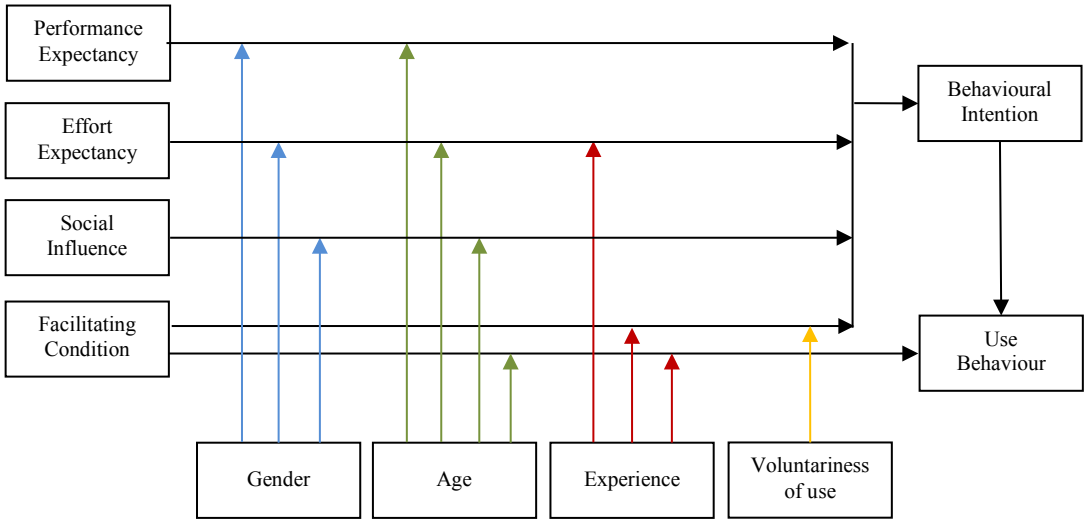

Figure 2.5: Unified theory of acceptance and use of technology *(adapted from Venkatesh et al., 2003*).

Performance expectancy is defined as 'the degree to which an individual believes that the use of any given system will help that individual to achieve gains in their job performance'(Venkatesh et al., 2003, p. 447). According to Venkatesh et al. (2003), performance expectancy was modified from perceived usefulness (as in TAM), intrinsic motivation (Davis et al., 1992), the capability of the system to improve individual job performance (Thompson et al., 1991), out come expectation (Compeau & Higgins, 1995b; Compeau et al., 1999) and relative advantage (Moore & Benbasat, 1991). Effort expectancy is defined as 'the ease use as sociated with the system' (p. 450) . This construct consists of elements of perceived ease of use (as in TAM), complexity (Thompson et al., 1991) and ease of use (Moore & Benbasat, 1991). Social influence is defined as 'the degree to which an individual perceives that important others believe he/she should use the new system' (p. 451). Social influence has been developed based on the constructs of subjective norm (as in TRA), social factors (Thompson et al., 1991) and image (Moore & Benbasat, 1991). Facilitating condition is an element that embodies three different bases: perceived behavioural control (Ajzen, 1991; Taylor & Todd, 1995a, 1995b), facilitating conditions (Thompson et al., 1991) and compatibility

(Moore & Benbasat, 1991). This construct is defined as 'the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system' (p. 453). Moreover, similar to previous work in Venkatesh and Davis (2000), Venkatesh et al. (2003) also proposed the moderator factors of gender, age, experience and voluntariness of use. The strength of the relationship between constructs (e.g. between performance expectancy and behavioural intention to use technology) can vary with age and gender.

TAM has been extended in a variety of ways. It has become robust over time as a broader scope of external variables (e.g. support, training, social influence and expectation) are integrated within the model. The addition of such variables contributes to the explanation of the variance in technology use, provides a better understanding of what influences user behaviour and guides the actions required to influence greater use (Legris et al., 2003).

2.4.2 Application of Technology Acceptance in Research

A number of studies have used TAM (Chuttur, 2009; King & He, 2006; Legris et al., 2003). The model has been used and tested in 140 papers in 22 selected journals (King & He, 2006). In a review by Legris et al. (2003), the model was applied to examine the use of IT and software application in a wide range of environments (e.g. workplace and university) and samples (e.g. professionals, workers and students). Some studies examined the use of the internet (Shih, 2004), World Wide Web (Laderer et al., 2000), web-based information system (Yi & Hwang, 2003), web-based learning (Gong et al., 2004), extranet (Horton et al., 2001), email (Davis, 1993; Gefen & Straub, 1997), e-commerce (Gefen & Straub, 2000), personal computing (Igbaria et al., 1997) and data information retrieval (Venkatesh & Morris, 2000).

Many researchers have also successfully applied TAM in studies in construction management. The model improves understandings of the theoretical perspectives, adoption and use of ICT. It is also able to explain the use of ICTs over time in construction projects. Examples of studies using this model address the adoption of mobile computing devices (Son et al., 2012), a collaboration tool for communicating and sharing project information (Adriaanse et al., 2010; Peansupap, 2004), building

information (Lowry, 2002), a crane navigation system (Lee et al., 2012), a user assessment tool of ICT adoption (Davis & Songer, 2008) and user perceptions of ICT impacts (Jacobsson & Linderoth, 2012).

In an example from one recent study in construction management, Son et al. (2012) extended TAM to explore user satisfaction and overall performance of mobile computing devices. Their model posited that overall performance of the technology could be directly measured by user satisfaction. User satisfaction is measured by perceived usefulness and perceived ease of use. The constructs of intention to use and actual usage (as in TAM) were named user satisfaction and perceived performance, respectively. Only two constructs remain; that is, perceived usefulness and perceived ease of use, and both have sets of external variables. The external variables for perceived usefulness are social influence, job relevance, result demonstrability and top management support. The external variables for perceived ease of use include training, technical support and technological complexity. Results from Son et al. (2012) revealed that user satisfaction is an important indicator of intention to adopt for mobile computing devices. Moreover, external variables such as social influence, job relevance, top management support, training and complexity are identified as critical determinants influencing the successful implementation of a technology.

Even though TAM is effective and successful, an analysis by Legris et al. (2003) proved that TAM is also a consistent model. The relationship between perceived usefulness and attitude towards using technology is shown to be significant in the majority of studies/research that applied the model. Of course, limitations do exist. For TAM, the limitations include the selection of the variables, the relationships between the variables and the veracity of TRA and TPB. There is evidence to suggest that the perceived usefulness and perceived ease of use expressed by a user about a particular technology/innovation may be less significant when compared to external factors (Burton-Jones & Hubona, 2005). External variables such as experience, level of education and age may have their own direct influence on technology usage (Chuttur, 2009). Bagozzi (2007a) criticises TAM on the basis that TRA presumes a particular link between user reaction, intention and actual technology use. Thus, the question is whether a link between intention and actual use, for example, is straightforward and

benign. TAM focusses explicitly on the end-state motives (actual use) of technology, and it largely ignores the behavioural issues that lead to the end-state. Indeed, the period between intention and adoption is such that any end-state is subject to uncertainty and other factors that might just as directly impact on the decision to adopt or reject a technology.

2.5 Social Network

2.5.1 Social Network Perspective

In Section 2.3, the thesis highlighted the significance of social network in DoI. DoI emphasises the role and relationship of people in the organisation (e.g. leaders and co-workers) in influencing users to adopt technology. In this section, the concepts currently associated with the term social network are reviewed.

Social network is the subject of interest in many disciplines. It has been developed out of social theory and application, with formal mathematical, statistical and software applications (Freeman, 1984; Marsden 1990; Marsden & Laumann 1984). In the literature, social network is often said to be a 'perspective', rather than a theory. The social network perspective contains theories, models and applications that address the processes of interaction between individuals (Borgatti & Halgin 2011; Brass et al., 1998; Tichy et al., 1979; Wasserman & Faust, 1994). Borgatti and Halgin (2011) stated that network theory refers to the mechanism processes that interact with network structure to yield certain outcomes for individuals or groups (p. 1). Some examples of network theory include the Strength of Weak Ties Theory (SWTT) by Granovetter (1973) and the Structural Holes Theory (SHT) by Burt (2009). Where one person in a project team posits an idea, support from the other members of that project team should be readily apparent. Propositions such as this can be tested by adopting SWTT. SWTT assumes that social relationships are characterised by infrequent contact, an absence of emotional closeness and no history of reciprocal favours. This theory posited that people actually frequently depend on other people with whom they maintain only 'weak ties'.

The social network perspective views social relationships between individuals in term of nodes and ties. Nodes are the individuals or actors that are connected by the ties between them. The ties or relationships, such as friendship, kinship and so on, exist between nodes. Tichy et al. (1979) define a social network as a specific set of linkages among a defined set of persons. An additional property is that, taken together, the characteristics of these linkages may be used to interpret the social behaviour of the persons involved (p. 2). Wasserman and Faust (1994) describe a social network as a finite set or sets of actors and the relation(s) between them. The term 'network' might imply that only those linkages that actually occur should be considered as part of the network. However, a network can take into account both those relations that do actually occur and those that do not. Based on these definitions, several key concepts or terms are fundamental to the discussion of the social network perspective: (1) actor, node or point; (2) tie, link, relation or connection; (3) dyad; (4) triad; (5) group and subgroup; (6) relation; and (7) network. These terms provide a core lexicon for discussing social networks. These terms are summarised from Wasserman and Faust (1994), as follows:

i. Actor, node or point: a social network focusses on the relations among actors. Actors are referred to as individuals or social units. Examples include employees within departments and members in a project team.
ii. Tie, link, relation or connection: actors are connected to one another by ties. Examples include the set of friendships among pairs of employees in an organisation, kinship or descent, expressed liking or respect, social support, political support, business relations, membership in a social club and so on.
iii. Dyad: is a pair of actors and the tie(s) between them.
iv. Triad: a larger subset of three actors and the tie(s) between them.
v. Group and subgroup: a group is the collection of a finite set of actors for whom ties are to be measured. A subgroup is a smaller group from a measured group. A subgroup contains actors from any subset of actors and the ties among them that share common criteria.
vi. Relation: the collection or composition of ties existing among actors of a group.
vii. Network: a finite set of actors and the variety of relations that might exist between them.

Since a network is defined as consisting of a finite set of actors, the boundary of the network should be established (Marsden 1990; Marsden 2011; Wasserman & Faust, 1994). However, according to Marsden (2011), the boundary for the overall network is often challenging to specify. The aim should be to focus on the entire structure of the social group by collecting one or more types of relations that link the nodes or actors within the group. In contrast, an egocentric (small world) and/or dyadic approach are focussed only on those network relations that immediately surround the actors. In this case, the aim is to make inferences about the features of a personal and personalised network. For example, in surveying one sample of respondents, each respondent identifies a set of people to whom they have ties, and indicates what the type of relationship is, along with the level of satisfaction they have with that relationship.

Data collection and analysis techniques associated with social networks are also quite different between the overall and the egocentric perspectives. In addition to surveys, questionnaires and interviews, the overall network data can sometimes be gathered through observations or archival records (Wasserman & Faust, 1994). Observation can be used to study a small group of people who have face-to-face interactions. Interaction can also be measured by examining diaries, emails, minutes of meetings and so on. Egocentric data is very often collected using questionnaires or a survey instrument called a name generator. A name generator relies on the respondent to recall and report data about all or just the important people with whom they are connected. Ego-centred networks have a wide literature, and established instruments are available for the study of social support. Studies have been undertaken to explain how personal relationships, as reflected by the ego-centred network, can affect the emotional state and stress (Cohen & Hoberman, 1983; Sarason et al., 1987), health and well-being and behaviours of an individual (Davis et al., 2007; Kogovšek et al., 2002; Turner & Marino, 1994; Wills & Shinar, 2000).

Social networks are also prominent in a number of research fields within the broad study of organisational behaviour (Borgatti & Foster 2003; Carpenter et al., 2012). Topics that have used social network include: diffusion and adoption of innovations (Abrahamson & Rosenkopf, 1997; Davis 1991; Rice & Aydin, 1991; Valente, 1996b), group and individual performance outcomes (Reagans & Zuckerman, 2001), knowledge

management (Borgatti & Cross 2003; Tsai, 2001), leadership (Pastor et al., 2002), trust (Macy & Skvoretz, 1998) and conflicts at work (Joshi et al., 2003; Krackhardt & Stern, 1988). In construction management, the social network perspective is relatively less used in research but its use is growing. Specific examples include in construction project governance (Pryke 2005) and conflict resolution (Loosemore, 1998; Pryke 2004).

One consistent finding from the literature review is that a network is more likely to be used to provide information pointing to individuals and others within an organisation because of the adoption of innovations (new technologies, process and practice). For instance, Valente (1996b) noted in the study of personal network thresholds that the social system in the adoption of innovation includes opinion leaders, peers and followers who are connected to (or may work with) innovation. Opinion leaders, peers and followers do not necessarily direct the adoption, but their own adoption behaviour (if combined) can influence the behaviour of others. Further, individuals vary in their willingness to take risks in adopting a new idea or product. Certain individuals accept the risk of adopting a new technology, idea or product before anyone else. Some people are reluctant to adopt a new idea or technology and prefer to wait until other people have tried it first.

In the context of this thesis, the SNT model proposed by Valente (1996b) is promising. It introduced a 'frame of reference' with respect to the social system and network that can be used to identify those individuals that will most likely play an important role in promoting adoption. Further discussion on the SNT concepts and model follows below, in Section 2.5.2.

2.5.2 Concepts and Model of Social Network Threshold

According to Rogers (1962, 2003), a threshold is the number of individuals who must be engaged in an activity before a given individual will join that activity. This number can vary. For instance, the individual who is earliest to adopt (or an innovator themselves) will have a low threshold of adoption. The early adopter will accept a new idea almost without intervention, and interpersonal network influences are rarely needed for adoption. Conversely, a late majority individual has a much higher threshold. The

late majority individuals' peer network must exert a heavy influence to overcome their resistance. In either event, however, an individual is more likely to adopt an innovation if more of the others in his or her personal network have already adopted that innovation. Not all members of a network are equal. There are typically particular individuals who are more interconnected than are others. These individuals are linked to others by patterned communication flows. The interconnected individual thus plays a more important role in DoI (Rogers, 1962, 2003).

The Social Network Threshold model/concept of Valente (1996b) was motivated by Rogers (1962) and several other sources related to DoI, such as Ryan and Gross (1943), Granovetter (1973) and Rogers and Kincaid (1981). According to these authors, diffusion is the process by which a few members of a social system initially adopt an innovation, over time causing more individuals to adopt until all (or a majority of) members have adopted the new idea. These authors argue that adopters can be created either with respect to the entire system or with respect to an individual's personal network. It is upon this basis that Valente (1996b, 2005) developed his SNT model. The threshold is the exposure at time of adoption. Exposure is a measure of the proportion of previous adopters in an individual's personal network. Exposure can be estimated by counting the number of adopters in each individual's network that provide information and influence with regard to adoption behaviour. Valente (2005) suggested a mathematical model as follows:

$$E_i = \frac{\sum w_{ij} y_j}{\sum w_i}$$

where E_i represents network exposure, w represents the social network weight matrix and y is the vector of adoptions. Using this equation in an example (see Figure 2.6), if an individual i reports that two out of their three network contacts had already adopted a particular technology before they themselves adopted it, then the network exposure E_i is estimated at 66 per cent. If only one contact out of three network contacts had already adopted, then the network exposure value is 33 per cent.

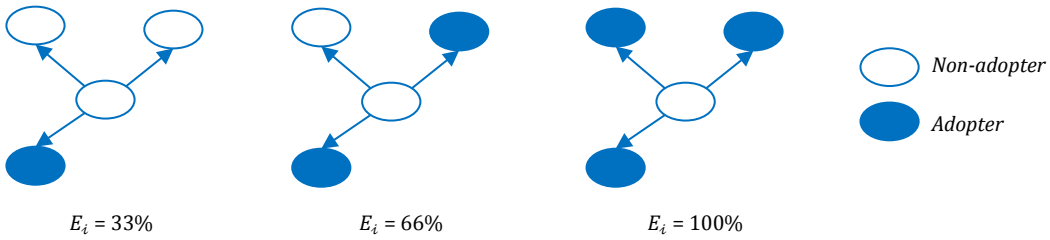

Figure 2.6: Example of different network exposures (*adapted from Valente, 2005)*.

The SNT model also estimates the number of times that direct communication may have happened between the adopter and their network partners. Network partners are those who act in terms of friendship, direction and advice, and as discussion partners. These people may have a position as opinion leaders, peers or affiliates. Opinion leaders have been theorised in Rogers (1962, 2003) as those individuals that have the greatest influence on the rate of adoption of an innovation. Peers are people who have the same position as the adopter, as based on the theory of structural equivalence (Burt, 1987). Affiliates, as derived from the SWTT by Granovetter (1973), are those who may know many facts about an innovation (e.g. technical staff, customer support service and technology providers), but who are only loosely connected to the adopter in the network.

2.5.3 Justification of Social Network Threshold in Research

The rationale behind the SNT is two-fold. First, in the organisation, individuals interact with and influence each other to produce homogeneity in attitudes, opinions, beliefs and practices (Friedkin & Johnsen, 1999; Rice & Aydin, 1991). A study by Rice and Aydin (1991) found that social network and opinions, especially of co-workers and supervisors, had an impact on individuals' attitudes towards an information system. Second, people do not belong to just one relationship or network in an organisation. They can be members of a number of different social networks, each based on different types of relationship. For example, Pryke (2005) explored construction project governance and identified the pattern of relationships between key actors including clients, consultants, main contractors and sub-contractors. Three main types of network were identified: contract, performance incentive and information exchange networks. Pryke (2005) showed that the consultants were involved in all three kinds of networks, often concurrently. However, the degree of involvement varied. The consultants' roles

were relatively weak in the contractual network and performance incentives network, but they played a very important role in the information exchange network.

Arguments for using SNT in observing the impact of a social system on resistance are clear: the behaviour and influence of others are important to how each individual responds to an innovation implementation process. To get a complete description of behaviour, the research must look at employee-to-employee relationships, such as relations with and support of managers, acquaintance with other employees, and other relational variables. Co-workers may form a network based on the exchange of information relating to getting their job done. At the same time, they may also form a different network based on friendships. A network perspective is critical to better understanding the decision to resist, and to shed some light on the role and variety of networks that affect the extent of resistance.

However, it is necessary to note some of the weaknesses of the SNT model. The parameters or estimations of a SNT model are typically based on two variables, and there is often a time lag between them. For example, if the two variables are exposure level and time of adoption, these can occur at different stages of implementation; yet, the time lag between them is typically not taken into account (Valente, 1996b). The lag happens because people might not adopt immediately upon availability, despite being influenced by others. Rather, they might choose to continually monitor the behaviour of others and wait until almost all of the others in their network have adopted before doing so themselves. Moreover, the assumption that personal thresholds determine the speed of adoption has not yet been subjected to a robust test (Valente, 1996a). The fundamental assumption about the SNT model may be insufficient and need further investigation. Despite these weaknesses, however, the concepts and elements introduced through the SNT literature can usefully contribute to the broader consideration of resistance, particularly in terms of the variety of networks, network partners and the roles of partners within networks at play and relative to resistance. The model also provides a basis upon which to measure the strength and utility of a network, using the number of times that direct communication occurs between the adopter and their network partners to indicate network influence.

2.6 Summary

This chapter has reviewed the issue of resistance as it is represented in several fields of literature. From this review, resistance can be regarded as constructive because it can highlight potential symptoms for a problematic innovation implementation. Resistance can happen because of individual interpersonal factors, technology attributes or social environment. If it is overlooked, resistance can significantly affect and slow the process of technology adoption. However, depending on the critical sources that cause it to happen, resistance can be overcome through flexible and particular approaches. Four key approaches are identified in this chapter: directive, participative, consultative and coercive. The directive, participative and consultative approaches can be seen as flexible since these involve cooperation, toleration and mutual understanding of user behaviour and the change or direction of the implementation itself. The coercive approach is more radical. It is appropriate for managing irreconcilable resistance, and can involve firing people who resist change.

This chapter also reviewed the theories and models used in addressing resistance from the broader perspective of information systems and organisational behaviour. It appears that resistance models are under-developed in that broader context. Moreover, resistance has been demonstrated to be a very complex issue. To understand resistance better, previous studies have sought to incorporate social theory, DoI, technology acceptance and change management. However, they have tended to incorporate each in isolation or in limited combination. Where the different theories have been combined, the results have been encouraging (Bhattacherjee & Hikmet, 2007; Cenfetelli, 2004; Davis, 2004; Kim & Kankanhalli, 2009; Klaus et al., 2010; Laumer & Eckhardt, 2010).

Individually, DoI is manifestly the most important body of theory relevant to innovation resistance. It directs a consideration towards the concepts and attributes of innovation and diffusion networks. DoI provides a baseline for other key considerations, such as the TAM and SNT. For example, relative advantage and complexity (two attributes of innovation introduced by DoI) are similar to (and indeed the basis of) the perceived usefulness and perceived ease of use parameters in TAM. The concept of a diffusion network originated from the social network perspective and it is now applied to DoI research. There is a strong case emerging from the literature review for the TAM and

SNT model to be considered along with the DoI in formulating a more comprehensive resistance theory. Further discussion about the elements, concepts, constructs and measures drawn from these theories is presented in Chapter 3.

Chapter 3: Conceptual Framework, Model, Hypotheses and Instruments

This chapter presents the resistance factor framework and a proposed integrated model. The chapter also defines and discusses the constructs in the model and the hypotheses tested in the study.

3.1 Conceptual Framework

3.1.1 Linking DoI with TAM in the Research Model

DoI defines the idea of technology diffusion in terms of stages, and describes in detail the factors that influence the scope of the diffusion and the speed with which technology is adopted. DoI is therefore taken as the baseline for this thesis. An instrument to measure the five characteristics of innovation of Rogers (1962, 2003) has been developed specifically for users of IT by Moore and Benbasat (1991). These authors sought to extend Roger's work, ultimately proposing a set of seven perceived characteristics for this purpose: relative advantage, ease of use, image, compatibility, visibility, result demonstrability and voluntariness of use.

Theoretically, DoI does not have an explicit relationship with TAM. However, both shares similar key constructs (Lee at al. 2011). According to Lee et al. (2011), the relative advantage factor in DoI is similar to the notion of perceived usefulness in TAM, and the complexity factor in DoI captures the perceived ease-of use factor in TAM. In addition, the complexity factor in TAM and DoI proposes that the formation of users' intentions is partially determined by how difficult the innovation is to understand or use (Davis et al., 1989; Roger, 1995, 2003). This means that the less complex the new technology is perceived to be by the user, the more likely an individual is to accept it. Other factors developed in DoI, such as image, visibility and voluntariness of use, can be treated as external variables in TAM.

The role of TAM in this thesis consists of two parts. First, TAM provides improvements to the development of technology attributes, or attributes of innovation as considered in DoI. TAM and its revised versions (TAM2 and UTAUT) underlie TRA and TPB.

Second, TAM gives a starting point for considering human attitude and behaviour regarding technology use. Originally, TAM relied heavily on perceived usefulness and perceived ease of use to determine behavioural intentions and actual use behaviour of using technology. Perceived usefulness broadly holds that it is the individual's belief that the technology will enhance his or her job performance. Perceived ease of use is the individual's belief that the technology will be intuitive and fit well with existing practices. TAM2 later expands the model by adding subjective norms and variables that were developed based on DoI (i.e. image, result demonstrability and job relevance). TAM2 also includes experience and voluntariness as attitudinal variables. For its part, UTAUT expands TAM to include social influence.

Both TAM and DoI are intended to be comprehensive models. They are consistently used within acceptance and adoption models in the field, but the direct influence of variable human attitudes to innovation is not fully articulated in either approach. Accordingly, for TAM and DoI, human attitude is regarded as increasingly independent and separate. Based on the findings of the literature review, however, this thesis seeks to reintegrate attitude and behaviour as important considerations for the implementation of any innovation. Thus, to study resistance comprehensively, the thesis frames the attitude and behavioural variables within a TRA and TPB context.

A comprehensive framework for resistance research is provided in Figure 3.1. A basis in DoI is retained, but complemented with direct links to TAM and SNT. This broader conceptualisation of the elements not only defines the diffusion process, but also explains in detail the characteristics of innovation that should be considered in evaluating technology for successful implementation.

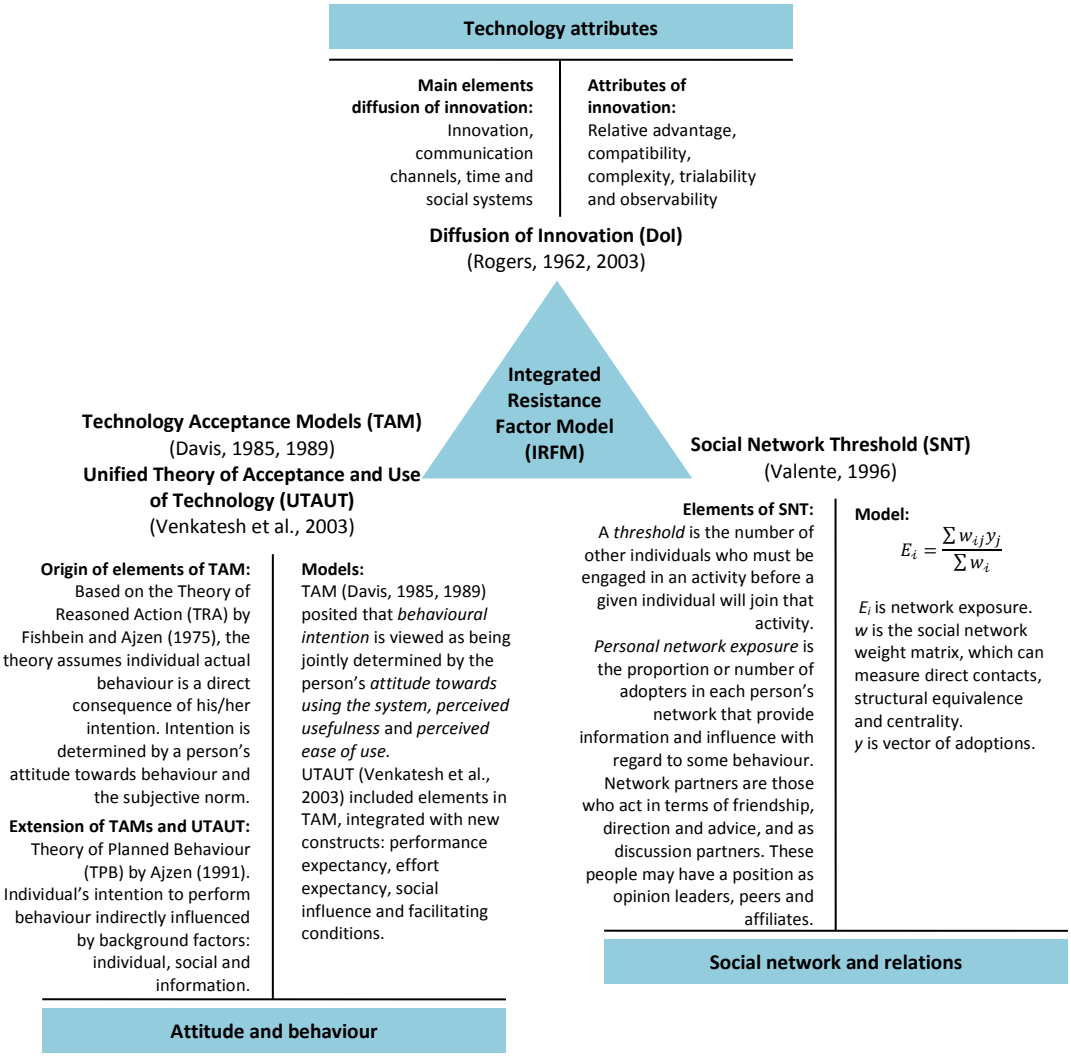

Figure 3.1: Theoretical framework for the integrated resistance factor.

In TRA and TPB, specific behaviour is seen as formed by attitude, subjective norms and external factors that control behaviour (e.g. learning, support and training). It is assumed that attitude is shaped by individual beliefs and their evolution. Norms are developed from individual perception constructed by social groups and individual motivation. For example, if an individual feels that innovation is being accepted within a social group, and they are motivated by job increment and high pay, then they are more likely to comply with adoption. TRA and TPB contribute the connection between the use of otherwise individual attitude factors to predict resistance such as experience, confidence, motivation, power and fear.

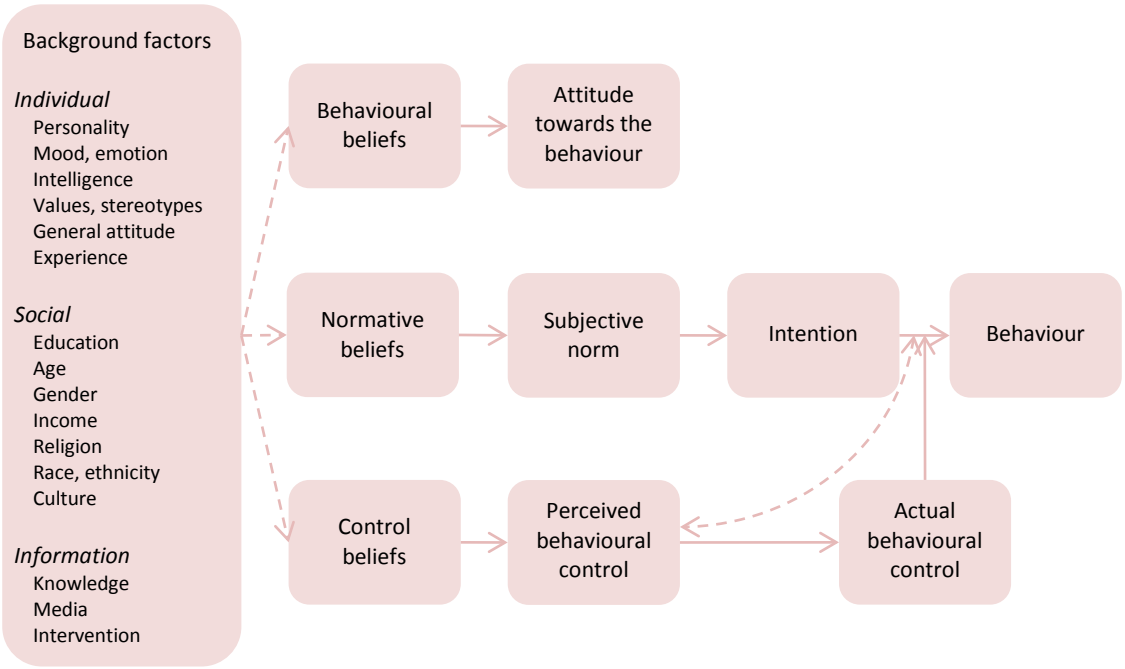

Figure 3.2: TRA and TPB *(adapted from Fishbein & Ajzen, 2005).*

Figure 3.2 illustrates that several of the factors arise from elements of behavioural belief, normative belief and control belief. These elements are in turn controlled by background factors, including the characteristics of the individual (i.e. personality, mood, emotion, intelligence, values, stereotypes, general attitude and experience), social setting (i.e. education, age, gender, income, religion, race, ethnicity and culture) and information environment (i.e. knowledge, media and intervention). According to Fishbein and Ajzen (2005), the variables proposed in TRA and TPB address the origins of all behavioural, normative and control belief elements. The dotted arrows in Figure 3.2 are to indicate that, while background factors might influence each belief, Fishbein and Ajzen (2005) assumed that a link between background factors and beliefs was not necessary. Whether belief is influenced by certain background factors should be determined through empirical analysis. However, there are a number of significant background factors and it would be difficult to measure each of them independently, certainly without a guiding theory. Theories explaining these background factors might also be insufficient as a reasoned action approach in themselves. However, they could contribute to the reasoned approach by identifying relevant background factors and thus expanding understanding of the source of the beliefs (Fishbein & Ajzen, 2010).

In particular, the work of Albert Bandura on self-efficacy (see Bandura, 1988) has been key to the reinvigoration of the theory behind the background factors introduced in TRA and TPB (Ajzen, 1991). Self-efficacy refers to the belief (accurate or not) that the person has the power to produce an effect by completing a given task or activity related to competency. It can be broadly defined as an individual's intelligence and confidence in their own ability to engage in a task. Other theories also conceptualise attitude and behavioural factors; see for example, Ferneley and Sobreperez (2006), Hirschheim and Newman (1988), Davis (2004), Waddell and Sohal (1998) and Val and Fuentes (2003). Concepts used for the attitude and behavioural factors will be further discussed in Section 3.4.

3.1.2 Inclusion of SNT

As identified above, using only elements and concepts developed for DoI and TAM will unduly constrain the scope of research into resistance and render it incomplete. There has been extensive use of DoI and increasing application of TAM to address resistance in isolation. The UTAUT signals the significant potential for the addition of a social factor in the adoption of technology, but UTAUT is limited to describing factors about why technology is important to users based on other users' beliefs. The need to identify a social related theory and scope for resistance research is clear.

Many studies have focussed on the technical functionality and benefits of particular technologies or on measuring the level of uptake by construction organisations and the potential barriers that impact uptake. While some studies focus exclusively on an explanation of the behavioural issues of technology adaption, there is a significant lack of empirical evidence specific to the integration of human, social and technology models. This thesis seeks to incorporate social network within, and along with, existing technology attribute and human attitude elements to frame a new body of knowledge and approach to resistance research.

Embedding a social network perspective in technology innovation research is not new. Some studies have shown encouraging results. For example, Haythornthwaite and Wellman (1998) used a social network perspective to examine work and friendship ties in a university research group. They showed how such ties were associated with

different types of media (i.e. scheduled and unscheduled face-to-face, telephone, fax, electronic mail and videoconferencing) and used for communication around different tasks (i.e. receiving work, giving work, collaborative writing, computer programming, sociability and emotional support). The study found that work and relationship ties determine factors that affect the types of information being exchanged, the quality of the exchange and with whom information is exchanged. Their approach also revealed the importance of underlying personal networks (pair relationships) in determining communication patterns and technology use. The research relates particularly to questions about what aspects of a network contribute to resistance, and the extent to which an increase or decrease in communication frequency might affect resistance.

The SNT model by Valente (1996b) suggested that an effective diffusion process occurs when individuals have sufficient information to satisfy their personal exposure (threshold) requirements. This aspect of the resistance context is used here in terms of personal exposure to innovation. Exposure is gained from a range of people (leaders, peers and affiliates) involved in an individual's adoption network and the communication that links and connects the people within that network. This concept of personal exposure is elaborated in terms of support network and will be further discussed in Section 3.3.

3.1.3 Integrated Resistance Factor Model

Combining DoI, TAM and SNT, this study proposed an IRFM. As shown in Figure 3.3, the proposed model comprises four key elements: (1) a resistance indicator, (2) a support network factor, (3) an experience and disposition factor and (4) an integration and accessibility factor. The model proposes that resistance can be identified by using two factors: the time to adoption of technology and usage level. Then, for adequate prediction, the model assumes that the factors of support network, experience and disposition, and integration and accessibility of technology to work significantly influence resistance.

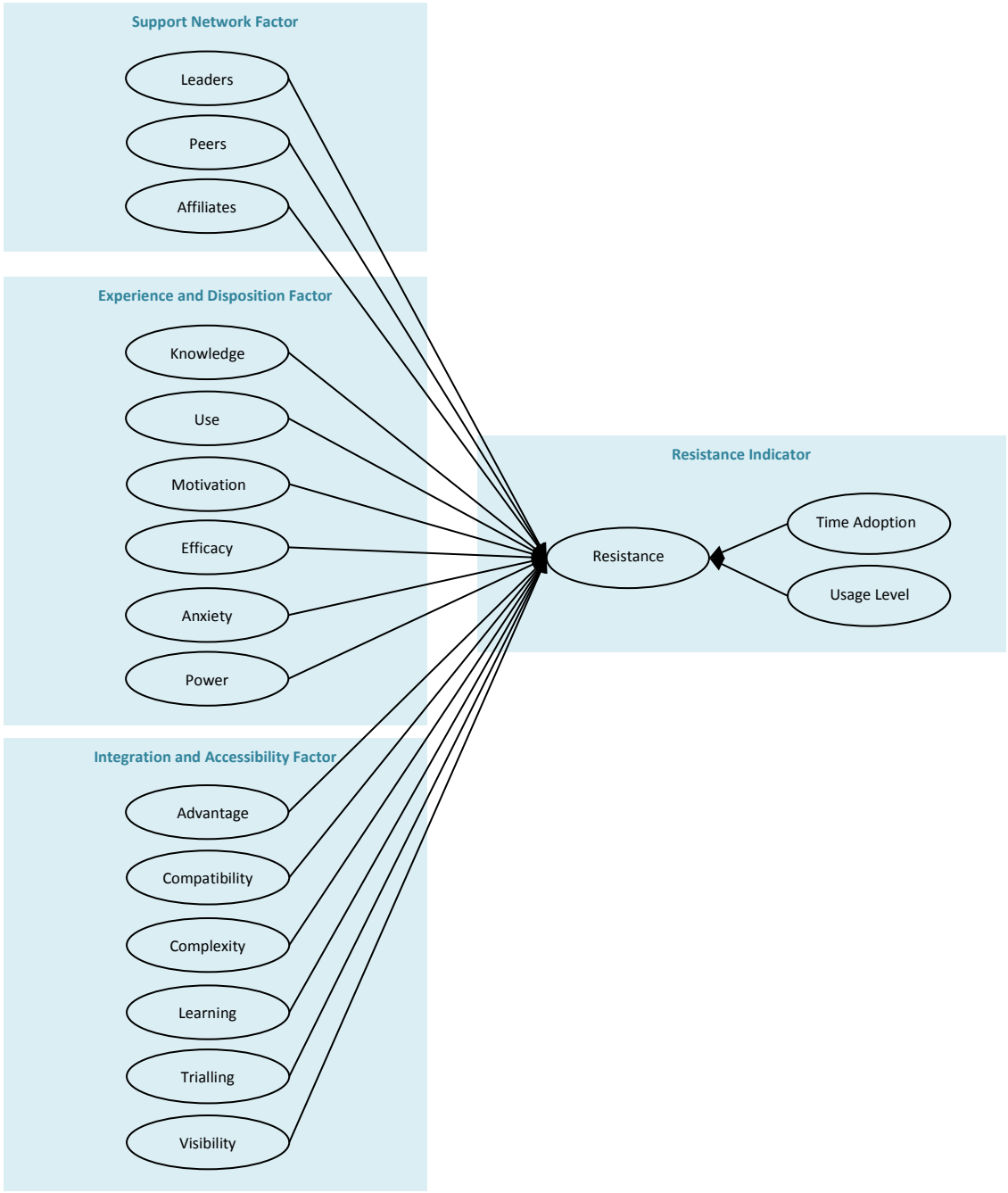

Figure 3.3: Integrated Resistance Factor Model.

Representing the concept of social relationships in the work place, the term support network is proposed. The model includes three constructs forming the support network: (1) leaders, (2) peers and (3) affiliates. A personal network and relationships in the workplace are very important when influencing users to adopt technology (Rogers, 2003; Valente, 1996b; Venkatesh et al., 2003). Leaders, close friends, co-workers or

supervisors also significantly affect beliefs about the use of a technology (Valente & Davis, 1999).

Derived from the psychology perspective and attitude-behaviour theories, an experience and disposition factor is developed. Disposition is best considered a persons' degree of favourableness/unfavourableness with respect to a psychological object. It represents a psychological evaluation of objects as good/bad or pleasant/unpleasant. Disposition also carries the accompanying variables that the model refers to as experience. Six constructs constitute experience and disposition: (1) knowledge of ICTs, (2) use of ICTs, (3) motivation, (4) efficacy, (5) anxiety and (6) power.

An individual's overall perceptions towards an innovation can be determined by the integration and accessibility factor associated with the innovation. The construct of the integration and accessibility factor is primarily based on Rogers (2003), extensive work by Moore and Benbasat (1991) and TAM. Integration includes the inherent characteristics of the technology: (1) relative advantage, (2) compatibility and (3) complexity. These factors are relevant to the operability issues of the technology, which can support individuals to conduct work tasks and enhance working collaborations with others. An accessibility factor is concerned with making technology available for (1) learning, (2) trialling and (3) visibility to users.

All constructs identified in the model are key variables that warrant consideration and testing in an integrated model for predicting resistance. The following sections define and discuss the constructs of the model, the measurement items for each construct and the proposed set of hypotheses for testing. The table in Appendix C details the label, name and brief definition of each construct in the proposed model, and summarises the hypotheses to be tested in the study.

3.2 Resistance Indicators

3.2.1 Time of Adoption

In the DoI literature, time is an important factor influencing an individual's decision process on whether to adopt or reject innovation (Rogers, 2003; Valente, 1996b). Time is used to establish who most needs the benefits of the innovation and who may be last

to adopt an innovation (Rogers, 2003). Time is also a factor in identifying an individual's familiarity with technology and exposure to technology to improve the diffusion process within a social system/network (Valente, 1996b). However, time has not been addressed in the resistance-based literature. Although resistance is broadly understood as caused by multiple factors, it happens at various stages of innovation development (i.e. development, implementation and operation stages) and at different organisational levels (Hirschheim & Newman, 1988; Klaus et al., 2010; Lapointe & Rivard, 2005; Prasad & Prasad, 2000). The impact of the time factor has not been adequately addressed or integrated in any of the current models.

To accommodate the role that timing of adoption has, it is necessary to examine when users choose to adopt the technology relative to when it was first introduced. It can be assumed that delay in adoption is generally a 'signal' that indicates resistance. Individuals in an organisation are typically directed to adopt an innovation by management. However, where those individuals perceive that adopting a technology will not be of benefit to them, even when others in the organisation have already adopted, they can tend to display unfavourable attitudes towards the technology (Joshi, 1991). For example, an organisation may decide to implement an OPIMS based on a top management decision. The length of time taken for adoption across the organisation will vary. Some people within the same organisation can require many years to adopt OPIMS, while others may easily adopt it within just a few months. These differences stem from various causes related to, for example, skills and training, motivation and concern/scepticism over the new technology. It is possible that early adopters might subsequently resist an innovation, needing to spend more time to understand its technical functionality and gain motivation before 'fully' adopting it. Thus, resistance may be dependent on the time of implementation of the innovation in the organisation. For this reason, the first hypothesis was formulated as follows:

> *Hypothesis 1: Resistance towards OPIMS is significantly indicated by time of adoption.*

The following statement will be used to gauge data regarding the time of adoption:

> *How long has it been since you first started using the technology?*

Time of Adoption has been used extensively as the key independent variable to predict adoption of an innovation (Valente & Rogers, 1995). However, this idea has limitations. It is argued that this variable can lead to inaccurate measurement, especially when respondent's recall of time of adoption is used as the measurement of the time dimension (Rogers, 2003). Respondents are usually asked to look back in time to reconstruct their memory about their experience of an innovation. However, people forget the past, and their recall is unlikely to be completely accurate. To overcome this limitation, it is proposed that the time of adoption should not be the only indicator of adoption. Another important variable to determine resistance is the individual usage level of an innovation. This complementary time factor is discussed below, in Section 3.2.2.

3.2.2 Usage Level

TAM is broadly related to both the intention and actual use of technology (Bagozzi, 2007a; Turner et al., 2010). It can be influenced by many factors, including ease of use, advantage, expectation and so on. TAM posits the baseline of the individual's acceptance or rejection of a technology. A second hypothesis is thus developed as follows:

> *Hypothesis 2: Resistance towards OPIMS is significantly indicated by the individual usage level of the technology at work.*

According to Turner et al. (2010), the actual usage of a technology can be measured objectively (from the software itself) or subjectively (based on the opinion of each individual). For example, as an objective measure, log-on data for the software being evaluated can be monitored to measure the overall system usage or record the number of times the software is accessed. A subjective measure of technology use might be self-reported usage measures of the frequency or intensity of using a particular technology. It is also important to be aware that technology is usually advocated to improve working practices in some way (e.g. to increase productivity, quality or timeliness of outcomes). For this reason, measures of technology usage (whether subjective or objective) need to capture the impact of the technology on work performance, generally by using measures

of effectiveness or productivity. With this consideration in mind, and to demonstrate the subjective form of technology usage, the following measure is proposed:

On average, I use the technology for _____ per cent (%) of my working day.

This research does not include an objective measure because of practical issues in accessing actual technology use and/or provision of data. As the research covers a wide range of software and users in large organisations, it is not feasible to retrieve data about log-on time, access and other records. Further, the identity restrictions and privacy policies of the software providers and some organisations constrained the collection of more objective measures.

3.3 Support Network Factors

3.3.1 Leaders

Martinko et al. (1996) proposed that if initially resistant users are exposed to co-workers that have been able to adjust to using a technology easily, then they will come to believe that they too can master the new technology. Conversely, where resistant users see supervisors and co-workers expressing their resistance to the new IT and/or placing blame on it for failures, the resistant user's negative attitudes will be strengthened. A study by Kissi et al. (2012) shows that middle managers have a significant leadership role in fostering innovation. The support and leadership demonstrated by middle management was particularly significant in encouraging championing behaviour towards the implementation of new ideas. Those with leadership responsibility (e.g. supervisors and middle managers) have the biggest influence in persuading users. Supervisor expectations and behaviours regarding technology affect and determine the expectations and behaviours of other users (Valente, 1996b). It follows that leadership behaviour in the workplace directly affects the behaviour and performance of others. For this reason, the following hypothesis is advanced:

Hypothesis 3: A network that consists of support ties from leaders will have a significant influence on resistance.

3.3.2 Peers

People are more likely to want to communicate with others if they share interests or perform similar tasks in similar settings (Granovetter, 1973). The introduction of a new technology can disrupt those common experiences. Where an individual seeks to adopt a new technology and attempts to do things differently, the traditional support network may be insufficient or unable to provide effective support with understanding and dealing with problems. Where a person is able to speak constructively to friends, peers or co-workers about a particular technology, such communication reinforces the positive user belief system and, consequently, innovativeness (Valente, 1996b). In a similar way, the experience and use of technologies outside of one context (e.g. the office, home or school) will influence the use of technology within that context. It is to be expected that a higher intensity of communication with supportive and/or similar users about the technology will lead to greater use and less resistance. This argument leads to the following hypothesis:

Hypothesis 4: Support from peers significantly influences resistance.

3.3.3 Affiliates

The DoI literature stresses the importance of interpersonal communication (word-of-mouth communication) in the diffusion process. For example, when users wish to discuss technical difficulties with others, particularly with more knowledgeable users, information can be more quickly exchanged if they communicate and network together. Communication can be quite intensive in close-knit or immediate groups such as among customer support, technical or admin staff (Rogers, 2003; Valente, 1996b). Those lacking a network or being unable to resolve difficulties alone may not be interested in the technology and may either limit the amount of time spent on the technology or abandon it completely. Hence, the following hypothesis is proposed:

Hypothesis 5: The support network that is formed through relationships with immediate people who are assigned to uncover new technology (i.e. technical staff) significantly influences individual resistance.

3.3.4 Strength of Ties (frequency of communication)

The structure of a network (the ties, relations and/or connections) is built up through the transmission of information and communication (Granovetter, 1973). Ties between people can be determined as being strong, weak or absent. Strong ties are those relationships with high significance (e.g. close friends), weak ties have moderate significance (e.g. acquaintances) and absent ties are relationships with low significance (e.g. minimal communication or contact). However, the 'strength of weak ties' notion (Granovetter, 1973) suggests that a measure of the support network should not ignore weak ties in the metric. One measure for the strength of a tie is the frequency of the communication or contact link between two nodes/actors. Granovetter (1973) proposed the following categories of frequency of communication: often = at least twice a week; occasionally = more than once a year, but less than twice a week; and rarely = once a year or less.

In social network terms, effective adoption of new ideas occurs through the exchange of opinions, exposure to new ideas and the sharing of experiences (Levin & Cross, 2004; Rice & Aydin, 1991; Rice et al., 1990; Valente, 1996b). Such exchange and exposure calls on the unique strength of both weak and strong social ties. While stronger ties may connect a number of individuals in particular ways, some weak ties may connect individuals who are similar in other ways (Granovetter, 1973). For example, Levin and Cross (2004) surveyed 127 mid-level managers from three different sectors who were engaged in knowledge-intensive work and relied heavily on colleagues for information to solve problems and coordinate the work of others. The research shows that weak ties do have a positive and significant effect on the delivery of useful knowledge. However, the process of knowledge transfer via weak ties needs to be predicated on trust. Considering this idea in the context of a technology implementation setting consisting of users with diverse job roles and attitudes, the value of weak ties can also be observed at the individual level in generating aversion or resistance towards new technology.

To capture the essence of a support network that contains both strong and weak ties, and to measure the strength of relationships, a five-point scale with the following labels is proposed: 5 = all the time (several times a day), 4 = most of the time (daily), 3 = some

of the time (once or twice a week), 2 = rarely (once or twice a month), 1 = very rarely and 0 = never.

3.3.5 Ties and Relations in the Workplace

In the literature, it is suggested that network relationships may be very important for technology adoption (Rice et al., 1990), learning (Rice & Aydin, 1991), teamwork (Pryke, 2005) and employee integration in the workplace (Borgatti & Cross, 2003; Krackhardt & Brass, 1994; Krackhardt & Stern, 1988). In organisations, relationships are formed through the accomplishment of tasks, need for technical support, requests for information, and through the need for social activities and friendships. In a situation in which people are focussed on work, they will draw on the option for support or from relationships that are based on expertise (Saint-Charles & Mongeau, 2009). In ambiguous situations, people tend to call for advice from friendships that are built on trust. It follows that the support created by different relationships can be very diverse (Agneessens et al., 2006).

By way of an example, based on a study by Zou and Seo (2006), in most companies, no proper support or training is introduced. Often, new staff are expected to glean sufficient knowledge from informal training conducted by expert peers (e.g. technical staff). Some organisations provide only informal and verbal training, fail to set any minimum time or training requirements, yet still expect that the full system functionality will be mastered after training. Due to ineffective support, learning and training, users more often seek out their immediate and senior peers for assistance. Of course, it is not always possible for peers to spend time training others. Workload pressures can result in these informal roles of teaching others being rejected. Consequently, new users can find that trying to learn to use a technology becomes uncomfortable and stressful, leading them to resist the new technology. The ties and relations within a support network are influential and relevant to the development or displacement of resistance. Based on work by Valente (1996b), Borgatti and Cross (2003), Pryke (2005), Agneessens et al. (2006) and Saint-Charles and Mongeau (2009), critical relations are therefore: (1) work direction, (2) technical assistance, (3) personal strength and weakness and (4) advice using the new technology.

3.3.6 Size of Network (number of individuals in specific network)

The concentration within a given network of relevant/empowered people that could improve adoption and reduce resistance is an important focus. The presumption is that the likelihood of adoption is increased as the proportion (or number) of users in a personal network increases (Valente, 1996b). Network sizes are assumed to vary and members in the network should be randomly selected to determine their relevance and status.

The instrument of choice for collecting data on network membership is the 'name generator' instrument (Campbell & Lee, 1991; Marsden, 1987). This instrument includes questions to identify the others in a given network and to obtain information about the relations between the individual and each of the others. The individual of interest is referred to as the 'ego'. Others in the network, refer to by the ego as leaders, peers and affiliates, are known as 'alters'. An example of a name generator instrument by Straits (2000) focusses on alters with whom respondents 'discuss important matters'. In Hirsch (1980), the Social Network List asks respondents to list up to 20 persons that they regard as 'significant' and have seen during the prior 4–6 weeks. Another example is the Social Support Questionnaire (SSQ) by Sarason et al. (1983), in which a 27-generator instrument is used to elicit alters to whom respondents can turn and on whom they can rely in certain circumstances.

3.3.7 Name Generator Instrument

The focus of this thesis is on the relationships (i.e. direction, technical assistance, personal strength and weakness, and advice about the use of technology) on which personal networks are built. Such alters may include friends and experts that the ego accesses because they are perceived by the ego as having the necessary expertise and/or proximity to advise on or relate to the technology. Details on the instrument and scales used in the research for collecting information regarding support networks are given in Table 3.1. Firstly, respondents are asked with whom they have significant communication at work. Use of the term 'significant communication' has been demonstrated elsewhere to elicit names of people with whom respondents have strong

personal relationships (Bailey & Marsden, 1999; Straits, 2000). The format of this instrument was designed as recommended by Vehovar et al. (2008).

To be comprehensive, respondents were also asked to identify as many others with whom they communicate as possible. No limits are placed on the number of people, or network size, that the respondent should recall (Killworth et al., 1990). Inevitably, network size will vary depending on the recall of the data. The accuracy and sensitivity of the name generator instrument has also been shown to be influenced by the respondent's mood (Hlebec & Ferligoj, 2001). Typically, however, respondents tend to name more than five persons (Marsden, 1987). Merluzzi and Burt (2013) believed that five names is a practical number because recording additional names can lead to redundancy. Lists beyond five names are expected to be 60–70 per cent redundant and can be a burden on respondents. Manfreda et al. (2004) found that respondents named an average of between only 7–8 persons, despite their study providing space for up to 30 names. Elsewhere, Gerich and Lehner (2006) obtained an average network size of 6–7. Considering practical aspects and cost effectiveness, and in line with some recommendations from previous studies, the instrument used in this thesis includes the option to list up to 10 names/others, with an indication that at least seven people should be identified.

To guarantee information privacy, this research instrument does not include any named individuals. Rather, respondents are required to identify only the job description for each person. Job position was then categorised and coded as 1 = Management (those with higher-level management responsibilities), 2 = Immediate Supervisor/Manager, 3 = Related Professional (e.g. Architect, Project Manager, Engineer, Quantity Surveyor) and so on.

Respondents are then asked to rate the communication they have with each identified person on a scale of 0 to 5 (where 0 = never, and 5 = all the time). The conversation can relate to the direction of the job, technical assistance while on the job, personal strengths and weaknesses, or advice in using the OPIMS technology.

Table 3.1: Support network name generator instrument.

List all people with whom you have significant communication related to your current work. *Please specify at least seven (7) people with whom you have relatively frequent or significant communications.*	**Job position**	**On average, how often have you received direction on how to do your job from this person?**	**On average, how often would you seek or get technical assistance to undertake your work from this person?**	**On average, how often would you have discussed your personal strengths and weaknesses specific to your work with this person?**	**On average, how often would you have discussed the use of OPIMS with this person?**
Person 1					
Person 2					
Person 3					
Person 4					
Person 5					
Person 6					
Person 7					
Person 8					
Person 9					
Person 10					
Categories of job position: 1 = Management (those with higher-level management responsibilities) 2 = Immediate Supervisor/Manager 3 = Related Professional (e.g. Architect, Project Manager, Engineer, Quantity Surveyor) 4 = Technical Colleague (e.g. CAD Operator, ICT Support Person) 5 = Construction Worker (e.g. Onsite Tradesperson, Foremen, Sub-contractor) 6 = Administrative Staff (e.g. Office Assistance, Secretary, HR person) 7 = Local Peers (Other students/cadets/graduates in a similar role WITHIN the same organisation) 8 = Other Peers (Other students/cadets/graduates in different organisation) 9 = None of the above					
Scales for frequency of communication: 5 = All the time (several times a day) 4 = Most of the time (daily) 3 = Some of the time (once or twice a week) 2 = Rarely (once or twice a month) 1 = Very rarely 0 = Never					

3.4 Experience and Disposition Factors

3.4.1 General Knowledge of ICTs

Theories and empirical evidence demonstrate that there is a positive relationship between experiences and the use of technology (Fishbein & Ajzen, 2005; Igbaria & Iivari, 1995; Liao & Lu, 2008; Peansupap & Walker, 2006b; Thompson et al., 1994). Thompson et al. (1994) tested the relationship between computer experiences and utilisation, along with the presence of indirect effects mediated by several intervening variables (e.g. job-fit, long-term use and facilitating conditions). The findings of Thompson et al. (1994) suggest that system experience is positively related to each individual's perceived ease of use and to increased utilisation of the system. Findings from a study by Liao and Lu (2008) suggest that prior experience can change the intention to adopt or continue to use an innovation. The technology adoption of learners with prior e-learning experience is different from those without e-learning experience. The perceived relative advantage, compatibility and image factor are higher for those with prior experience of using e-learning websites, which positively affects the intention to adopt. In this light, the following hypothesis is proposed:

> *Hypothesis 6: General knowledge of ICT-related technologies significantly influences an individual's resistance towards OPIMS.*

In this thesis, General Knowledge of ICT-related technologies is defined as the level of exposure and familiarity a person has with a broad range of ICT-related technologies. ICT refers to information and communication technologies such as desktop and laptop computers, and intelligent hand-held devices such as the iPad and iPhone. It also includes applications such as the World Wide Web, Facebook and Google. To adequately measure general knowledge requires that several additional items be formulated, as follows:

i. *I have an excellent understanding of how to use and apply ICT effectively.*
ii. *I can see clear advantages from using ICT in my work.*
iii. *My skill in using ICT at work is well above average.*

3.4.2 Use of ICTs

Group and individual user knowledge and skills play a key role in understanding how best to deploy ICT applications (Peansupap and Walker (2006b). Users with just basic computer skills typically develop an understanding of any given ICT application faster than those who lack such skills. Even a rudimentary understanding appears to relieve the demands on new users and helps them to increase their absorptive capacity when learning. Basic computer skills and background also appears to influence the use of an ICT application. Indeed, generally, adoption and use of technology varies with experience, both direct and indirect (Mao and Palvia, 2005). Direct experience is gained through using the target technology, while indirect experience involves working with or experiencing a similar technology. Taking the broad influence of ICT use as a potential influence on resistance to a specific innovation, the following hypothesis is proposed:

> *Hypothesis 7: General use of ICT technology at work significantly influences resistance towards OPIMS.*

Use of ICT technology is defined in terms of literacy specific to a particular use of ICT for work-related purposes. In the context of OPIMS, this includes technology used for communication and collaboration. The measurement items to test this hypothesis were formulated as follows:

i. *I use ICT to communicate, manage and coordinate work with my immediate work team within the organisation.*
ii. *I use ICT to communicate, manage and coordinate work with external organisations (e.g. project teams, consultant and clients).*
iii. *How frequently would each of the following technologies be used by you at work for work-related purposes? Please refer to Attachment A.*

Attachment A: ICT tools at work

ICT Tool's Name	*5 = Several times a day*	*4 = Daily*	*3 = Once or twice a week*	*2 = Once or twice a month*	*1 = Very rarely*	*0 = Never*
Electronic Calendar (e.g. MS Outlook Agenda)						
Email						
Facsimile						
Instant Messenger Service (IMS)						
Mobile Computing (PDA/Smart Phone/PC Tablet)						
Mobile Phone						
Organisation's Own Intranet System						
Pager						
Radio Transceiver (Walkie Talkie)						
Short Message Service (SMS/Text)						
Telephone (Landline)						
Telephone-conferencing						
Video conferencing (e.g. Skype)						
World Wide Web in General						

3.4.3 Motivation

Motivation is one of the main forces for individuals to resist or accept new ideas. Prior research has shown that motivation is one of the key determinants of behavioural intention to use technology (Davis et al., 1992; Hartmann, 2006; Hartmann & Fischer, 2009; Venkatesh et al., 2003). Employees are only motivated to go beyond their designated role and get involved with innovative activities if they have a strong identification with the organisation (Hartmann, 2006). Commitment and motivation require that management induces and reinforces several actions, including recognition (intrinsic and extrinsic rewards) and participation (Davis et al., 1992; Hartmann, 2006). Employee motivation can be gained through pay rises, fringe benefits, work autonomy,

job enlargement, flexible working conditions and so on. The following hypothesis is formulated to address the influence of user motivation on resistance towards using OPIMS:

Hypothesis 8: Motivation will have a significant influence on resistance.

Motivation is defined in terms of the interests and drivers for users, as they perceive them, which increase adoption/decrease resistance. Motivation is measured using the following items:

i. *I use OPIMS in my work because I believe it is a requirement of the organisation.*
ii. *I use OPIMS in my work because I find it is a requirement of my work.*
iii. *I use OPIMS because of the intangible rewards I get from work (enjoyment, satisfaction, etc.).*
iv. *I use OPIMS because of the tangible rewards I get from my work (job security, advancement, new skills, etc.).*

3.4.4 Efficacy

Self-efficacy involves personal judgement as a key factor in the use of a particular technology to accomplish a particular job or task. There is strong evidence that self-efficacy plays a key role in the decision to use computers (Compeau & Higgins, 1995b; Hasan, 2006; Hsu et al., 2009; Igbaria & Iivari, 1995). Indeed, self-efficacy judgements have significant influence on the emotional and cognitive responses of individuals in general (Compeau & Higgins, 1995b). Individuals tend to prefer and enjoy behaviours that they feel capable of performing, and dislike those they do not feel they can successfully master. Efficacy has significant direct and indirect effects on computer usage. Hence, the following hypothesis is proposed:

Hypothesis 9: Efficacy significantly influences an individual's resistance towards OPIMS.

Efficacy is defined as the level of confidence an individual expresses in the use of OPIMS for their work. Based on the above hypothesis, the research posits the following items:

i. *I am confident in my ability to use OPIMS to complete a range of tasks related to my work.*
ii. *I am confident in my ability to find useful help should a problem arise in using OPIMS for my work.*

3.4.5 Anxiety

Anxiety about using technology has been suggested as a possible explanation for the tendency of some users to avoid direct involvement with it. Broadly, anxiety towards ICT is defined as the fears, apprehension and hope people feel when considering its use or actually using computer technology (Hsu et al., 2009; Igbaria & Chakrabarti, 1990; Kay, 1993). More specific is the notion of computer anxiety (Igbaria and Chakrabarti (1990), which leads to confusion on the part of the individual, causing unease, apprehension and phobia towards current or future use of technology. Computer anxiety is strongly linked to avoidance tendencies relative to any new ICT technology (Chua et al., 1999; Hsu et al., 2009; Meutera et al., 2003). For example, one study found that customers who were uncomfortable and hesitant about using one's self-service technology also had issues with any equivalent self-service technology (Meutera et al., 2003). Self-service technologies in that context included automatic teller machines, internet information searches, phone banking and internet shopping. To explore this issue within the OPIMS context, the following hypothesis is proposed:

> *Hypothesis 10: Feelings of strong anxiety or uncertainties related to the use of OPIMS will significantly influence resistance.*

Anxiety is defined as the level of apprehension and hesitation in the use of OPIMS for work. This hypothesis will be tested using measures as follows:

i. *It concerns me that I could lose a lot of important information using the OPIMS should I make a mistake.*
ii. *I try to avoid using OPIMS in my work because the information it contains is so critical to the organisation.*

3.4.6 Interpersonal Power

Adoption of a new technology can be used by employers as a measure of self-improvement, but it can also improve how a person is perceived more generally in terms of their image and interpersonal relationships (Moore & Benbasat, 1991; Rogers, 2003; Venkatesh et al., 2003). People who use new technology tend to experience more prestige and a higher profile and status than those who do not (Moore & Benbasat, 1991). Hence, the following hypothesis is proposed:

> *Hypothesis 11: Interpersonal power will significantly influence an individual's resistance to OPIMS.*

Interpersonal power is defined as the subjective qualities an individual gains from the use of technology at work. As interpersonal power is to be measured elsewhere using self-reported information; against this hypothesis, it is distinguished as 'perceived' interpersonal power. The following items were included:

i. *Using OPIMS effectively is an important factor if I want to work in this industry in the future.*
ii. *Knowing how to use the OPIMS is an important factor for getting people in this organisation to take you seriously.*

All items proposed within Section 3.4 are measured based on a five-point Likert-type scale. The justification of using a five-point scale will be further discussed in Chapter 4. Sentences and wording for all of the items were subsequently modified slightly to decrease the length of the questions and to improve the overall design. A copy of the complete questionnaire is included in Appendix E.

3.5 Integration and Accessibility

3.5.1 Perceived Advantage

Theory suggests that better relative advantage and benefit in one's job means better adoption will be achieved (Moore & Benbasat, 1991; Rogers, 2003). In some research, the advantage or perceived usefulness of a technology remains one of the most significant factors to its adoption. For example, in a study of mobile computing in

construction, it was found that the perceived usefulness of the technology by construction professionals was more significant than how easy the technology was to use (Son et al., 2012). If greater perceived relative advantage of a technology reduces resistance to that technology, then the following hypothesis can be proposed:

> *Hypothesis 12: Perceived advantage towards use of OPIMS significantly influences an individual's resistance towards OPIMS.*

Modified from Moore and Benbasat (1991) and Rogers (2003), this thesis proposes the construct of 'perceived' advantage. This is defined as the extent to which an OPIMS user believes that the technology complements their work. The following items will indicate the construct:

i. *Using OPIMS makes me productive.*
ii. *Using OPIMS gives me greater control over the work I do.*
iii. *Using OPIMS improves the quality of the work I do.*

3.5.2 Compatibility

Similar to perceived advantage, compatibility is a consistently significant factor that influences adoption. Technology that is incompatible with the employee's work task will frustrate the user and cause a negative reaction (Liao & Lu, 2008). If the technology fails to perform reliably and does not meet the expectations of a user, the technology will be used less frequently and put to less use than originally intended (Rogers, 2003). It is therefore expected that the compatibility factor will become significant in predicting resistance.

> *Hypothesis 13: Compatibility of the OPIMS with work tasks significantly influences resistance.*

In this thesis, Compatibility refers to the extent to which an OPIMS user believes that the technology suits, and is well integrated with, the work they do. Items for measuring this construct are:

i. *The OPIMS provides a good fit with my current work practices and requirements.*

ii. *The OPIMS allows full compatibility with other systems and software required for my work.*

3.5.3 Complexity

This factor remains a principal obstacle to the acceptance of technologies, and its impact has been demonstrated in a number of studies (Davis et al., 1989; Meutera et al., 2003; Thompson et al., 1991; Venkatesh et al., 2003). In the study of mobile computing devices, users were more influenced by usefulness attributes than by ease of use (Son et al., 2012). However, in some situations, adoption is a combination of the usefulness factor and ease of use. When the use of technology is perceived to bring an improvement to work productivity and is relatively effortless, users are likely to develop a positive attitude towards its use (Teo, 2011). The level of complexity, in terms of how difficult a technology is to use, is shown to moderate resistance. Thus, the following hypothesis is proposed:

Hypothesis14: How complex the technology is perceived to be will significantly influence resistance towards OPIMS.

Complexity is defined in terms of how a user views the degree of difficulty involved in applying OPIMS in their work. Complexity is to be measured by the following items:

i. *Interacting with the OPIMS is clear and intuitive.*
ii. *Overall, I find the OPIMS easy to use.*

3.5.4 Learning

In the literature, the concept of learning has also been linked with knowledge sharing and training among users (Abrahamse & Lotriet, 2012; Love et al., 2001; Peansupap, 2004). Learning and training can either strengthen or weaken the innovation process. Learning is about knowledge transfer: in this context, between experienced users that have already adopted and use the technology and inexperienced users. A lack of employee knowledge has been shown to be the main barrier to e-commerce implementation in construction organisations (Love et al., 2001). Peansupap (2004) has also associated the learning concept with innovation theory. Inadequate employee knowledge and management's lack of experience in ICT have been identified as

potential causal factors leading to user resistance (Peansupap, 2004). To test this proposition, the following hypothesis is included:

> *Hypothesis15: Inadequate learning in developing competency on OPIMS significantly influences resistance behaviour.*

The Learning construct is defined as the adequacy of learning and training received by users at work to use the OPIMS effectively. Adequacy of learning and training is measured through user perception of the quality and time provided for training:

i. *The quality of the learning and training that I have received in OPIMS is very good.*
ii. *The time and opportunity provided for me to learn how to make effective use of the OPIMS in my work is sufficient.*

3.5.5 Trialling

Trialability is the degree to which an innovation can be experimented with or used on a trial basis before full implementation (Rogers, 2003). Hands-on experience gained through trial use and training may help to reduce uncertainty and create favourable user perceptions (Meutera et al., 2003; Venkatesh, 1999; Venkatesh et al., 2011). For example, governments increasingly offer a trial use of technologies to enable citizens to access government electronic services (e-government) before they are deployed (Venkatesh et al., 2011). The benefit of such a trial is that citizens get more involved in the development process and gain hands-on experience. Such experience improves their knowledge of the technology and enhances the quality of user evaluation, particularly as regards the potential consequences of adopting the technology. Therefore, the trial use of technologies provides an opportunity for agencies to gather feedback from users before implementation. In this light, the following hypothesis is proposed:

> *Hypothesis 16: Opportunities to trial the OPIMS before using it will significantly influence resistance behaviour.*

Trialling is defined as the degree to which a user has had opportunities to use the OPIMS system prior to it being formally implemented. The items below are proposed to measure trialling:

i. *I was permitted to use OPIMS on a trial basis.*
ii. *I have had ample opportunity to use OPIMS during a trial period.*

3.5.6 Visibility

Visibility is where both potential and current adopters are able to observe others using the technology in the organisation (Moore and Benbasat, 1991). This is important as a demonstration that the technology is being used. Also of significance is the degree to which the results of innovation are visible to others (Rogers, 2003). This is important as a demonstration that the technology is of benefit. In virtual team collaboration (e.g. video conferencing), when social cues become visible, team members become aware of each other's actions and presence and adjust their own actions accordingly (Bjørn & Ngwenyama, 2009). General exposure to a technology within the workplace appears to promote technology transfer across the industry, organisation and project team. Presenting users with the opportunity to see the technology's progress has the potential to change user perceptions and resistance. Thus, the final hypothesis is proposed as:

Hypothesis 17: Visibility of the use of OPIMS at work will significantly influence resistance behaviour.

Visibility is defined as the degree to which the OPIMS has become familiar to a user through observing its use by others. This construct will be measured by the following items:

i. *I have had an opportunity to see OPIMS being used by others in the construction industry.*
ii. *I have seen that the use of OPIMS in my organisation is widespread.*
iii. *My perception is that most of the key people in this organisation are active users of OPIMS.*

3.6 Summary

This chapter presented the theoretical framework of the research and developed an IRFM. The IRFM draws on concepts and theories from resistance research, social network, attitude and the behavioural and technological fields. A comprehensive review

of the IRFM defined all of the constructs comprising the model and proposed a set of hypotheses. For each hypothesis, specific measurement items were identified. The table in Appendix C gives the label, name and brief definition for each construct in the proposed model. The constructs are categorised under six key constructs: resistance indicators, support network, experience, disposition, integration and accessibility. Appendix C summarises the proposed hypotheses categorised by key construct. The following chapter discusses the methodology used to collect the data and the techniques used to estimate the final model configuration.

Chapter 4: Methodology

This chapter discusses and defends the methodology chosen for this thesis. It explains why a sequential mixed methods approach was deemed appropriate for the purpose of this research, and what the strengths and weaknesses of the approach are in the context of this thesis. The chapter is also structured to present a detailed explanation of each process and phase of the research. Phase 1 of the research comprises the literature study and theoretical background to the work. This concluded with the development of the research model. Phase 2 of the research is a pilot study. The purpose of the pilot study is to test the survey instrument before conducting the main data collection exercise. Phase 3 comprises a questionnaire survey. The data gathered in Phase 3 is analysed using PLS of SEM techniques. The findings from Phase 3 will be verified from the interview results obtained in Phase 4.

4.1 Research Strategy and Design

4.1.1 Ontology, Epistemology and Methodology of Research

It is important to recognise that there is no single or accepted way of doing research. How research is conducted depends on a range of factors including the researcher's belief about the nature of the social world and what can be known about it (ontology), his or her belief about the nature of knowledge and how it can be acquired (epistemology), the purposes and goals of the research, the characteristics of the research participants, the position and the resources available (Crotty, 1998). Ontology is the branch of philosophy that deals with the nature of being or what exists. The word ontology has been used in many different ways, but the most common is to refer to the 'the study of being' (Blaikie, 1993: 6; Crotty, 1998: 10–11). In a social science context, ontology refers to the claims or assumptions that a particular approach to social enquiry makes about the nature of social reality (Blaikie, 1993: 6; Guba, 1990: 18; Guba & Lincoln, 1994: 108). The philosophy or paradigms that emerged as related to ontology are realism, critical realism and relativism (Blaikie, 1993; Crotty, 1998; Guba, 1990). However, as Crotty (1998) stated, although it is important to highlight the ontological matters, these are not as essential as the epistemological matters, which tend to emerge at the same time. Crotty (1998) argues that the researcher's assumptions about ontology

predicate those on epistemology and methodology. For example, realism is a belief that 'reality' is driven by immutable natural laws and mechanisms (Guba & Lincoln, 1994). The aim of a realist is to predict, control and solve the phenomena/problem under study. This is often taken to imply objectivism in epistemology, suggesting the use of experimental or manipulative methodologies that permit the adoption of quantitative methods such as surveys (Crotty, 1998). Objectivism is also compatible with the epistemological position of constructionism, and qualitative methods such as interviews, focus groups and field observations can be applied (Crotty, 1998).

Epistemology 'is concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can unsure that they are both adequate and legitimate' (Maynard, 1994, p.10 cited in Crotty, 1998, p.8). It focusses on how we know what we know and on identifying the most valid ways to reach truth (Neuman, 2011). Crotty (1998) suggested that researchers can hold three epistemological positions: objectivism, subjectivism and constructionism. Objectivism assumes that knowledge about reality is objectively given and can be measured. Knowledge exists whether we are conscious of it or not. Researchers hold this position often when trying to find cause-effects and explanations, predict events and test theories and hypotheses. Subjectivism and constructivism are contrary to objectivism. Subjectivism involves understanding specific events based on the researcher's self-understanding. Constructivism holds that people construct knowledge and understanding in different ways; knowledge is obtained by researchers interacting with events and individuals within events. A constructivist tends to combine objectivity and subjectivity in their enquiry to generate knowledge.

In addition to the perspectives as identified by Crotty, the social science literature describes the epistemological stances of post-positivism, pragmatism and emancipator (Creswell, 2003). As shown in Table 4.1, according to Creswell (2003), researchers taking the post-positivist stance develop knowledge using a quantitative approach, which is focussed on precisely measuring variables and testing hypotheses. Researchers focus on quantifications in data collection and analysis, employ methods such as experiments and survey questionnaires and collect statistical data with predetermined

instruments. In addition, they tend to use large data samples to inform reliable and valid results that represent the population under study.

Table 4.1: Four alternative combinations of knowledge claims, strategies of inquiry and methods.

Research Approach	Knowledge Stances	Strategy of Inquiry	Methods
Quantitative	Post-positivist assumptions	Experimental design	Measuring attitudes, rating behaviours
Qualitative	Constructivist assumptions	Ethnographic design	Field observations
Qualitative	Emancipator assumptions	Narrative design	Open-ended interviewing
Mixed methods	Pragmatic assumptions	Mixed methods design	Closed-ended measures, open-ended observations

Adapted from Creswell (2003, p. 18)

By contrast, constructivists and emancipators use the qualitative approach. Constructivists develop theories and knowledge by using multiple meanings of individual experiences, which are socially and historically constructed. The emancipator does the same, but also pursues advocacy/participatory perspectives (i.e. political, issues-oriented, collaborative or change-oriented). Constructivists and emancipators might use a research strategy that is based on narrative, phenomenology, ethnography, grounded study or case study design. The methods surrounding these research strategies include open-ended questions, interviews and text analysis.

It is also possible to combine methodologies into a mixed methods approach. Commonly, mixed methods researchers base their epistemological stances on pragmatism, in which multiple types of data provide a comprehensive understanding of the phenomena/problem under study, potentially solving it (Creswell, 2003; Tashakkori & Teddlie, 1998). Mixed methods is also believed useful in the validation of findings process (Campbell & Fiske, 1959; Johnson et al., 2007).

There are three common research approaches adopted in social research: (1) qualitative, (2) quantitative and (3) mixed methods (see Table 4.1). Each of these approaches has its own epistemological position, strategy of inquiry and methods. For this thesis, the mixed methods approach was deemed appropriate. This is because resistance towards innovation is explicable; it was believed to exist naturally in the social world. In addition, resistance was assumed to arise from a wide range of factors related to the

individual, and as knowledge about what influences resistance to technology adoption is lacking (as discussed in Chapters 1 and 2), knowledge should be developed through comprehensive means using both quantitative and qualitative methods. This research proposed that a single research approach could potentially miss important explanations of resistance. Thus, a new theory on resistance was explored using a combination of quantitative and qualitative methods, which focussed on understanding the views of users in relation to their involvement with OPIMS technology. The knowledge generated not only led to the development of a model, but also allowed for recommendations to be made regarding how to overcome resistance. Section 4.1.2 will further explain the mixed methods approach and design of the research.

4.1.2 Choosing the Mixed Methods Approach

Mixed methods uses qualitative and quantitative viewpoints, data collection, analysis and inference techniques for the broad purposes of breadth and depth of understanding and corroboration (Johnson et al., 2007). Two epistemological stances have been identified as underlying the mixed methods approach: pragmatism (as mentioned in Section 4.1.1) and the transformative-emancipatory paradigm. The transformative-emancipatory stance was proposed by Mertens (2003), and relates to the study of the lives and experiences of marginalised groups who suffer oppression and discrimination. The ontological view of this paradigm describes reality within a historical, political, cultural and economic context. The transformative-emancipatory paradigm holds that interaction between the researcher and participants is essential and requires a level of trust and understanding to accurately represent the viewpoints of all groups fairly (Mertens, 2003).

In the literature, a number of researchers have linked mixed methods with pragmatism (Creswell, 2003; Johnson & Onwuegbuzie, 2004; Maxcy, 2003; Morgan, 2007; Tashakkori & Teddlie, 1998). According to Creswell (2003), pragmatists believe in both objective and subjective facts. They believe that the external world is independent of the mind, and that subjective truth is lodged in the mind. For pragmatists, truth is anything that is considered as working at the time, and this puts the emphasis on what works to solve research problems (Morgan, 2007). Pragmatism also emphasises solving the research problem (Tashakkori & Teddlie, 1998). Pragmatists believe that the

practicalities of research cannot be driven by theory or data exclusively. The research questions/problems define a good research study, rather than only the selected method itself. Using this approach, the weaknesses of one method are offset by the strengths of another (Jick, 1979). A recent study by Teye (2012) stated that mixed methods helps the researcher to broaden the dimension of the study. The researcher is able to gather different views from research participants. In Teye's study, quantitative data from the questionnaire survey were useful in areas in which rates, percentages and charts were necessary for showing the patterns of the research problem. Conversely, the qualitative interviews and focus group discussions were useful for understanding the underlying reasons for the observed patterns. In this study, quantitative and qualitative methods were used to complement each other, to improve the validity of the findings. The central premise of pragmatism is that the combination of qualitative and quantitative approaches may provide a better understanding of a research problem and complex phenomena than either approach alone (Molina-Azorı´n, 2011).

Although it is evident that a mixed methods approach offers significant value, there have been criticisms, limitations and barriers for its practice (Bazeley, 2004; Bergman, 2011; Bryman, 2007; Cameron, 2009; Creswell, 2011; Mingers, 2001; Onwuegbuzie & Collins, 2007; Teddlie & Tashakkori, 2003, 2010, 2011; Teye, 2012). Some of the criticisms relate to the incompatibility thesis or paradigmatic foundations, by 'methodological purists' (Creswell & Plano Clark, 2007). Methodological purists argue against the combination of quantitative and qualitative approaches, due to what they believe are the very different ontological and epistemological origins of the quantitative and qualitative methods (Creswell & Plano Clark, 2007). However, Howe (1988) suggests that researchers should adopt a pragmatic approach and use 'what works' for the research.

There is also a problem of representation, integration and legitimation in mixed methods research. Onwuegbuzie and Johnson (2006) state that, because mixed research involves combining the complementary strengths and offsetting the weaknesses of the quantitative and qualitative research methods, assessing the validity of findings can be particularly complex. Cameron (2009) identified design, analytical and display issues in sequential mixed methods research, and found that mixed methods can lead to a

complex blend of data and analysis across different data collection points. Other important barriers to conducting a mixed methods research approach are timing, resources and researcher proficiency. Ivankova et al. (2006) also identify that sequential studies have drawbacks, as it may take considerable time and resources to undertake the distinct phases of a study.

Conducting a mixed methods study is not easy. It requires an advanced set of skills related to both qualitative and quantitative methods. Teddlie and Tashakkori (2003, p. 45) referred to the need for mixed methods researchers to be 'methodologically bilingual'—having skills in both quantitative and qualitative research methods. A researcher should at least have a sufficient knowledge of both quantitative and qualitative methods independently, and how to mix these methods appropriately to achieve good study outcomes.

4.1.3 Mixed Methods Research Design

Mixed methods research can be conducted for various purposes, such as knowledge enrichment, improvement of an instrument and integrity (Collins et al., 2006). Greene et al. (1989) suggested that mixed methods are typically used for the purposes of:

a) Complementarity (seeking elaboration, illustration, enhancement and clarification of the results from one method with the findings from another method).
b) Development (when the researcher uses the results from one method to help develop or inform the use of another method).
c) Initiation (discovering paradoxes and contradictions that lead to the research questions being reframed).
d) Expansion (seeking to extend the breadth and range of inquiry by using different methods for different inquiry components).

For this thesis, the purpose of using mixed methods is to determine the nature of the resistance problem, answer the research questions and keep within the time, position and resources available to the research, and develop robust study outcomes. How mixed methods achieve these purposes will be discussed in more detail in the following sections.

4.1.3.1 Nature of Resistance and Exploring the Issue

In construction organisations, for employees to adopt and use new technology, it must first gain an implementation commitment from the higher management. This involves many individuals, or technology champions, including the manager, technical staff and the technology provider. From these individuals, the adoption process diffuses to the targeted users or adopters. Acceptance or resistance towards adoption of a new technology depends on the implementation strategy and the training used by technology champions in passing the required operating skills and knowledge on to the targeted adopters, who should in turn become the effective end users.

However, the technology champions, implementation strategy and training do not alone ensure that the new technology will be successfully used by the targeted adopters. The relationship between architectural, engineering and construction firms and other organisations in the construction industry is highly fragmented. This creates additional complexities for the use of technology, which consequently involves a number of different potential adopters in different professions (e.g. architects, surveyors, contractors and engineers). Every one of these professionals has different needs and requirements for the technology they are using at work. This is of some concern to the project management. Resistance to the technology implemented to manage the project information flow and exchange cannot be controlled.

Robust research is needed to explain why some technology is rejected, despite having well understood benefits. This lack of success is not only related to the technical aspects of the technology; the behaviour, experience and social relationships of those championing and using the technology also needs to be investigated. Ongoing support and training is another important mechanism for the acceptance of new technology to ensure it will be effective in the long term. From the literature, technology champions are recognised as being responsible for repeating training received. Some organisations do not have the resources or time to spare for this important transfer of information and skills.

This thesis was designed to be exploratory in nature. Exploratory research aims to discover new insights or ask new questions about an issue. It uncovers facts about a

certain subject or setting (Babbie, 2013). The goal is to discover as much as possible about the general topic and then develop propositions or hypotheses that can be examined at a later date. For this thesis, which aims to identify the factors behind resistance to a new technology, the pursuit of purely exploratory methods is suitable. This style of method can pose and answer questions on why some but not other factors cause resistance and, more generally, why resistance occurs. The explanatory phase is important, as it can establish the relationships, causal orders and connections between the variables in the hypotheses of the problem. Moreover, this phase allows a broad and comprehensive illustration of the research problem. Using an exploratory strategy, there is no need to rigorously test hypotheses and explain the modelled causal relationships.

4.1.3.2 Solving the Research Problem

The research aimed to contribute a solution to the research problem, which was to identify the factors that influence individual resistance towards a new technology (OPIMS) and make basic recommendations on how to overcome resistance. As outlined in Table 4.1, a wide range of research strategies and methods are available to answer various research questions/problems. A mixed methods approach could have a combination of survey, interview and field observation. Field observation, for instance, could answer questions on how users of technology experience adoption of that technology, conducted through interacting with and engaging in conversations with informants. Survey questionnaires are largely conducted for the estimation of scenarios (e.g. demographics of a population) and hypothesis testing. For hypothesis testing, surveys are used to measure hypotheses using a numerical rating scale (e.g. Likert's scale), and subsequently manipulating the data using statistical software, likely including correlation and/or causality analysis. An in-depth survey generally attempts to obtain detailed evidence from a relatively small number of informants through a series of interviews.

To identify the critical factors that influence individual resistance towards a new technology, one of the objectives of this research is to test and confirm the significant variables and relationships of the proposed resistance factor model. This requires a naturalistic research design, incorporating both quantitative and qualitative research data. Qualitative data are expected to complement the quantitative data, to illuminate the

underlying reasons for resistance to using new technology. The use of a closed-ended questionnaire can provide a precise indication of resistance factors, so a survey questionnaire is appropriate for this research. However, this kind of data lacks details and 'authenticity'. Thus, to complement the survey questionnaire, in-depth interviews with participants are conducted after the questionnaires (with those participants that have agreed to take part in the interview). Using this additional qualitative data, which was volunteered by survey respondents, enables general reflection on the limitations of the survey questions. This helps to qualify, validate and interpret the findings, as well as the conclusions from the whole of the research (Morell & Tan, 2009). Using mixed methods research as part of the validation process can ensure that the result of the research is not due to the method, but instead is the true findings of the research (Campbell & Fiske, 1959; Johnson et al., 2007).

4.1.3.3 Timing of Research: Sequential

The researcher must make a decision regarding whether the quantitative and qualitative study sections should follow in sequence (one following another) or be conducted concurrently/in parallel (Ivankova et al., 2006; Tashakkori & Teddlie, 1998). Concurrent timing requires quantitative and qualitative data to be collected, analysed and interpreted at approximately the same time. Conversely, sequential mixed methods collect data over two distinct phases, collecting one type of data before another. According to Ivankova et al. (2006), sequential design is the most common approach in mixed methods research. Usually, in a sequential mixed-method study, the researcher will use a questionnaire and then interviews to obtain a more detailed understanding of the results (Bryman, 2006). As the sequential order uses the qualitative data to complement the quantitative data, the results from the first phase can be said to support the later phase.

For this research, a sequential mixed-method research design is ideal. The sequential mixed method is adopted due to both the nature of the research problem and question, and the availability of participants. The mixed methods sequential design in this research consists of two distinct phases. First, the research collects and analyses quantitative data using a questionnaire. Then, data are collected and analysed qualitatively, with the aim of explaining, or elaborating on, the quantitative results

obtained in the earlier phase. The rationale for this approach is that the quantitative data and its subsequent analysis provide a general understanding of the research problem. The qualitative data and analysis then validate and explain the quantitative results by exploring the participants' views in more depth. For the qualitative stage, interviews are sought with selected end users already having responded to the survey in the first stage. This is because it is challenging to arrange interviews with potential participants without their earlier engagement with the survey, due to concerns over the privacy of the organisation and employee workload.

4.1.3.4 Subject, Location and Position of Research

Other weighting decisions of the research design are the subject, location and position of the study. The research needed to cover two subjects: human and physical (technology). The human subjects, or participants of this study, were industry professionals and students in a wide range of disciplines related to the built environment, such as building, construction management, quantity surveying, engineering and architecture. The informants for this study were thus highly related and accessible. The physical subject (technology) in this study was the OPIMS used to deliver and exchange documents during projects. The benefits of this technology are very well understood in the construction industry, but after more than a decade of implementation, it is still facing slow adoption.

This research was also triggered by the initiation of the Australian Built Environment Industry Innovation Council (BEIIC) on the skills needed, and new technologies available, in the construction industry. This research will contribute new knowledge to understand resistance to technology, and on how to manage it. It will provide insights into the tactical decisions about how required technologies are obtained and maintained, and who is involved. It will also improve operational implementation, such as through learning support and system trials.

4.1.4 Process and Phases of Research

This sequential mixed-method study comprised four major phases, as follows:

i. Phase 1: Theoretical framework, model, hypotheses and instrument development.
ii. Phase 2: Pilot survey.
iii. Phase 3: Survey.
iv. Phase 4: Interview, conclusions and recommendations.

Briefly, Phase 1 is about theory building. This stage was conducted to identify the resistance factors from the literature and concepts developed from past studies. It was later formulated into a model, set of hypotheses and survey instrument. This phase has been presented in Chapters 2 and 3. Following this, Phase 2 involved pilot testing to evaluate the feasibility of, and improve, the main data collection instrument (the survey questionnaire). Phase 3 is the main survey, the data from which is used in hypothesis testing and verification of the research model using statistical analysis. The final phase, Phase 4, uses interview data to improve the model further and make recommendations.

The following sections (Sections 4.2, 4.3, 4.4 and 4.5) will discuss in detail the specific methods and steps associated with the data collection and analysis for each phase.

4.2 Phase 1: Theoretical Framework, Model, Hypotheses and Instrument Development

4.2.1 Objectives of Phase 1

The primary objective of Phase 1 of the study is to develop an initial model of resistance factors from the literature review and previous empirical studies. Information collected from the literature and empirical studies (as discussed in Chapter 2 and 3) has simultaneously helped to develop the background theory into practical concepts, hypotheses and measurements that need to be tested further in Phases 2, 3 and 4. In Phase 1 of the study, significant research activities involve:

a) Establishing the theoretical background, concepts and research methodology.
b) Formulating the research model and hypotheses (presented in Chapter 3).

c) Selecting a research case (i.e. OPIMS), as discussed in Chapter 1.
d) Developing survey instruments (presented in Chapter 3).
e) Sampling and selecting research subjects (i.e. students, cadets, interns, graduate trainees and professionals).

Sampling techniques, population of sample, subject and size will be discussed further in Section 4.2.2.

4.2.2 Sampling and Selecting Research Subjects

In quantitative research, there are four types of probability sampling approaches: simple random sampling, systematic sampling, stratified random sampling and multi-stage cluster sampling (Bryman, 2012). The aim of any of these sampling approaches is that samples are selected to be broadly representative of the population from which they are drawn, and any member of the population has a chance of being selected. If samples are not required for even representation and some members in a population have low accessibility, then the sampling approach can be substituted by a non-probability method such as convenience sampling, snowball sampling or quota sampling (Bryman, 2012). Sampling in quantitative research is mostly oriented towards probability sampling, while qualitative research tends to use purposive sampling (Bryman, 2012).

However, for mixed methods research, the sample can be selected either randomly (by means of probability sampling) or non-randomly (by means of purposive sampling), or by a combination of both (Teddlie & Yu, 2007). As illustrated in Figure 4.1, there are four sampling type combinations. The most frequently used sampling combination in mixed methods research is Type 4, which is a combination of non-random sampling in both the quantitative and qualitative components. Type 2, consisting of non-random sampling for the qualitative component(s) and random sampling for the quantitative component(s), is the second most frequent combination in mixed methods research. The least common approaches are Type 1, which is a combination of random sampling for both the qualitative and quantitative components, and Type 3, which involves random sampling for the qualitative component(s) and non-random sampling for the quantitative component(s).

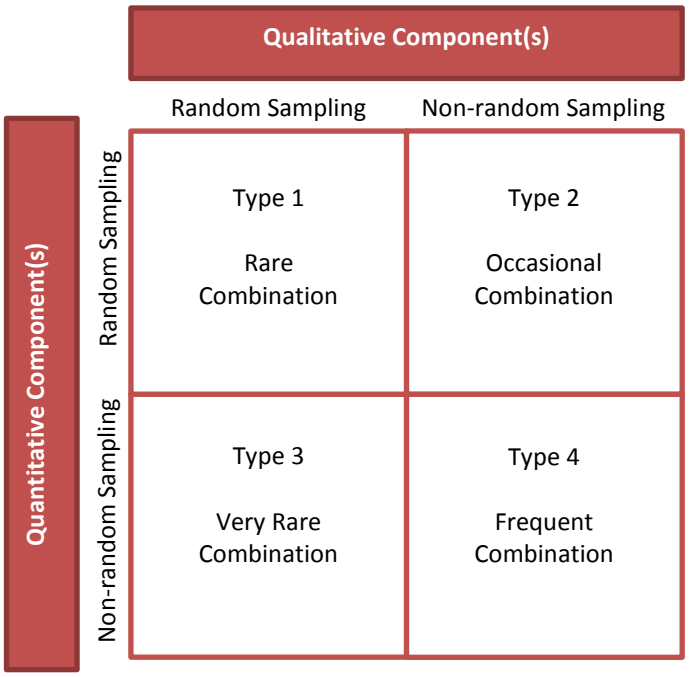

Figure 4.1: Type of sampling scheme *(adapted from Onwuegbuzie & Collins, 2007).*

Preference for any of these combinations (random or non-random) of sampling approaches also depends on the purpose of the research for which the sample is taken. According to Onwuegbuzie and Collins (2007), if the objective of the study is to generalise the quantitative and/or qualitative findings to the population from which the sample was drawn, then a random sample for that component is preferred. In such a situation, five random sampling (probability sampling techniques) approaches are possible: simple random sampling, stratified random sampling, cluster random sampling, systematic random sampling and multi-stage random sampling. If the objective is not to generalise to the population but to obtain insights into research problems and questions, then purposive sampling techniques are more appropriate. There are 19 purposive sampling techniques, including convenience, snowball and intensity. A complete list of purposive sampling techniques is given in Onwuegbuzie and Collins (2007, pp. 285–287).

For this thesis, the research objective of the quantitative data was to provide insight, a broad understanding and confirmation of the model of resistance factors, rather than to be representative of the population. Thus, for collecting quantitative data, the sampling can be non-random. Given the second phase is influenced by the first phase, and the

qualitative data were intended to complement the quantitative data and results, sampling for the second phase can also be non-random.

4.2.2.1 Population and Research Sample

Onwuegbuzie and Collins (2007) present approximately 19 purposive sampling schemes/techniques. Of these, two techniques are identified as being most suitable for this style of research: convenience sampling and intensity sampling. The convenience sampling technique is used in the quantitative data collection and the intensity sampling technique is used for the qualitative data collection. The advantage of the convenience sampling technique is that this technique allows the researcher to choose settings, groups and/or individuals that are accessible, conveniently available and willing to participate in the study (Onwuegbuzie & Collins, 2007). Intensity sampling allows the researcher to choose the setting, groups and/or individuals due to their experiences relative to the phenomena of interest (Onwuegbuzie & Collins, 2007).

The relationship of the quantitative and qualitative samples needs to be considered in the sampling design for concurrent or sequential types of mixed methods research (Collins & Onwuegbuzie, 2007). The relationship can be identical, parallel, nested or multilevel. A multilevel relationship uses two or more sets of samples, extracted from different levels of the study (i.e. different populations). A parallel relationship is where the samples in the quantitative and qualitative components of the research are different but drawn from the same population of interest. Identical means that the sample members of the later phase are the same as in the earlier phase. Nested, the type used in this research, draws the sample for the latter phase of the study (interview) from among the participants in the earlier phase (survey).

This research included a sequential design by using identical samples for both the quantitative and qualitative components of the investigation. In this sampling design, the quantitative phase preceded the qualitative phase, such that the quantitative phase informed the qualitative phase. To highlight again, the objective of the quantitative phase of this study is that potential users of OPIMS are surveyed to identify the critical factors of resistance to use of the technology at work. The objective of the qualitative phase is to interview and gather an in-depth understanding of the critical factors related

to the resistance and to corroborate the quantitative results. For the qualitative/interview phase, a number of participants are selected to contribute in an interview study to gather an in-depth understanding on the critical factors for the resistance and to provide the quantitative/survey results. Based on these objectives, the purposive sampling approaches used (i.e. convenience sampling and intensity sampling) are appropriate. Both sampling techniques are able to increase accessibility to respondents in collecting data. Non-random sampling or probability sampling is always best for quantitative data, but large-scale random sampling is simply not feasible given the resources and time limitations of the present research. The nature of mixed methods research is in any event always considered to be lengthy and resource intensive (Collins & Onwuegbuzie, 2007; Teddlie & Tashakkori, 2010). The purposive sampling approach renders mixed methods more practical, as it makes the task of data collection much cheaper and a little quicker to conduct.

4.2.2.2 Sample Size

For mixed methods research, there is no optimal sample size (Onwuegbuzie & Collins, 2007; Teddlie & Yu, 2007). According to Teddlie and Yu (2007), probability sampling are usually at least 50 samples, as it is designed to generate a sample that can represent a selected population. Purposive sampling, on the other hand, can be smaller. It could be 30 samples or less, as the aim is not to be representative, but rather to select a sample that can respond to the research questions. For this thesis, the decision on sample size for collecting the quantitative data was to some extent a result of the decision to use the PLS of SEM technique as the tool of analysis (discussed in Section 4.4). This technique requires a sampling size of 200 or larger (Kline, 2005). Some researchers suggest a sample size between 300 and 400 (Yuan et al., 2010); with less than 100 being considered too small by some researches (Bentler & Yuan, 1999; Fan et al., 1999b). However, several works, for example Anderson and David (1984), Bearden et al. (1982), and Boomsma (1985), argue that sample sizes as low as 100 are adequate, and 200 or more can be considered safe (cited in Bagozzi & Yi, 1988; Bollen, 1990). It is also useful to consider the ratio of sample size to number of variables in the model, such as five subjects per variable, 10 subjects per variable or 20 subjects per variable (Bentler & Chou, 1987). Using the ratio method, this research has 17 variables to be measured;

so, under the 10 subjects per variable rule, the research would require 170 subjects (sample size).

Studies specific to the construction management field that have used PLS or SEM as a tool for statistical analysis, have used a sample size in the range of 50 to 100 (e.g. Aibinu et al., 2011; Doloi et al., 2011; Dulaimi et al., 2005; Eriksson & Pesa¨maa, 2007; Islam & Faniran, 2005; Wong & Cheung, 2005). Wong and Cheung (2005) argued that compared to similar studies about the same research inquiry conducted in other countries, a valid sample size of 51 was reasonably good for their study. A larger sample could yield better results, but due to the complexity of the research inquiry and limitations in obtaining a large sample in the research, studies can only utilise small samples (Eriksson and Pesa¨maa, 2007; Islam and Faniran, 2005).

The issue of sample size in the SEM literature is to some extent controversial. There are no absolute numbers regarding the sample size to be used in SEM, and small sample sizes are not uncommon. This research initially set the target of obtaining at least 100 subjects. The sample size will be further justified in Section 4.4.

4.3 Phase 2: Pilot Survey

4.3.1 Objectives of Pilot Survey

The main aim of the pilot survey is to improve the internal validity of the survey instrument developed in Phase 1. A pilot test was also conducted to improve the survey distribution procedure and maximise the potential response rate during the main survey. Consideration of the statistical analysis technique used for assessing the validity of the survey instrument will be limited for the pilot study itself, as the analysis of the pilot study should be mainly descriptive (Lancaster et al., 2004). Hypothesis testing is inappropriate at this stage because the pilot study only involves a small number of participants.

4.3.2 Transformation of Research Instrument into Questionnaire Survey

To improve the reliability of the survey questionnaire, the research focussed on four areas when designing and constructing the questions: (1) wording of the questions, (2)

response choices, (3) sequence and (4) the general appearance of the questionnaire (Buckingham & Saunders, 2004; Christian et al., 2007; Fowler, 1995; Krosnick & Presser, 2010; Rada, 2005; Synodinos, 2003). The wording of the instrument was modified to be short, with an easy question format and improved visual design (i.e. using numbers, symbols and graphics). Effective visual design is important to convey particular meaning, can increase response efficiency and improve the survey experience for respondents (Christian et al., 2007). The questionnaire also used number and symbol elements (e.g. percentage = %, drop-down menu list, check box button) and graphic elements (e.g. shape, colour, font size and type, placement of information on page and skip-logic) to deepen the meaning of the survey questions (Christian et al., 2007).

The questions were more generally designed as close-ended questions, and answers were based on a scale and/or ordered category. There are many approaches to creating ordered categories, such as three-point scales (e.g. good, fair and poor), or five- or seven-point Likert-type scales (Krosnick & Presser, 2010). The optimal number of options/points in a Likert scale is the subject of debate (Jacoby & Matell, 1971; Komorita & Graham, 1965; Matell & Jacoby, 1971). Essentially, however, the choice of scale should reflect the theoretical background, scale point meaning, practicality of translation and evidence on the optimal number of scale points from other work (Krosnick & Presser, 2010). Based on the theoretical background and previous work, several researchers use a seven-point scale (e.g. Davis, 1989; Venkatesh et al., 2003), although others (Moore & Benbasat, 1991) have used a variety of scales in their survey instruments. The most common option, and generally the best regarded, is a five-point scale (Krosnick & Presser, 2010).

For ease and practicality of translating the meaning of a question, each question was provided with a choice of answers based on a five-point Likert scale. Using the Likert scale, respondents can indicate their perceptions by defining how strongly they agree or disagree in terms of a range from very positive to very negative, relative to the given statement/question. A standard scale was used: strongly agree = 5, agree = 4, neither agree/disagree = 3, disagree = 2 and strongly disagree = 1. This agree–disagree scale is broadly considered the simplest and most straightforward for participants. However, in certain cases, the agree–disagree format is less appropriate and can be insufficient to

provide meaningful data (Fowler, 2009; Krosnick & Presser, 2010). To provide more reliable, valid and interpretable data, in this questionnaire, the use of an agree–disagree question format is only used in limited situations. Other scales, such as important–unimportant, active–passive, easy–difficult, extensive–limited and excellent–minimal, are used wherever they provide added meaning.

For overall appearance, the survey was developed into a commercial web survey tool in SurveyMonkey® (see: http://www.surveymonkey.com/OPIMS_PRO). SurveyMonkey® allows not only a more refined appearance in terms of colour and font style, it also provides a more dynamic interaction between the respondent and the questionnaire. Questions were allocated into a specific flow and skip-logic (allowing questions to be excluded based on previous user responses) between five subjects/parts. Figure 4. 2 provides an illustration of the flow logic used in the pilot study. Using skip-logic, respondents were asked to skip one or several questions based upon which answer they selected for a particular question. The survey contained seven main parts:

a) Introduction—The questionnaire contained an introductory page (Page 1: Project Information Statement) which explained the purpose of the research, definitions of OPIMS and instructions on how to complete the survey. The introductory page was required by UNSW FBE Human Resources Ethics Panel (please refer to Appendix D).
b) Demographic of Respondent—This part was about the respondent's background and included questions on age, gender, education, work experience and employment position.
c) General Knowledge and Experience about ICTs—This enquired about the participant's knowledge of and experience with ICT in general. The questions were about whether the respondent used ICT at work and/or in their personal life, their opinions on whether the ICTs were particularly useful at work, what type of technologies they use and how frequently it is used at work.
d) Attitude and Disposition towards OPIMS—This part specifically focussed on the attitudinal factors of using OPIMS at work such as motivation, efficacy, anxiety and power.

e) Integration and Accessibility of OPIMS to Work—This part focussed on questions related to the integration and usefulness of OPIMS at work.

f) Support Network—This part was developed based on instruments used in a social network perspective. It was developed exclusively to assess the social network of respondents at work and the relations associated with the use of OPIMS.

g) Closing—Respondents were required to click the 'next' button if they agreed to their participation in the survey, and completed the questionnaire by clicking the 'submit' button. Respondents were also asked to provide their contact details if they wished to participate in the next stage of research, a short interview session.

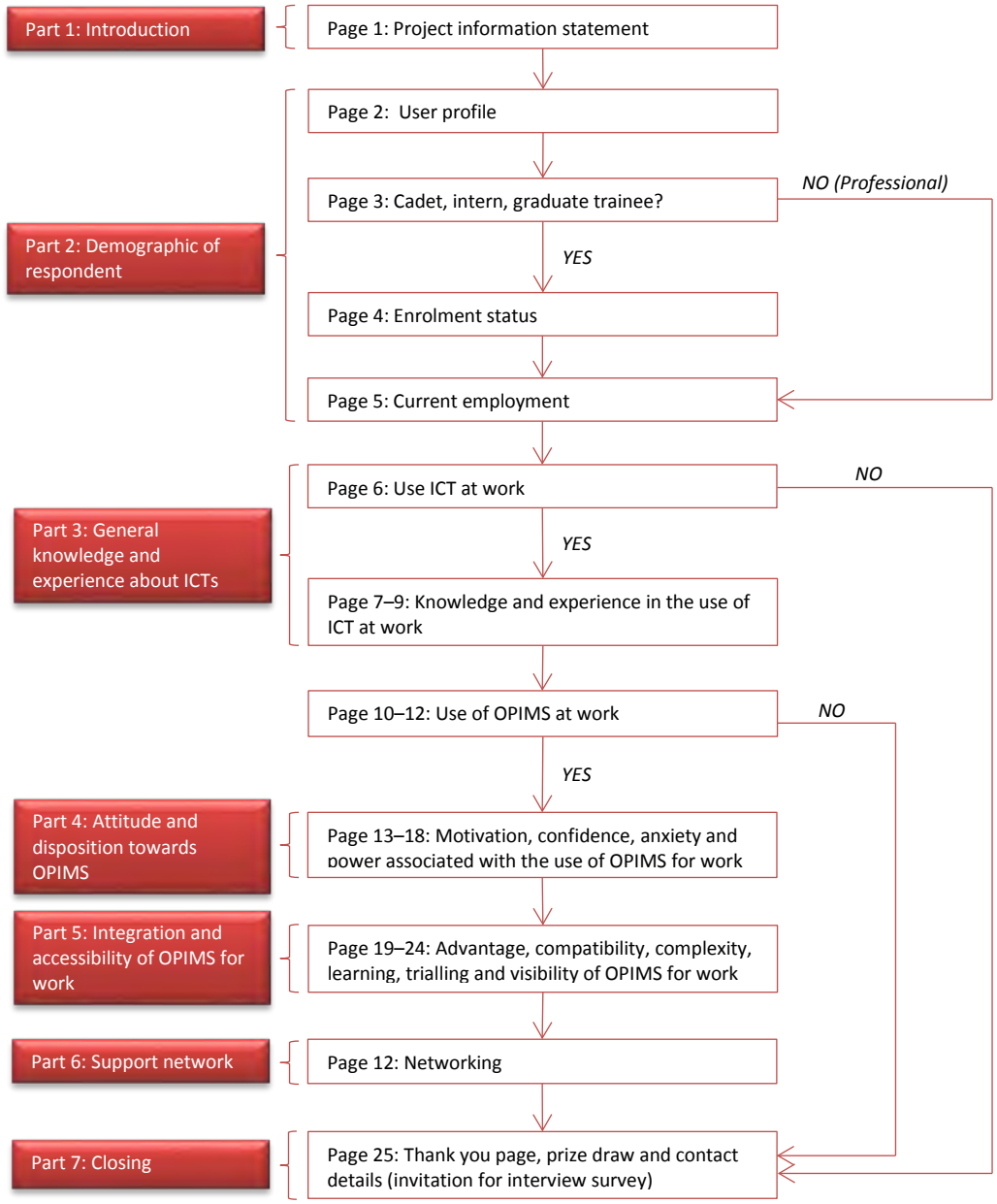

Figure 4.2: Survey flow chart.

4.3.3 Pilot Survey Coverage and Outcome

The survey questionnaire was placed online using the SurveyMonkey® website. The online format allowed respondents to complete the survey at any time and make changes to their responses before finalising their submission. It was also intended to automate data collection and quickly reach respondents in different geographical locations (Dillman et al., 2009).

During March–April 2012, the survey invitation was sent randomly to a limited number of undergraduate and postgraduate students currently enrolled in a construction management program of study in institutions across Australia. The invitation to participate was send to 14 schools of architecture, engineering and construction via the relevant Program Head by email. As shown in Table 4.2, 49 students from different backgrounds including full-time students, cadets, interns and graduate trainees participated in the pilot study. From these responses, only one uncompleted response was received, making the total number of completed responses 48. However, among all respondents, only 10 identified themselves as OPIMS users.

Table 4.2: Responses to pilot survey.

Responses	Number of responses (count)	Percentage (%)
Total responses received	49	100.0
Uncompleted responses/skipped questions	1	2.0
Completed/answered all questions	48	98.0
Users of OPIMS	10	29.0

The low response rate to the pilot study was disappointing, but anticipated. It is likely that the low responses were caused by survey 'coverage'. For some schools, the successful completion of the degree or masters in construction management program does not include a compulsory industry-based learning program, cadetship, internship or graduate program. In addition, some programs offer courses on IT but not specifically on OPIMS. As such, some students may not experience OPIMS during their studies, affecting the respondents targeted for this study (people who have experience using the technology).

The social support instrument was observed to be adequate. In this instrument, respondents were asked to indicate at least seven people that they had frequent, significant communications with, along with anyone relevant who was significant to their work. As shown in Table 4.3, the pilot survey recorded that 30 per cent of respondents who used OPIMS had connections to only one such person. A similar percentage was connected to seven significant people at work. The rest of the

respondents had connections with two people (10 per cent), three (10 per cent) and five (10 per cent). Although they were encouraged to name at least seven people (with space available for as many as 10), only one respondent listed nine people with whom he or she had relevant communication. Overall, the average reported network size was four people per respondent, a mean value of 4.20. In general, all of the questions used in the pilot study proved relevant and suitable for use in the main survey. No major changes were made, with only a slight modification of the layout and wording for the final questionnaire. A copy of the final questionnaire survey can be found in Appendix E.

Table 4.3: Mean value of support network size.

Statistics

Network Size

Valid	10
Missing	0
Mean	4.20

Network Size

Network Size	Frequency	Per cent	Valid Per cent	Cumulative Per cent
1	3	30.0	30.0	30.0
2	1	10.0	10.0	40.0
3	1	10.0	10.0	50.0
4	1	10.0	10.0	60.0
7	3	30.0	30.0	90.0
9	1	10.0	10.0	100.0
Total	10	100.0	100.0	

4.4 Phase 3: Survey

4.4.1 Objectives of Phase 3

The main objectives of this phase are to obtain data concerning the resistance to using OPIMS, and to verify the significant constructs and relationships between the constructs as outlined in the initial resistance factor model. The items previously discussed in

Chapter 3 were included in the survey measuring the construct of the proposed model to predict resistance to the adoption and integration of technology at work.

The objective of this phase is to test the model and to confirm the significant variables in the research model. This stage involved data collection using a survey, analysis of survey data and verification of the initial resistance model. As mentioned in Section 4.2.2, sampling for this research focussed on students and professionals. These two cohorts were included in the sample population because technology implementation can affect different levels of employees within the organisation (e.g. cadets, interns, trainees and experienced employees). A questionnaire was distributed to them with the assistance of:

i. Sales and Marketing Personnel in OPIMS Software Provider organisations.
ii. Head of Departments in architecture, engineering and construction companies.
iii. Administrators in the respective architecture, engineering and construction Professional Bodies.
iv. Head of Departments in Built Environment Schools.

Respondents were provided with a SurveyMonkey® web-link, and a letter emphasising the research purpose, the guarantee of respondent anonymity and the response deadline. Follow-up reminders were only sent to the representatives, requesting them to remind the potential respondents to complete the questionnaire due to the organisation's privacy policy and employee workload. The research does not name or list the organisations or individuals involved in this study due to the need to protect their privacy. However, a general profile of respondents is presented in Chapter 5.

The techniques used for the data analysis and model testing in this phase will be discussed further in the next section.

4.4.2 Introduction to Structural Equation Modelling Techniques

The technique used to evaluate the overall quality of the resistance model was PLS of SEM. SEM is a combination of statistical techniques. It is an increasingly popular approach that incorporates multivariate statistics, for example, multiple regression

(examining dependence relationships) and factor analysis (representing unmeasured concepts/factors with multiple variables), to estimate a series of interrelated dependence relationships simultaneously (Hoyle, 1995; Kline, 2005; Maruyama, 1998; Schumacker & Lomax, 2010). SEM is often illustrated graphically by a path diagram that is part of the path analysis, which can determine causal and directional relationships. According to Matsueda (2012), the development and popularisation of SEM is seen in the works of Blalock (1961), Duncan (1966), Jöreskog (1969) and Goldberger (1972), who were prominent scholars in the SEM development wave of the 1960s and 1970s. However, the origins of SEM can be traced to the development of path analysis by Sewall Wright (1921), making him the earliest SEM theorist (Bollen & Pearl, 2013; Maruyama, 1998).

SEM has been widely used in social and behavioural sciences (Hershberger, 2003). It is seen as a suitable method for testing theories and models of causal-predictive relationships among observed variables (OVs) and latent variables (LVs) (Bollen, 1989, 2002; Jöreskog, 1993). OVs are sometimes known as indicators, measures or manifest variables, whereas LVs are sometimes known as constructs, unobserved variables, unmeasured variables, concepts or factors. To be more specific, LVs are theoretical concepts that cannot be observed or measured directly. LVs can only be measured indirectly due to their nature; that is, exogenous (independent variables) and endogenous (dependent variables). The relationship between variables can be formed into a structural model and a number of measurement models. A measurement model is a model linking a set of OVs to a LV. A structural model is a model linking hypothesised LVs. The significance relationship between OVs to the respective LV can be assessed using the factor analysis technique. Once the OVs in the measurement models are verified, the relationship between the exogenous and endogenous LVs can be assessed by path analysis. A clearer distinction between the measurement model and structural model is depicted in Figure 4.3.

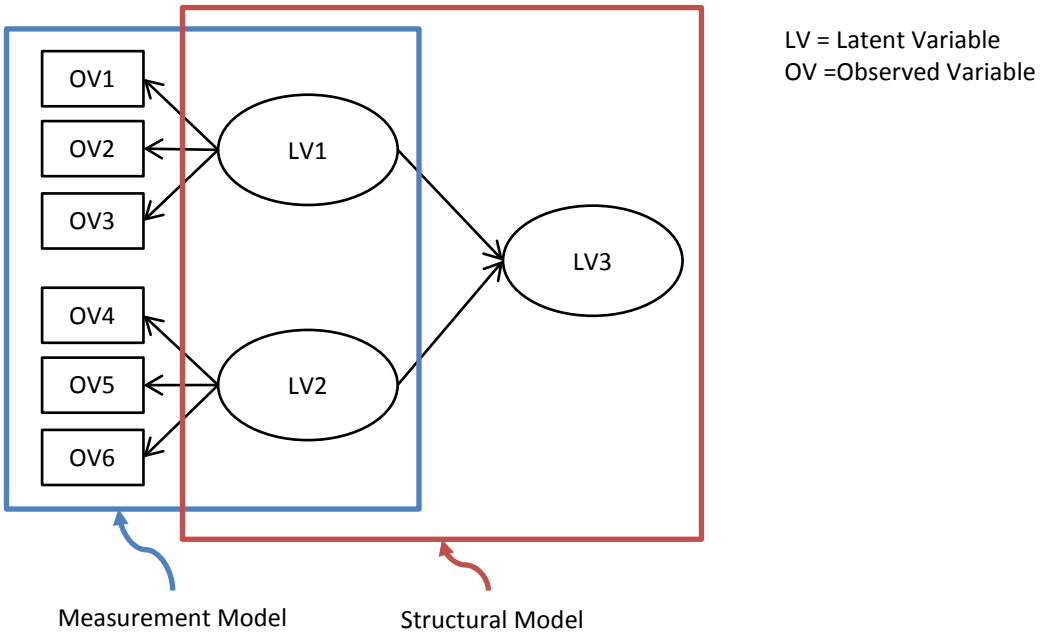

Figure 4.3: Measurement Model and Structural Model.

In the advanced SEM literature, the term measurement model is also called block structure (Wold, 1980) and outer model (Chin, 1998b), and the structural model is known as the inner model (Chin, 1998b). As illustrated in Figure 4.3, in the measurement model, LV1 is inferred through its indicators, OV1, OV2 and OV3, which are displayed as rectangles. In the structural model, LVs are treated in a continuous manner. There are three LVs as hypothesised: LV1, LV2 and LV3. Arrows connect directly to LV3 from LV1 and LV2, which form and control the behaviour and significance of LV3.

Using SEM to estimate multi-layer constructs and multiple correlations of variables as well as the whole quality of the model has some advantages. For example, SEM allows more direct translation of substantive theory into comprehensive statistical practice and gives flexibility in modelling different types of interaction relationships and effects (Chin, 1998a). This means that SEM allows for the development of LVs and the modelling of a relationship among them to identify OVs for each of the LVs and statistically test the theoretical and measurement assumptions against empirical data (MacCallum & Austin, 2000). Another advantage is that, in addition to the factors, measures or variables that the researcher intended to test and determine, SEM is able to take validity and reliability issues into account. Reliability refers to the consistency of

measures. Measurements are considered reliable if they are repeatable and any errors of measurement that affect reliability are constant errors. Cronbach's alpha is one of the most commonly used techniques for reliability analysis, but other techniques such as composite reliability and average variance extracted (AVE) are used also (Gefen et al., 2000). For validity analysis, discriminant and convergent validity are often the focus (Anderson & Gerbing, 1988; Gefen et al., 2000). Convergent and discriminant validity indicators are used to check whether the measure applied actually measures the construct that it is supposed to measure.

Despite its advantages, there are also a few disadvantages of using SEM. These relate to model evaluation and methodology. First, for model evaluation, SEM assessment and parameter estimation are very complex (Chin, 1998a). SEM requires a detailed understanding of the purposes of the measure's application with the objectives, hypothesis and model of research. In the case of research in the earlier stage of theoretical development, and which is intended to test and validate exploratory models, component-based SEM is more appropriate. Covariance-based SEM may be more or less credible in that case because the assumption and analysis methods are confirmatory in nature (further discussion on component-based and covariance-based SEM follows in Section 4.4.3). Moreover, SEM requires a large sample/data size of at least 200 (Kline, 2005). Thus, collecting adequate data for use in SEM would be time consuming. However, if applied appropriately, these procedures will have tremendous potential for advancing research practice, particularly for model development (Chin, 1998a).

4.4.3 Types of SEM Approach: Covariance-Based and Component-Based

There are two types of SEM approach: covariance-based SEM and component-based SEM (also known as PLS). Between these two approaches, the most popular is covariance-based SEM. This approach was developed by Karl Jöreskog in the early 1970s (Jöreskog & Wold, 1982). The covariance-based SEM technique uses the maximum likelihood (ML) estimation. ML estimates a model's parameters so that the theoretical covariance matrix implied by the system of structural equations is as close as possible to the empirical covariance matrix observed within the estimation sample (Jöreskog & Sörbom, 1983). ML tends to minimise the differences between the sample covariance and that implied by the theoretical model, to maximise the degree of

consistency between the data and the theoretical model. The goal of the tests is to confirm the theory and judge the overall model fit. The indicator or index assessing model fit, known as the goodness-of-fit index, should have values in the range of zero to infinity. An index value close to zero indicates an imperfect fit and infinity indicates a perfect fit (Mulaik et al., 1989).

The most common technique for measuring goodness-of-fit is the chi-square (χ^2) test. The estimation of the χ^2 statistic should be insignificant with a p-value above 0.05, because an insignificant χ^2 shows good model fit (Jöreskog & Sörbom, 1989). Jöreskog and Sörbom (1989) also introduced two goodness-of-fit indices called GFI (Goodness-of-Fit Index) and AGFI (Adjusted GFI). Both indices have been created as an alternative to the χ^2 test. GFI and AGFI calculate the proportion of variance that is accounted for by the estimated population covariance. Two other well-known measures are the Tucker-Lewis Index (TLI) by Tucker and Lewis (1973) and the Normed Fit Index (NFI) by Bentler and Bonett (1980). These statistics assess the model by comparing the χ^2 value of the model to the χ^2 value of the null model. The null model is a model where all variables are uncorrelated. While there are many different possible indices for calculations of fit, good fit values can be regarded as universally acceptable. If the model fits perfectly, all fit indices (i.e. GFI, AGFI, TLI and NFI) should have a value of 1, but a value of at least 0.90 is also acceptable (Hu & Bentler, 1999). Another approach to model fit is called Root Mean Square Error of Approximation (RMSEA), developed by Steiger and Lind (cited in Steiger, 1990). For RMSEA, the smaller the value, the better the approximation: RMSEA should be in the range 0 to 0.08.

However, goodness-of-fit does not imply that the model is right or wrong. Goodness-of-fit only means that the inferred correlation matches the observed data, that the model is empirically adequate for theory-purposes and that it can be scrutinised for 'measurable' outcomes of issues in the real world (Barrett, 2007). In addition, while fit indices are useful aspects in SEM and provide a seemingly straightforward method to evaluate the hypothesised model, over-reliance on them is not appropriate. A good model should also be examined with respect to substantive theory. This is because models and hypotheses usually imply causality. Causality cannot be determined by results of any of the techniques in SEM. Instead, an examination of the soundness of the underlying

theory and research design is required (Weston & Gore, 2006). Thus, it is important for researchers to provide a compelling justification for a model (based on empirical evidence and theory) before undertaking covariance-based SEM, as a researcher can establish a good model based on a substantive basis, and allow greater reliance on theory in analysing data (Mueller & Hancock, 2008). Otherwise, the researcher might require additional estimates and greater amounts of data, which may lead to over-sensitive statistics and misspecification in the model (Fan & Sivo, 2007; Fan et al., 1999a). In addition, it is the nature of the ML algorithm that OVs follow a specific multivariate distribution (i.e. normal distribution) and there is an adequate sample size (Reinartz et al., 2009). Inadequate sample size may result not only in poor parameter estimates and weak empirical relationships between variables, but also lead to estimation problems and unreliable research results (Marsh et al., 1988). A small sample may also potentially lead to omit some variables of model when a complex model with LVs is involved (Tanaka, 1987). Covariance-based SEM often requires large sample sizes of at least 200 (Kline, 2005; Raykov & Widaman, 1995).

A complementary approach to covariance-based SEM is PLS. PLS is sometimes referred to as variance-based SEM (Chin, 1998b; Haenlein & Kaplan, 2004). According to Chin (1998b), PLS has its origins in the early work of Wold (1975). PLS is based on a series of linear aggregations and ordinary least square (OLS) regressions. Originally, the key idea behind the OLS technique was for estimating the unknown parameters in a linear regression model and to predict if an acceptable linear relationship may exist, for example, between variables x and y. Comprehensive reviews on the development of PLS are given in Chin (1998b) and Tenenhaus et al. (2005).

There are substantial differences between PLS and covariance-based SEM in terms of objectives and purposes. First, according to Chin (1998b), unlike covariance-based SEM, which uses a model for explaining the 'covariation' of all of the indicators and confirmatory purposes, the PLS estimation is to obtain the values of the LVs for predictive purposes. PLS attempts to maximise the variance explained for constructs and parameter estimates by minimising each residual variance separately for improved prediction of corresponding constructs. By obtaining estimates of all latent constructs, the PLS algorithm maximises the proportion of variance of all dependent variables

(both latent and observed) that are explained by the predictors (Chin & Newsted, 1999). Second, estimation in PLS is based on OLS regressions, which implies that no assumptions regarding the distribution or measurement scale of observed indicators are required. PLS is considered a soft modelling approach in which no strong assumptions with respect to the distributions are made (Vinzi et al., 2010). Further, PLS works with small sample sizes (Chin & Newsted, 1999). In contrast, covariance-based SEM requires normally distributed and interval-scaled variables (Fornell & Bookstein, 1982), and a large sample size to avoid non-convergence and improper solutions (Boomsma & Hoogland, 2001 cited in Reinartz et al., 2009). Third, PLS has been shown to be a suitable approach in situations in which research is in the early stages of theory development, and where the aim is to predict the LVs in the model and identify relationships between them. In contrast, covariance-based SEM is appropriate if the focus is on confirming theoretically assumed relationships (Chin, 1998b). A summary of the comparison of these two methods is given in Table 4.4.

Table 4.4: Comparison between covariance-based SEM and PLS.

Criteria	Covariance-based SEM	PLS
1. Objective	Parameter-oriented	Prediction-oriented
2. Approach	Covariance-based	Component-based
3. Assumption	Typically multivariate normal distribution and independent observations (parametric)	Predictor specification (non-parametric)
4. Parameter estimates	Consistent	Consistent as indicators and sample size increase
5. Latent variable score	Indeterminate	Explicitly estimated
6. Epistemic relationship between a latent variable and its measures	Typically only with reflective indicators	Can be modelled in either formative or reflective mode
7. Implications	Optimal for parameter accuracy	Optimal for prediction accuracy
8. Model complexity	Small to moderate complexity (e.g. less than 100 indicators)	Large complexity (e.g. 100 constructs and 1,000 indicators)
9. Sample size	Minimal recommendations range from 200 to 800	Minimal recommendations range from 30 to 100 cases

Adapted from Chin and Newsted (1999, p. 314).

4.4.4 Justification for Using Component-Based or PLS

According to Marcoulides et al. (2009), there is a misconception that PLS becomes an alternative approach in the information systems research discipline only in the situation of non-normal distribution and small sample size. However, PLS should also not be used as an *ad-hoc* approach for achieving adequate statistical power at small sample sizes (Goodhue et al., 2006). PLS is adequate if the research objective meets certain characteristics and the basic assumption of PLS, in which, if the research objective is for theory development and prediction, regardless of data distribution and sample size, PLS is preferable to covariance-based SEM (Chin, 1998b). In addition, both techniques, covariance-based SEM and PLS, should be seen as complementary rather than competitive, because both are theory-oriented and emphasise the transition from exploratory to confirmatory analysis (Jöreskog & Wold, 1982). Covariance-based SEM is perceived as being more related to theory confirmation, while PLS is for theory development, which is primarily intended for causal-predictive analysis in situations of high complexity but low theoretical information (Chin, 1998a).

Having considered the objective of the research, the PLS approach was used for the present study. As shown in the preceding section on comparisons of covariance-based SEM and PLS (see Table 4.4), the conditions of this study conform closely to PLS techniques. Thus, justification for using PLS in this study is based on the following:

a) PLS provides better prediction capability. The primary objectives of this research were to predict and generate a model of resistance factors that best describe the resistance behaviour of users who have used OPIMS.
b) PLS focusses on causal-predictive analysis, which also suits the objective. The objective is to build a model of resistance and not to test a well-known theoretical model.
c) The theoretical information of the resistance factor influencing technology innovation is under-developed, specifically in the area of construction management. The use of PLS is more appropriate in this study, in which most of the measures used are newly developed for the purposes of this resistance model.

d) The data distribution in this study does not follow a multivariate normal distribution, which is required under covariance-based SEM, but not under PLS.
e) The sample size of this study is small; there are only 88 cases (see Chapter 5). PLS has the ability to run an analysis with a sample size as low as 30. However, the study treated this advantage with caution, and made moderate assumptions regarding consistency between data and the model because this could be a drawback of the study in the early stage of theory development.

4.4.5 PLS Technique, Process and Procedure in Research

Urbach and Ahlemann (2010) developed a key process that might be involved when applying PLS in research. This process includes problem definition and research design, theoretical foundation, model construction and development, data collection, model validation and interpretation. Possible activities involved in the later processes are developing the measurement and structural model, specifying the scope and level of analysis and specifying the intended validity analysis. The later stages also include the model validation process; that is, validating the reflective and/or formative measurement model, validating the structural model and performing 'bootstrapping' or 'jackknifing'. This process developed by Urbach and Ahlemann (2010) is very comprehensive. To simplify, this thesis will only discuss the latter part of the process, relating to specifying the measurement model and structural model, and defining the techniques and sequence of model validation. Parts of the process; that is, the theoretical foundation and hypotheses, have already been detailed in Chapters 2 and 3, respectively.

For this study, as shown in Figure 4.4, the initial analysis process began with specification of the PLS model. The thesis specified the factors/constructs structure from a theoretical framework and model. It is important to specify the indicators and relationships intended to be measured (directly or indirectly) based on modelled phenomena and theoretical concepts because some of the concepts may not be testable and may not reflect the respective factors appropriately. The research created links for each observed variable based on association with a LV. Next, the links for each LV, based on its association with other LVs, were drawn. The links and associations of these variables can go in any direction, either exclusively formative or reflective, or a

combination of both. However, based on the theoretical basis and objectives of this research, only formative directions are involved. LVs can also extend with other LVs, such as in a hierarchical order in which indicators of each LV in the higher order are determined by indicators in the lower order.

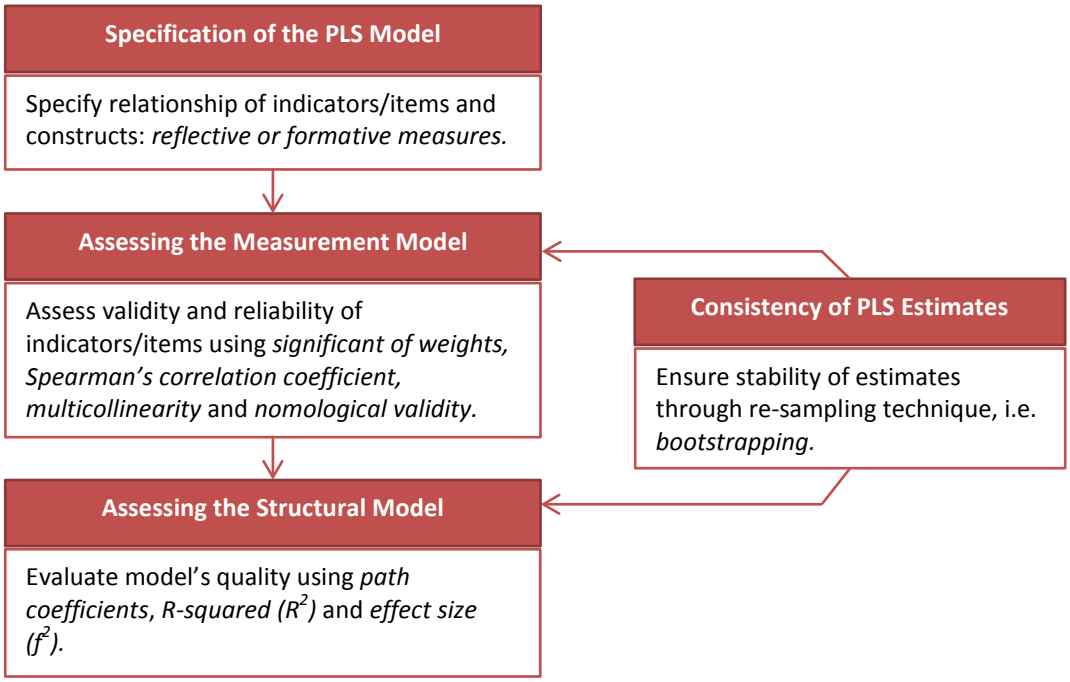

Figure 4.4: Process and procedure of PLS techniques used in this study.

The following process is used for testing the components in the measurement model. The assessment of reliability and validity of the measurement model should be evaluated first because the OVs have a corresponding direct linear relationship with the LVs (Chin, 1998b). The measurement model becomes the basis for analysing the structural model. The final process is the assessment of the structural model. The relationships between the LVs are assessed using the path analysis techniques. The proposed statistical techniques are path coefficients, R-square (R^2) and effect size (f^2). To ensure the overall consistency of the statistical results, a re-sampling technique (bootstrapping) was used. A detailed discussion on the directional association of the variables and statistical techniques employed in this study are presented in the following sections.

4.4.6 Specification of PLS Model Analysis: Formative Measures and Reflective Measures

There are two types of measures: formative and reflective. Reflective measures consider cause and change in the underlying construct, whereas formative measures shape the characteristics of the construct (Chin, 1998b). As illustrated in Figure 4.5, for formative measures, the direction of the arrows points from the observed variables (OV1, OV2, OV3) to the construct (C). For the reflective measure, the arrows are in the opposite direction.

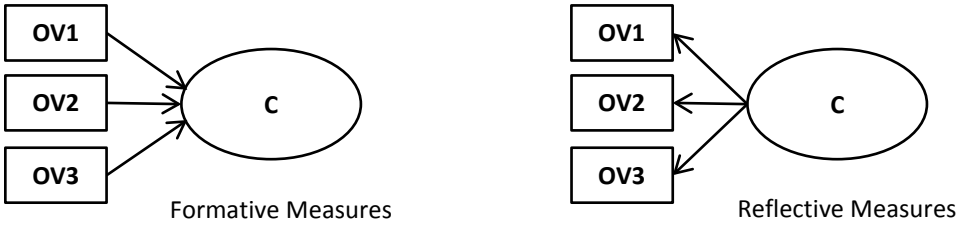

Figure 4.5: Formative Measures and Reflective Measures.

Table 4.5 provides a comprehensive summary of the differences between the formative and reflective measures in the model. The reflective measures are also called 'effect' measures because they influence the underlying construct they represent and they are expected to correlate reasonably to each other, because they all manifest the construct and share a common theme. Dropping one measure should not alter the conceptual meaning of the construct, based on internal consistency. Formative measures, on the other hand, are not expected to influence the construct. Rather, they are expected to define the characteristics of the construct. Hence, the measures are also not expected to correlate with each other. Internal consistency is consequently unimportant for formative measures, and dropping one measure could be inappropriate, as it may cause the omission of a unique element of the conceptual domain.

Table 4.5: Comparison between formative measures and reflective measures.

Considerations	Formative Measures	Reflective Measures
1. Direction of causality from construct to measure implied by the conceptual definition	• Direction of causality is from items to construct • Indicators are defining characteristics of the construct • Changes in the indicators should cause changes in the construct • Changes in the construct do not cause changes in the indicators	• Direction of causality from construct to items • Indicators are manifestations of the construct • Changes in the indicators should not cause changes in the construct • Changes in the construct do not cause changes in the indicators
2. Interchangeability of the indicators/items	• Indicators/items need not to be interchangeable • Indicators/items need not have the same or similar content, need not share a common theme • Dropping an indicator/item may alter the conceptual domain of the construct	• Indicators/items should be interchangeable • Indicators/items should have the same or similar content, should share a common theme • Dropping an indicator/item should not alter the conceptual domain of the construct
3. Covariation among the indicators/items	• Not necessary for indicators/items to covary with each other	• Indicators/items are expected to covary with each other
4. Antecedents and consequences	• Indicators/items are not required to have the same antecedents and consequences	• Indicators/items are required to have the same antecedents and consequences

Adapted from: Jarvis et al. (2003)

According to Jarvis et al. (2003), it is important for researchers to consider the norm of reflective and formative indicators/items in models because these will substantially affect estimation procedures. According to Jarvis et al. (2003), it is not only items that are formative or reflective, constructs are also able to be either formative or reflective. The PLS model can have constructs, indicators and items that are measured in reflective or formative ways, or any combination thereof, depending on the underlying theory. For example, in a project management study, typical measurements for a successful project are variables such as time, budget, quality and environmental sustainability. In a model, these variables are usually considered as being in the reflective mode, which affects and causes project success. However, in real life, a change in any one of these variable (e.g. financial shortage) may also affect the project success factor. Conversely, in the reflective mode, a change in the financial shortage variable does not necessarily imply a change in project success. Misspecification of the direction of causality between a construct and its measures is a serious issue.

The study by Jarvis et al. (2003) showed that 28 per cent of the latent constructs with multiple indicators published in the top marketing journals were incorrectly specified as reflective when they should have been formative. Another study by Petter et al. (2007) found that 30 per cent of models in information system journals are subject to this misspecification. Misspecification can lead to inaccurate estimations and incorrect conclusions on the structural relationships between constructs. One way to mitigate misspecification is to follow the guidelines proposed by Jarvis et al. (2003), which hold that the research must explicitly identify the direction of causality from the construct to the measure implied by the conceptual definition.

In this study, three key theories and perspectives influence the shape of the conceptual framework towards the formative order: DoI, TAM and SNT. Based on the discussion of those theories presented in Chapters 2 and 3, the research assumes that resistance can be identified by time of adoption and level of usage of technology. In explaining resistance comprehensively, the research considers that resistance towards new technology is influenced by a large number of factors, including support network, experience and disposition, integration, and the accessibility of technology to the individual. Based on the theoretical framework underlying the research model, as well as the research problems and aims, all items and constructs in the PLS model are formative (see Figure 4.6).

Techniques for model estimation and hypothesis testing will be discussed in Sections 4.4.7 and 4.4.8. As mentioned in Sections 4.4.2 and 4.4.6, there are two types of model and estimation: (1) measurement model and (2) structural model. Estimation of a measurement model is focussed on ensuring the consistency of all items to an individual construct. Estimation of a structural model emphasises the quality of all the constructs and the relationships between them.

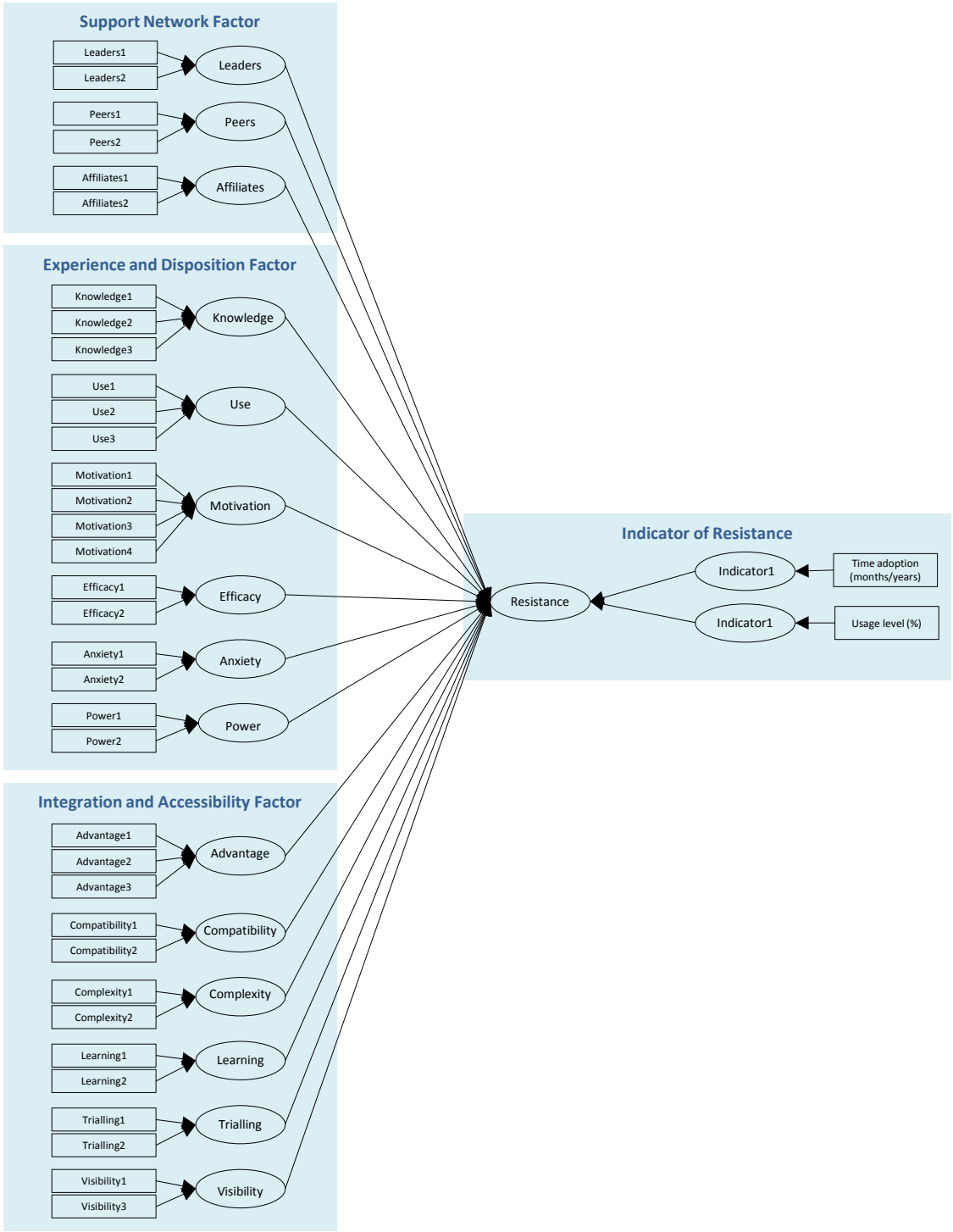

Figure 4.6: PLS diagram of estimation research model.

4.4.7 Assessing the PLS Measurement Model

Part of the PLS equation is built on evaluations to ensure the quality and consistency of measurement items. Another part is the whole quality of the hypothesised structure or path model (discussed in Section 4.4.8). The estimation process was specified by following the guidelines proposed by Diamantopoulos et al. (2008). The measurement model level will be estimated in two steps. The first step is an estimation of the quality of the formative measurement model through the indicator of significant weights. The second stage estimation is an assessment of the validity and reliability of all formative constructs using a multicollinearity and nomological validity approach. These estimations are described below.

4.4.7.1 Significant Weight

At the indicator level, the indicator needs to be assessed as to whether it significantly contributes to forming the relevant construct. The most appropriate statistic for assessing the validity or significance of a formative indicator is 'weight' or 'path coefficient' (Chin, 1998b). Significance of weights is usually built in such a way that each indicator/item is positively correlated to a construct. Acceptable cut-off values of weight (or t-value) for a two-tailed test are 1.65, 1.96 and 2.58 at significant levels (p-value) of 0.1, 0.05 and 0.01, respectively. To ensure the quality of the overall significant results, according to Chin (1998b), this estimation should also be examined by using a re-sampling technique (see Section 4.4.8.3).

The inclusion or exclusion of a non-significant variable or items should counter the conceptual foundation and theory. This is because a non-significant indictor is sometimes caused by a lack of theoretical relevance. Careless exclusion may remove a significant domain concept of the construct. However, a significant item sometimes contains redundant information, termed multicollinearity (Cenfetelli & Bassellier, 2009; Diamantopoulos et al., 2008).

4.4.7.2 Multicollinearity

According to Diamantopoulos and Winklhofer (2001), multicollinearity refers to an unnecessary element in a formative model. It can cause estimation difficulties in

assessing indicator validity. This problem arises because of the nature of the formative model itself: indicators must not be correlated or share a common theme to each other. Thus, it becomes difficult to separate the influence of individual items on the respective constructs. To deal with multicollinearity, the degree of multicollinearity is examined by calculating the variance inflation factor (VIF). According to Diamantopoulos and Siguaw (2006), VIF values in the range of 0.35 to 10 indicate the presence of critical collinearity. If the VIF is less than 3.5, it is considered as an excellent value.

However, in practice, the whole idea of the degree of multicollinearity is ambiguous. Diamantopoulos and Winklhofer (2001) themselves emphasised that the indicator elimination should not be purely statistical nor separated from the conceptual when a formative measurement model is involved, as this would eliminate the true meaning of the construct. For this study, multicollinearity is relevant, but it can also complicate the analysis process and create danger to the research results. To make it straightforward, multicollinearity will be treated as a secondary item. If multicollinearity exists in the statistics, it is probably not theoretical. Therefore, the model will be left as it is. This is the recommendation of Chin (1998b), who suggested that the problem of multicollinearity can be ignored if the research focus is at the structural level. Indeed, the focus of this study is on the structure of the model and the formation of new theory.

4.4.7.3 Nomological Validity

A few statistical techniques have been developed by scholars in the PLS area, to test the validity and reliability of the model. These include loadings, composite reliability, convergent and discriminant validity, and AVE. The composite reliability measure can be used to check how well a construct is measured by its assigned indicators. However, when employing formatively measured constructs, these techniques are inappropriate, as they are only valid for reflective constructs (Diamantopoulos & Siguaw, 2006). Use of these statistics for the formative construct would mislead the analysis and interpretation of results (Cenfetelli & Bassellier, 2009). In fact, according to Diamantopoulos et al. (2008), several scholars, including Bagozzi (2007b), Bollen and Lennox (1991) and themselves, continue to debate the necessity of reliability and validity measures in formative design. Bagozzi (2007b), for instance, believes that reliability testing of the formative measure by statistics is not meaningful, as the results

of the research can be supported by theory and expert opinion. However, a procedure for establishing the validity of formative constructs is important.

An approach to assess construct validity (either formative or reflective) is through nomological validity. Nomological validity determines whether a given construct relates to the focal construct as anticipated and is used as the basis for choosing which factors and questions are included in the study. As presented in Figure 4.6, the focal construct of this study is resistance. The statistics for assessing nomological validity are in the form of path coefficients. Each factor is validated based on the significance of the path coefficients derived from the statistical analysis. According to MacKenzie et al. (2011), if the path coefficients are significant then the constructs are conceptually related and the degree of confidence in the validity of the indicators is increased accordingly. Chin (1998a, p. xiii) stated that a path coefficient should have a value of at least 0.20 and ideally above 0.30 to be considered meaningful/significant in this regard.

4.4.7.2 Spearman's Correlation Coefficient

Generally, formal validity analysis techniques for formative design have not received the broad research attention. It is less developed within the SEM and PLS literature (Diamantopoulos et al., 2008; Henseler et al., 2012; Ringle et al., 2009). Until now, the consistency and validity of formative design have been almost exclusively limited to multicollinearity and nomological measures (Andreev et al., 2009; Diamantopoulos et al., 2008; Roberts & Thatcher, 2009). The validity assessments used for reflective design, such as loadings, composite reliability, convergent and discriminant validity and EVE, are not applicable to formative design (Andreev et al., 2009; Diamantopoulos et al., 2008).

Therefore, to improve the validity of all items, the research used Spearman's rank correlation coefficient, which is appropriate for measurement items based on scales (Kendall & Gibbons, 1990; Spearman, 1904). Spearman's rank correlation coefficient is a non-parametric method that assesses the relationship between two variables. The value or strength of the relationship between the two variables in a Spearman's correlation calculation is between +1 and -1. A Spearman's correlation closer to zero indicates no

tendency for the two variables to correlate. This technique has been applied successfully once previously, in a study by Haenlein (2004) on e-business success factors.

4.4.8 Assessing the PLS Structural Model

For the PLS, the structural model has to be designed as a causal chain, also known as a path model. Likewise, the path analysis in the regression technique, the path analysis of PLS, can be interpreted in a similar way. The quality of the structure of the model is based on the estimation of path coefficients and significance levels (Chin, 1998b). A statistical analysis for judging the structural model is a determination coefficient; that is, R^2. This estimation requires using a re-sampling technique (e.g. bootstrapping) to ensure accurate inferences, especially when the sample size is small.

4.4.8.1 R-square

The interpretation of R^2 in the PLS is similar to the multiple regression analysis (Chin, 1998b). In PLS, R^2 is used to predict the outcome of the model based on the relationship between the independent variables and dependent variables. The value of R^2 is in the range of 0 to 1. A R^2 near 1.0 indicates that a regression line fits the data well, while a R^2 closer to 0 indicates that the regression line does not fit the data well. No generalisations can be made about an acceptable value of R^2. The specific R^2 value depends on the individual study, although Chin (1998b) suggested R^2 values of 0.67, 0.33 and 0.19 in the PLS path model as substantial, moderate and weak. The higher the value of R^2, the better: a lower value demonstrates a weakness in the theoretical underpinnings and irrelevant LVs in the model.

4.4.8.2 Effect Size (f^2)

R^2 can also be extended to examine how well the exogenous LV acts as a predictor to the endogenous LV. This is known as the effect size (f^2). The f^2 values can be obtained based on the following calculation:

$$f^2 = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{included}}$$

$R^2_{included}$ is the R^2 of the exogenous LV when an endogenous LV is used in the model. $R^2_{excluded}$ is the R^2 of the endogenous LV when the same endogenous LV is removed from the model. According to Chin (1998b), once f^2 is obtained, the degree of effect can be determined with reference to criteria as set out by Cohen (1988), where the f^2 values are 0.02 (small effect), 0.15 (medium effect) and 0.35 (large effect).

4.4.8.3 Bootstrapping

Bootstrapping is a re-sampling technique that is commonly used to ensure the accuracy of PLS estimates (Chin, 1998b). Bootstrapping can create and replicate a number of random samples by selecting them from the original data set. Each case in the original samples provides a reliable probability that will enhance the path coefficient estimation. This is a very effective technique and it is often an alternative, especially for small samples, to increase the accuracy of the data analysis. There are no optimal numbers or correct sample sizes for PLS in the literature. However, for this study, 500 random replications of the orginal sample were used. This was assumed large enough and sufficient to achieve consistent analysis.

4.5 Phase 4: Interviews, Conclusion and Recommendations

4.5.1 Objectives of Phase 4

The objective of Phase 4 is to verify and improve the resistance model. This stage is also to seek informed opinion on the strategies being considered to manage resistance towards OPIMS. Data collection for this phase is from a series of semi-structured interviews. The interviews were undertaken from January to February 2013. The interview participants were selected from those who had participated in the questionnaire survey and expressed a willingness to be involved further.

4.5.2 Review of Techniques for Qualitative Approach

Five strategies are commonly used for the analysis of the qualitative interview data: narrative and life histories, visual data, discourse and spoken action, material assemblages and technologies, and places and space (Atkinson and Delamont, 2005). In framing the preferred approach, the consideration of each alternative technique should

be driven by the research objectives (Tesch, 1991). These are classified in terms of whether the focus is on language, description or theory building (Fellows & Liu, 2009). If the focus is on how language is used and what it means (talk and text), then the appropriate techniques will include content analysis, thematic analysis, discourse analysis and conversational analysis. If the research is attempting to develop a comprehensive understanding of the subject material or artefacts, then the most appropriate technique would be a narrative analysis. If the research seeks to develop theory from the data collected, then a grounded theory method is most likely the most appropriate option.

4.5.2.1 Conversation Analysis

Conversation analysis is sometimes referred to as talk-in-interaction analysis technique. In this method, the analysis can go deeper than what the participants might have said during a conversation. The researcher is interested in the language as an object of study (Sidnell, 2013). Words used in conversation behave as objects that can both form the conversation and reveal the expression of intentions, such as accusations, opinions, complaints and so forth. Conversation analysis is generally considered as a method that is purely for analysing speech. A related method, often referred to together with conversation analysis, is discourse analysis (Silverman, 2001). Discourse analysis, however, has a broader scope than does conversation analysis. Discourse analysis is a method that can be used to analyse written, verbal or semiotic events (sign language or body gesture language) (Peräkylä, 2005). A detailed comparison between conversation analysis and discourse analysis can be found in Hepburn and Potter (2004).

4.5.2.2 Content Analysis

Similar to conversation analysis, content analysis focusses on the characteristics of language as communication. Particular attention is given to the content or contextual meaning of the text as a means to provide knowledge and understanding of the phenomenon under study (Krippendorff, 2004 ; Lindkvist, 1981 ; Rosengren, 1981 ; Tesch, 1990; Weber, 1990). Words, phrases or units of text that have been classified or coded in the same category are assumed to have similar meanings (Weber, 1990). The source of such data/text can be collected from interviews, focus groups, observation or print media, and might be in verbal, print or electronic form.

4.5.2.3 Thematic Analysis

Another technique that seems identical to content analysis is thematic analysis. The main difference between these is that content analysis involves establishing meaning by quantifying the theme, while a thematic approach is based on specific patterns or manifestations of the theme in which the researcher is interested (Joffe & Yardley, 2004). This technique is employed to identify what themes exist in an information source, and to seek the most important theme systematically (Boyatzis, 1998). There is always the possibility, when data is very rich and robust, that some themes tend towards being latent and/or exist in a text at a different level. Hence, the structure (or network) of the themes needs to be identified prior to coding to have a clear depiction of themes (Braun & Clarke, 2006). Coding is the process of defining the data by specific meanings. Codes are labels to represent the meanings (Miles & Huberman, 1994). Codes can contain chunks or only part of phrases, words, sentences or paragraphs in the text. Codes can emerge independently, but have greater reliability when the codes/themes are extracted into specific categories that require logic or a conceptual lens. It is prudent when handling a thematic analysis that codes/themes are adequately supported by pre-existing theory.

4.5.2.4 Grounded Theory Method

According to Charmaz (2005), the grounded theory method is the most appropriate approach for theory development in qualitative studies. This method is characterised by the development of new theories based on data. The grounded theory method was introduced by Glaser and Strauss (1967). However, a bifurcation occurred later because of a disagreement between these two original authors on which epistemological stance (objectivist or constructivist) is most correctly underlying the grounded theory method (Bryant & Charmaz, 2007). Glaser and Strauss (1967) state that when developing a new theory, it should be drawn from the data and not from pre-existing concepts or theories. This was justified to allow the researcher more freedom in understanding the situations under study. Later, however, Strauss and Corbin (1990) reworked grounded theory and proposed the technique of the coding matrix to conceptualise the theme and develop a new theory. This was in contrast to Glaser's (1992) argument that developing a new theory should only be explained by the phenomenon under study (Goulding, 2002). The

consequence of this dispute is that the coding procedure has been split into two techniques. Strauss and Corbin (1990) suggest that codes have dimensions and properties, where codes and coding can be chosen/based on the theory. Glaser (1992) argues that codes do not emerge from data, which is influenced by pre-existing theory; rather, codes emerge within the data. The process of identifying codes advocated by Glaser (1992) relies on hunches and intuition (Holton, 2007).

4.5.2.5 Narrative Analysis

Narrative analysis differs from, but can complement, techniques such as content analysis and discourse analysis. There are general similarities between the characteristics of these techniques, which are interpretive and use language/text as an object of analysis. The tradition of narrative is the field of sociology, early life histories and anthropology (Chase, 2005). Researchers in this field typically use stories, life experiences, old photos, drawings and other artefacts as the objects of the analysis (Clandinin & Connelly, 2000). The range of objects provides for a better understanding across the whole meaning; for example, the means by which people create meaning in their culture. Narrative analysis is also used to build information on personal experiences, the experiences of others or fictions (such as stories, myths and folktales). Objects for analysis using the narrative method are typically gathered through interviewing. The researcher and participants are engaged in creating the meaning of questions and answers and understanding through language (Czarniawska, 2004; Riessman, 1993). For instance, to study the history of the construction of the Sydney Harbour Bridge, researchers would collect stories through interviews with engineers and project workers who were involved with the construction at that time. However, rather than solely relying on a coding of the text/speech/language gathered from such interviews as the only object of analysis, various artefact sources (e.g. drawings and photographs) can be used to identify the chronological history.

4.5.3 Justification for Using Thematic Analysis

All of the techniques reviewed thus far are relatively common in construction management research. Content analysis, for example, has been used in a study by Lingard et al. (2000) to examine employee perceptions of the solid waste management

system, and in Teo and Loosemore (2001) to analyse participants' opinions on waste management via focus group study. Narrative analysis has been used in Löwstedt and Räisänen (2012) to draw out middle managers' stories on the chronology of changes occurring in a construction organisation. A combination of grounded theory and content analysis has been used in Loosemore (1999) on crisis management research. Thematic analysis has been used in Bowen et al. (2012) to study the corruption problem in the construction industry. Results of thematic analysis in the study of Bowen et al. (2012) were used to confirm the results of a quantitative survey, and to build up a theoretical understanding of the nature and emergence of corruption. The source of data used in Bowen et al. (2012) was texts that had been transcribed from interviews.

Like Bowen et al. (2012), thematic analysis is appropriate for analysing interview data in this study. Thematic analysis was chosen because of the correlation between the research objective and methodological needs. The research objective of Phase 4 is to support the quantitative findings and to seek recommendations to manage resistance. Even though there is little apparent theory and empirical work specifically representing resistance or on how resistance can be managed, existing theories (i.e. DoI and TAM) can be used to support the building of codes/themes.

The current research used a thematic method mainly because of its flexibility. Thematic analysis can be used in two different positions at the same time: inductive and deductive (Attride-Stirling, 2001; Boyatzis, 1998; Tuckett, 2005). From an inductive perspective, thematic analysis can be used in theory building, interpretive or early exploration. It has been suggested that thematic analysis is the most appropriate method for any study that seeks to explore new ideas using an interpretative approach (Attride-Stirling, 2001). This method allows meaning to be associated with and derived from an analysis of the frequency of themes. The focus of thematic analysis is on the 'essence' of a text; that is, on what is said, more than how it is said. Thematic analysis assumes that language and text are relatively direct in their meaning, unlikely to lead to an ambiguous interpretation. The presumption is that themes can be explored and 'induced' from the data. From a deductive point of view, themes that need to be identified often are already partly conceptualised. Codes emerge from the data, influenced by the concepts of a pre-existing theory. The concepts can be transformed into specific codes/themes and

predetermined prior to analysis. It is a systematic procedure, in which coding can link the data to pre-existing theory, and the process of removing unnecessary themes can be managed efficiently.

Thematic analysis has a few disadvantages. The main drawback is reliability (Boyatzis, 1998; Braun & Clarke, 2006). Thematic analysis is a text-based analysis, so any interpretation is subjective. For this reason, without an existing theoretical and conceptual framework, interpretation and description of the thematic results is limited. Thus, to ensure greater reliability of research results, data should be coded according to an appropriate theory and concepts.

For this thesis, the pre-existing concepts were integrated with emergent codes/themes. It is often useful and effective to use theory to generate codes/themes, but it is also possible for a theme to emerge and go beyond the theory. With this in mind, the coding included pre-existing concepts as part of the constant comparative process, but new themes were also identified during the course of the coding process. The approach adopted here is therefore a balance between deductive and inductive coding. Still, coding can be a fraught process because there is always a tendency for researchers to focus on issues related to their interests rather than those that concern the participants (Fereday & Muir-Cochrane, 2006).

4.5.4 Process of Thematic Analysis and Themes Development

Thematic analysis was performed based on the systematic process proposed by Braun and Clarke (2006):

i. Step one is data familiarisation. Familiarisation involves immersion in the data, listening to audio recordings, reading transcripts and studying observational notes. A transcription may have to be read several times before it is understood and the relevant codes can be noted down for step two.
ii. Step two involves production of initial codes, as derived from the data.
iii. Step three is about searching for themes. At this stage, initial codes are sorted into potential themes.

iv. Step four is about reviewing the themes. The themes are checked and refined to ensure coherent meaning. Some themes can be removed and some can be split into sub-themes. During the process, a thematic 'map' of the analysis is produced.

v. Step five is defining and naming themes. At this point, the meaning of each theme has to be in accordance with the overall story about the data and the research objectives. This must conform to the resistance factor model, discuss relationships among resistance factors/variables and find strategies to manage resistance.

vi. The final step, step six, is reporting the thematic analysis results. The task of writing-up the report or telling the complicated story of interviews and thematic results is strengthened by including representative narrative arguments (quotations from the interviews) connected to the research objectives.

The current research combined different positions in its thematic analysis. This included engage with the underlying theoretical and conceptual themes when coding, and discover emergent codes that exist in the data. Prior to each interview, the codes/themes in the already collected data were mapped to identify the patterns of meaning and issues of potential interest. Mapping themes into networks can help to structure the extraction onto three levels (Attride-Stirling (2001):

i. The basic theme is the lowest order evident in the text. This theme acts as a backing statement that established significance around the central notion of the organising theme. The organising theme is a middle-order theme, surrounded by basic themes.

ii. The organising theme is a cluster or a group formed by basic themes. The organising theme is more abstract and about a broader subject matter. A group of organising themes are very significant to enhance the meaning of the principal theme. A group of organising themes constitutes a global theme.

iii. The global theme is the principal theme. This theme is a subject or claim that is formed by a group of cluster or organising themes. It is also considered as a super-ordinate theme that generates and encapsulates the principal metaphor in the text as a whole.

The resulting thematic network can be developed starting from the basic themes inwards towards the global theme. First, basic themes are identified and classified according to the organising themes. The organising themes are then reinterpreted based on basic themes, and brought together to illustrate the principal theme. The principal theme then becomes the global theme.

A thematic analysis was also used to support the quantitative findings. Thus, all themes developed were guided by the research model and the qualitative findings from Phase 3. Two principal themes are proposed in this study: (1) critical factor of resistance and (2) strategy to overcome resistance. These two themes were created in relation to the research objectives, which are to discover the critical factors of resistance and develop a strategy to overcome resistance in an organisation. The lowest order themes that support the principal themes were not identified because the research aimed to obtain as much information and as many opinions as possible from participants, to create results as free from bias as possible.

4.5.5 Interview Instrument

The interviews were used to support/challenge the overall survey findings. Thus, in designing the interview questions, some key information from the survey results was used to give structure and as a guide.

There are three possible approaches to a qualitative interview: informal conversational interviews, the interview guide approach and standardised open-ended interviewing (Patton, 1990). The informal conversational interview is the purest form of qualitative approach. It is completely unstructured and questions are often delivered naturally and spontaneously. The guided interview approach is pre-structured and topics are listed explicitly in the interview procedure. A guided interview can still be reworded as required, and questions can be presented in any sequence or order. The standardised open-ended interview is completely structured. This type of interviewing is based on open-ended questions. The wording and sequence of questions outlined in the interview procedure is consistently applied across all participants. In mixed methods, the researcher may use one or a mixture of unstructured, pre-structured and structured forms of question and procedure in the interview. Open-ended and close-ended items

can be included in a single interview procedure, or in two separate procedures that are used in a single study, to produce a deep interview result and breadth of understanding about the research problem (Johnson & Turner, 2003).

For the purpose of the current study, a pre-structured interview was deemed appropriate. The questions are formulated based on several critical topics and sub-topics derived from the quantitative survey results from phase 1. Topics and sub-topics are identified rather than specific questions. In that circumstance, the research benefits from a fairly open and unstructured framework that gives the researcher more freedom to explore issues as a matter of course rather than pre-empting the issues (Patton, 1990). Deeper information can also be obtained from the guided interview procedure, which is delivered through natural and spontaneous interaction with participants in an informal conversational mode. Even though the research identified a set of topics and sub-topics beforehand, so that the interview process functioned smoothly, the interviews were conducted flexibly by asking questions such as 'what else might be a significant resistance factor?' This flexible approach was made possible because the interview participants were selected from the survey participants and/or had a clear understanding of the research inquiry.

4.6 Summary

The main aim of this research is to develop a comprehensive model of resistance factors identified from the literature, and to test and verify the model. To that end, a quantitative approach alone is deemed inadequate for studying resistance. Because of the dynamic nature of the industry and the resistance problem itself, complementing a quantitative approach with a qualitative approach may be helpful to understand the relationships that exist among the resistance factors. Thus, a mixed methods approach was adopted.

For the purposes of this research, the mixed methods approach will be utilised sequentially. Priority will be given to the quantitative approach, with the quantitative phase conducted first, before the qualitative phase. Data is also collected in two stages. The quantitative data is collected and analysed prior to collecting and analysing the qualitative data. This decision was influenced by the main objective of the study, to

explore the critical factors associated with resistance to new technology. Qualitative analysis is for the purposes of confirmation of the factors and understanding more deeply how to overcome the resistance problem. A summary of methods and processes involved in the research is illustrated in Figure 4.7.

Even though the mixed methods approach is resource intensive and time consuming, the potentially divergent findings created through using differing data collection and analysis techniques in combination will provide richness, depth and breadth to the overall results and increase the credibility of the findings. Discussion of the quantitative and qualitative findings will be presented individually in Chapters 5 and 6.

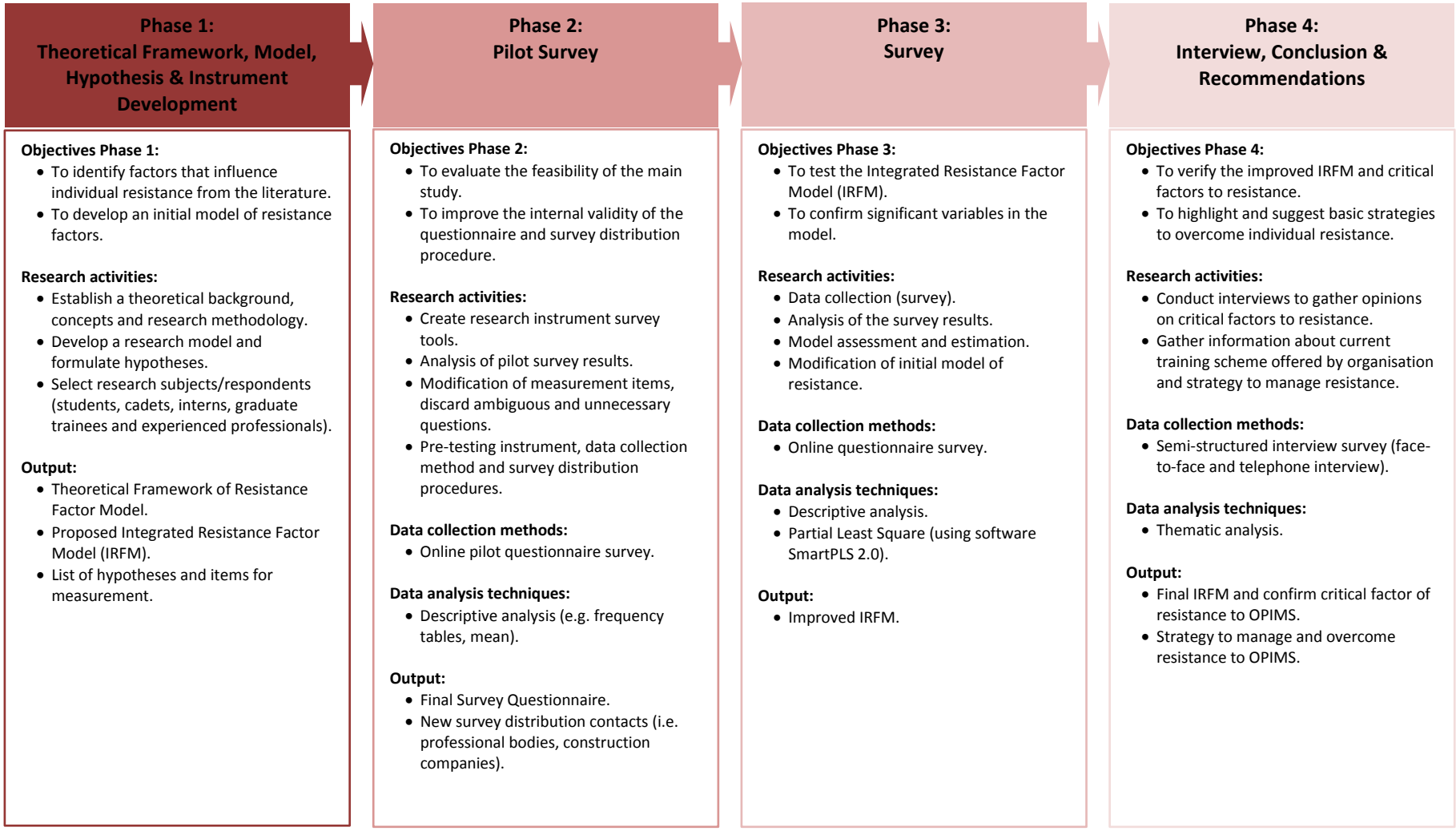

Figure 4.7: Method, process and phases of research.

Chapter 5: Quantitative Data Analysis and Results

This chapter presents the quantitative analysis and results of the survey data. It consists of five sections. The first section describes the preliminary analysis and data examination prior to model analysis. This is followed by the response analysis, and the distribution and profile of respondents. The results of the evaluation of the measurement and structural models are presented in the subsequent two sections, in which both models were analysed and tested using the PLS method and the statistical software SmartPLS 2.0 (M3) Beta.

5.1 Preliminary Analysis and Data Examination

A missing values analysis was conducted to produce a clean data set for model estimation. Missing values can be categorised as missing completely-at-random, missing-at-random and not-at-random (Little & Rubin, 2002). When data are missing completely-at-random, this implies there is no systematic pattern to the missing data. This can happen when the data is either not theoretically related or not part of the target sample. Missing-at-random implies that some of the missing data is known and is examinable by other patterns or from collected data within the sample. If the pattern of missing data is somehow related to other outcomes or unobserved data, then it is said to be not-at-random or non-ignorable missing data.

In the current research study, data from 112 cases were collected, including approximately 22 per cent missing values. The following cases were deleted or omitted from the data set: (1) five cases in which the questionnaires were incomplete and (2) 19 cases in which a targeted criterion (previous user experience of OPIMS) was not satisfied. This relatively low percentage of missing values can be characterised as data missing completely-at-random (Little & Rubin, 2002). This left 88 valid cases for the analysis. The research also contained data that were missing-at-random. However, those missing data can be defined by a combination of other observed values. In any event, the missing data within the valid 88 cases only accounted for one per cent of the total data; and in that circumstance, the small shortfall can be resolved by a number of approaches (Little & Rubin, 2002). No not-at-random or critical unobserved missing data were identified.

Several methods are available by which small proportions of missing data can be made up. Two popular approaches are the ML approach and the substitution of simple mean and/or regression mean (Allison, 2001; Little & Rubin, 2002; Schafer & Graham, 2002). Table 5.1 provides a summary of the elements of each data set that were missing. The total data to be analysed totalled 3344 cases, with each variable in the model being associated with one of the 88 data sets. However, some of the variables, for example, Knowledge1 had one data point missing. Missing data were replaced with the mean value most relevant to the variable. Data were missing in 32 cases, which is close to one per cent of the total expected data. In a situation such as this, where the amount of missing data is relatively small, the mean approach is the most effective and practical. Some researchers suggest that with 1 per cent missing data, mean substitution and regression are efficient procedures (Rubin et al., 2007).

Table 5.1: Number of missing data points within valid cases.

Data set / Variable name	Number of missing values in data set	Expected data set
Resistance		
Indicator1(Time) -> Resistance	0	88
Indicator2(Usage) -> Resistance	0	88
Leaders		
Leaders1 -> Leaders	0	88
Leaders2 -> Leaders	0	88
Peers		
Peers1 -> Peers	0	88
Peers2 -> Peers	0	88
Affiliates Support		
Affiliates1 -> Affiliates	0	88
Affiliates2 -> Affiliates	0	88
Knowledge of ICTs		
Knowledge1 -> Knowledge of ICTs	1	88
Knowledge2 -> Knowledge of ICTs	1	88
Knowledge3 -> Knowledge of ICTs	0	88
Use of ICTs		
Use1 -> Use of ICTs	1	88
Use2 -> Use of ICTs	0	88
Use3 -> Use of ICTs	0	88
Motivation		
Motivation1 -> Motivation	0	88
Motivation2 -> Motivation	1	88
Motivation3 -> Motivation	1	88
Motivation4 -> Motivation	2	88
Efficacy		
Efficacy1 -> Efficacy	0	88
Efficacy2 -> Efficacy	0	88
Anxiety		
Anxiety1 -> Anxiety	1	88

Anxiety2 -> Anxiety	2	88
Power		
Power1 -> Power	1	88
Power2 -> Power	1	88
Advantage		
Advantage1 -> Advantage	1	88
Advantage2 -> Advantage	2	88
Advantage3 -> Advantage	1	88
Compatibility		
Compatibility1 -> Compatibility	1	88
Compatibility2 -> Compatibility	1	88
Complexity		
Complexity1 -> Complexity	2	88
Complexity2 -> Complexity	1	88
Learning		
Learning1 -> Learning	1	88
Learning2 -> Learning	0	88
Trialling		
Trialling1 -> Trialling	1	88
Trialling2 -> Trialling	2	88
Visibility		
Visibility1 -> Visibility	1	88
Visibility2 -> Visibility	0	88
Visibility3 -> Visibility	1	88
Total	**32 (0.96%)**	**3344 (100%)**

5.2 Responses, Distribution and Profile of Respondents

5.2.1 Age and Gender

Over the six-month period of data collection, between June and December 2012, 112 responses were received. Of these, 24 responses were excluded due to invalid responses or having no direct link to the targeted respondent (OPIMS user), leaving the number of valid questionnaires to be analysed at 88. Out of these valid questionnaires, as shown in Table 5.2, 65 respondents were male and 23 were female. The table also shows that the age distribution of respondents within the sample indicates a high concentration of employees in the 20 to 40 year age band. The largest proportions of respondents were in the 30 to 40 year age group (45 per cent), followed by the 20 to 30 year age group (38 per cent) and 40 to 50 year age group (13 per cent).

Table 5.2: Age and gender of respondents.

		Gender			
		Female	Male	Total	Per cent
Age	< 20 years	0	2	2	2%
	20 < 30 years	9	24	33	38%
	30 < 40 years	12	28	40	45%
	40 < 50 years	2	9	11	13%
	50 < 60 years	0	2	2	2%
	Total	23	65	88	

5.2.2 Education Level, Employment Status and Work Experience

Sixty respondents described themselves as a professional: a person who is engaged in full-time employment. Professionals in this study were varied and employed as architects, building surveyors, CAD operators, construction managers and so on (see Table 5.3). Thirteen respondents regarded themselves as project managers and 11 described themselves as 'other'. Among respondents, specified job positions were project coordinator, document controller, risk manager, human resources manager, procurement officer and IT manager.

The sampling in this study was taken from a frame that covered all possible categories of interest, different levels of OPIMS user and different levels of employee, including permanent employees and cadets (refer Section 4.2.2). Table 5.3 also shows that 28 of the respondents who participated in the survey were enrolled in university as a student and involved in a cadetship, internship or graduate program. Eight of the students were in the broad position of contract administrator, five were engineers and the rest had varied roles such as surveyor, architect and site supervisors.

Table 5.3: Employment status and job position.

Employment Status				
		Employee	Student	Total
Job Position	Architect	2	1	3
	Building Surveyor	4	3	7
	CAD Operator	2	1	3
	Construction Manager	2	0	2
	Contract Administrator	8	8	16
	Engineer	5	5	10
	Facilities Manager	2	2	4
	Foreman/Builder	0	1	1
	Project Manager	13	1	14
	Property Development	2	0	2
	Quantity Surveyor	6	3	9
	Site Supervisor	3	1	4
	Others	11	2	13
	Total	60	28	88

The education levels of the respondents (included experienced employees and students) in this study are given in Tables 5.4 and 5.5. As shown in Table 5.4, half of those who identified themselves as employees held a bachelor degree (50 per cent), followed by diploma and certificates (27 per cent) and masters or PhD (23 per cent).

Table 5.4: Education level of professional respondents.

Education Level		
Diploma and Certificates	16	27%
Undergraduate, Bachelor and Honours	30	50%
Postgraduate, Masters and PhD	14	23%
Total	60	

Respondents in this study who identified themselves as students were still studying at the certificate or diploma level (2 respondents), undergraduate level (24 respondents) or postgraduate level (2 respondents). The distribution by education level and status of students is shown in Table 5.5. Students were enrolled in a variety of programs: 39 per cent of students were enrolled in the area of building and construction, 21 per cent in engineering, 18 per cent in architecture and the rest were in quantity surveying or property management and development.

Table 5.5: Student enrolment status and field program.

		Current Enrolment Status				
		Diploma & Certificates	Undergraduate, Bachelor & Honours	Postgraduate, Masters & PhD	Total	
Field Program	Architecture	1	3	1	5	18%
	Building & Construction	1	10	0	11	39%
	Engineering	0	5	1	6	21%
	Facilities Management	0	3	0	3	11%
	Property Development	0	1	0	1	4%
	Quantity Surveying	0	2	0	2	7%
Total		2	24	2	28	

Table 5.6 shows the work experience of the respondents in this study. About 25 per cent of respondents had five or more years working with their current employer, 10 per cent 4 < 5 years, another 10 per cent 3 < 4 years, 13 per cent 2 < 3 years and 8 per cent were within 1 < 2 years. The remaining 34 per cent had worked for less than 1 year with their current employer.

Table 5.6: Work experience.

		Respondents			
		Employee	Student	Total	
Work experience with current employer	< 6 months	1	11	12	14%
	6 months < 1 year	8	10	18	20%
	1 < 2 years	2	5	7	8%
	2 < 3 years	9	2	11	13%
	3 < 4 years	9	0	9	10%
	4 < 5 years	9	0	9	10%
	5 or more years	22	0	22	25%
Total		60	28	88	

5.3 Evaluation of Measurement Model

5.3.1 Significant Weights

The aim of evaluating the measurement model is to address the validity and reliability of the items in the measurement variables. Validity is concerned with whether appropriate measures have been used to reflect the concept of the construct, while reliability assesses the accuracy of the actual measuring instrument. For a formative design, the validity of measures should be determined based on significant weight.

Indicator weights measure the contribution of each formative indicator and can be obtained via a bootstrapping procedure in SmartPLS 2.0 (M3) Beta, developed by Ringle et al. (2005). The weights, coupled with the associated t-value and p-value, provide evidence for the extent to which particular indicators are statistically significant and explain the variance in the formative items of the model. Conventional cut-off values for significant weights in t-values are 1.65, 1.96 and 2.58 at significant levels (p-values) of 0.1, 0.05 and 0.01, respectively (see Section 4.4.7.1). In a social science context, the ideal p-value is generally taken to be 0.05 (at t-value 1.96) and 0.01 (at t-value 2.58). However, given the exploratory nature of the study, more conservative and substantially higher values have been applied. A p-value of 0.1 (t-value 1.65) is achievable for this study.

The significant weight results for all measurement items are shown in Table 5.7. The results reveal that 16 of the estimated formative indicators are statistically insignificant, based on a p-value of 0.1 (t-value should be greater than 1.65). However, based on consistency with correlation analysis (discussed in Section 5.3.2), only six items were removed from the model. The items removed were item Knowledge3 of construct Knowledge, item Use3 of construct Use, items Motivation1 and Motivation3 of construct Motivation, item Advantage3 of construct Advantage and item Visibility2 of construct Visibility. Several items were retained even when the p-value did not reach 0.1 (t-value less than 1.65); namely, items Immediate2, Leader1, Knowledge2, Efficacy2, Anxiety1, Power2, Advantage2, Compatibility2, Complexity2 and Learning2. These items were retained because they are conceptually relevant. Removing these items would have reduced the meaning of the construct. Another validation method to support retaining these items is presented in Section 5.3.2.

Table 5.7: Formative constructs, indicators, items and significant weights.

Constructs and Items	PLS weights	t-statistics	p-value
Resistance			
Indicator1 (Time Adoption) -> Resistance	0.84	4.16	0.00
Indicator2 (Usage Level) -> Resistance	0.55	2.01	0.05
Leaders			
Leaders1 -> Leaders	0.35	1.18	0.24
Leaders2 -> Leaders	0.88	3.14	0.00
Peers			
Peers1 -> Peers	0.74	2.53	0.01
Peers2 -> Peers	0.70	2.61	0.01
Affiliates			
Affiliates1 -> Affiliates	0.92	4.82	0.00
Affiliates2 -> Affiliates	0.33	1.28	0.20
Knowledge of ICTs			
Knowledge1 -> Knowledge of ICTs	1.15	3.36	0.00
Knowledge2 -> Knowledge of ICTs	0.21	0.66	0.51
Knowledge3 -> Knowledge of ICTs	***-0.45***	***1.36***	***0.18****
Use of ICTs			
Use1 -> Use of ICTs	0.95	2.96	0.00
Use2 -> Use of ICTs	-0.53	1.65	0.10
Use3 -> Use of ICTs	***-0.35***	***1.00***	***0.32****
Motivation			
Motivation1 -> Motivation	***-0.27***	***0.75***	***0.45****
Motivation2 -> Motivation	0.46	1.67	0.10
Motivation3 -> Motivation	***0.00***	***0.00***	***1.00****
Motivation4 -> Motivation	0.80	2.86	0.00
Efficacy			
Efficacy1 -> Efficacy	1.17	4.51	0.00
Efficacy2 -> Efficacy	-0.27	0.86	0.39
Anxiety			
Anxiety1 -> Anxiety	0.32	0.75	0.45
Anxiety2 -> Anxiety	0.76	1.84	0.07
Power			
Power1 -> Power	0.91	4.54	0.00
Power2 -> Power	0.18	0.75	0.45
Advantage			
Advantage1 -> Advantage	0.95	2.19	0.03
Advantage2 -> Advantage	0.31	0.95	0.34
Advantage3 -> Advantage	***-0.26***	***0.72***	***0.47****
Compatibility			
Compatibility1 -> Compatibility	0.84	2.42	0.02
Compatibility2 -> Compatibility	0.22	0.58	0.56
Complexity			
Complexity1 -> Complexity	0.90	3.72	0.00
Complexity2 -> Complexity	0.18	0.69	0.49
Learning			
Learning1 -> Learning	1.30	3.90	0.00
Learning2 -> Learning	-0.48	1.09	0.28
Trialling			
Trialling1 -> Trialling	-2.08	2.37	0.02
Trialling2 -> Trialling	2.68	3.15	0.00
Visibility			
Visibility1 -> Visibility	0.68	2.29	0.02
Visibility2 -> Visibility	***-0.53***	***1.24***	***0.22****
Visibility3 -> Visibility	0.89	2.26	0.02

** Items for deletion

5.3.2 Spearman's Correlation Coefficient

According to the formative principle (refer Section 4.4.6), items do not need to be correlated or to share similar contents/meaning. Correlation between items should be low because high correlation will imply overlapping items or items that measure the same thing. For example, in the measuring construct Knowledge (as shown in Table 5.8), there are two items: Knowledge1 and Knowledege3. The two items show a high correlation (.612). On further consideration, and mostly due to the ambiguous phrasing of the questions in the survey, both of these items measure respondents' understanding of how to use and apply ICT effectively. In light of this duplication, one of the items was removed.

Table 5.8: Correlation between items measuring Knowledge of ICTs.

	Knowledge1	Knowledge2	Knowledge3
Knowledge1	1.000	.336	.612
Knowledge2	.336	1.000	.425
Knowledge3	**.612**	.425	1.000
Note: Cohen's conventions for correlation .100 = small, .300 = medium, .500 = large			

An analysis of the results in this way confirmed a consistent pattern in the correlation between items and the significant weight values. A similar process was then used to qualify items and remove all unnecessary items for the final model. The other unnecessary items were identified as Use3, Motivation1, Motivation3, Advantage3 and Visibility2. While the relevance and application of this procedure/technique has not been proven beyond doubt in the PLS domain, it has been used previously by others (Haenlein, 2004). A comprehensive correlation analysis for all items is given in Appendix F.

5.3.3 Multicollinearity Analysis

Multicollinearity analysis deals with redundant items/indicators in the formative model (Diamantopoulos et al., 2008; Diamantopoulos & Winklhofer, 2001). This analysis was performed using a multiple regression procedure in SPSS. In the regression results, VIF and condition index were used as indicators of multicollinearity. VIF values in the range of 3.5 to 10 and a condition index greater than 10 suggest critical collinearity

(Diamantopoulos & Siguaw, 2006). VIF values below 3.5 are considered excellent values.

As shown in Table 5.9, almost all VIF values for the formative variables in this study were less than 3.5. Only one variable (i.e. Compatibility) exceeded 3.879 for VIF; however, this is still within the index and much less than 10. Thus, the VIF test indicated no multicollinearity problems. This confirms the reliability of the indicators.

Table 5.9: Analysis of multicollinearity using VIF.

Construct Name	VIF
Leaders	1.357
Peers	2.154
Affiliates	2.064
Knowledge of ICTs	1.215
Use of ICTs	1.319
Motivation	2.593
Efficacy	2.144
Anxiety	1.666
Power	2.472
Advantage	2.334
Compatibility	3.879
Complexity	2.653
Learning	2.134
Trialling	1.764
Visibility	2.131

5.3.4 Nomological Validity

Table 5.10 gives a concise summary of the nomological validity. Nomological validity was assessed after the items were reduced (see Sections 5.3.1 and 5.3.2) and after the results of the structural model were obtained (see Section 5.4.1). The validity was examined through the standardised path coefficient (or PLS weights) and significance level of the estimated structural path between the independent constructs and dependent construct (Diamantopoulos et al., 2008). For the purpose of nomological validity analysis, Resistance was specified as the dependent construct and the constructs Leaders, Peers, Affiliates, Knowledge and the rest were considered as independent.

Table 5.10: Nomological validity.

Independent Construct -> Dependent Construct	PLS weights	t-statistics	p-value
Leaders -> Resistance	0.24	2.26	0.02
Peers -> Resistance	0.17	1.60	0.11
Affiliates -> Resistance	0.07	0.76	0.45
Knowledge of ICTs -> Resistance	0.01	0.05	0.96
Use of ICTs -> Resistance	-0.06	0.73	0.47
Motivation -> Resistance	-0.08	0.35	0.73
Efficacy -> Resistance	0.12	1.08	0.28
Anxiety -> Resistance	0.16	1.34	0.18
Power -> Resistance	0.07	0.60	0.55
Advantage -> Resistance	0.17	1.47	0.14
Compatibility -> Resistance	0.27	1.70	0.09
Complexity -> Resistance	0.38	2.37	0.02
Learning -> Resistance	-0.05	0.41	0.68
Trialling -> Resistance	0.37	1.94	0.05
Visibility -> Resistance	-0.06	0.54	0.59

Based on these results, support network from Affiliates (e.g. technical staff), thought to be conceptually important, was not statistically significant on Resistance. The path coefficient (PLS weight) between Affiliates and Resistance was found to be 0.07, with a p-value of 0.45. This is far greater than the acceptable value for the 0.10 significance level. However, since the constructs are all formative, they should not be discarded based on statistical outcome, as this action could substantially change the formative meaning. The result for Affiliates and Resistance shows that, for the case of this study at least, Affiliates may not be a critical factor in influencing Resistance towards OPIMS.

Further, the assumption that independent constructs influence the dependent construct of this study was supported by the robust underlying theory. A number of independent constructs were not significant towards Resistance. However, given the aim of this study to present a research case for forecasting the presence of resistance and understanding this issue, it was not necessary for the independent constructs to be statistically significant. The insignificant constructs were shown to be 'non-critical' factors in statistical terms; yet, these same constructs have been identified as critical influences in the research literature specific to OPIMS. More generally, the results were found to be consistent with the theory detailed in Chapter 2, and are supported by the results from the R^2 test in Section 5.4.1.

5.4 Evaluation of the Structural Model

5.4.1 R-squared

The structure of the model was assessed using the R^2 statistic. R^2 is a suitable statistic to assess the goodness of the prediction of the model. It indicates to what extent the independent construct helps to predict or explain the dependent construct. The R^2 was also evaluated using the t-statistics and p-values of the structural path coefficients (PLS weights) using the re-sampling procedure (bootstrap). Path coefficient values should be in the range of 0.20 to 0.30, or greater (Chin, 1998a).

The structural model resulting from the PLS analysis is illustrated in Figure 5.1. Table 5.11 gives a detailed summary of the estimated structural path coefficient (PLS weights), the observed t-values from the re-sampling procedure and the significance level of the path coefficient. In Figure 5.1, the proposed model has a performance R^2 value of 0.484, which is sufficient to conclude that the values are substantial (Chin, 1998b). Based on this result, overall, the structural model has been verified as adequate. It explains a reasonably large and acceptable proportion of the variance in all the constructs to predict the resistance factors.

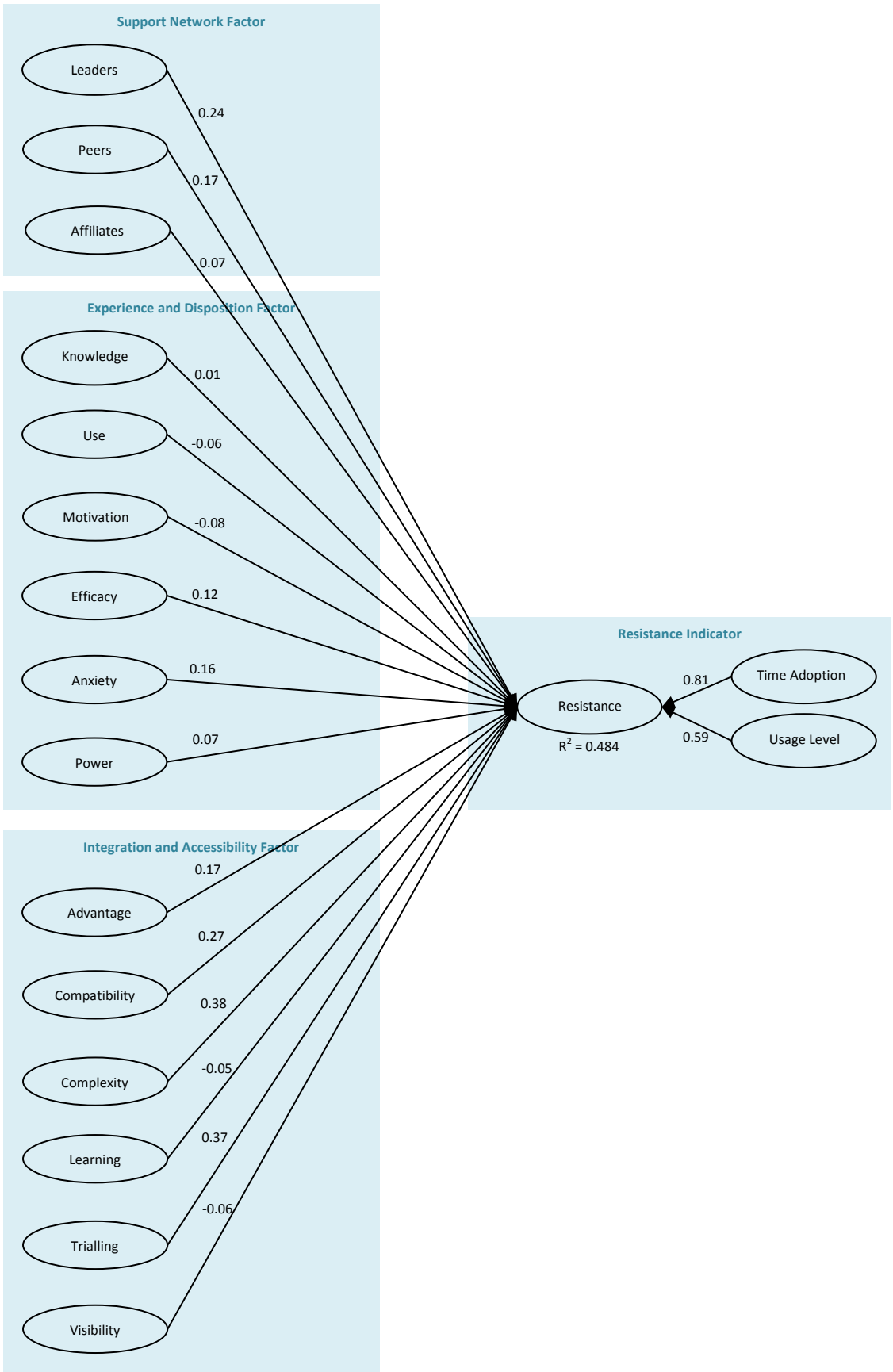

Figure 5.1: Structural model result.

Table 5.11: Summary of structural model path results.

Constructs and Items	PLS weights	t-statistics	p-value	Significance Level
Time Adoption -> Resistance	0.81	3.50	0.00	Significant at 0.00 level
Usage Level -> Resistance	0.59	2.09	0.04	Significant at 0.05 level
Leaders -> Resistance	0.24	2.26	0.02	Significant at 0.05 level
Peers -> Resistance	0.17	1.60	0.11	Not significant
Affiliates -> Resistance	0.07	0.76	0.45	Not significant
Knowledge of ICTs -> Resistance	0.01	0.05	0.96	Not significant
Use of ICTs -> Resistance	-0.06	0.73	0.47	Not significant
Motivation -> Resistance	-0.08	0.35	0.73	Not significant
Efficacy -> Resistance	0.12	1.08	0.28	Not significant
Anxiety -> Resistance	0.16	1.34	0.18	Not significant
Power -> Resistance	0.07	0.60	0.55	Not significant
Advantage -> Resistance	0.17	1.47	0.14	Not significant
Compatibility -> Resistance	0.27	1.70	0.09	Significant at 0.10 level
Complexity -> Resistance	0.38	2.37	0.02	Significant at 0.05 level
Learning -> Resistance	-0.05	0.41	0.68	Not significant
Trialling -> Resistance	0.37	1.94	0.05	Significant at 0.05 level
Visibility -> Resistance	-0.06	0.54	0.59	Not significant

As a result of the retention and reduction of items that was performed (discussed in Sections 5.3.1 and 5.3.2), some formative constructs show insignificant path coefficients towards the construct Resistance. As can be seen in Table 5.11, 11 constructs did not reach path coefficients (PLS weights) greater than 0.20, a significant p-value of at least the 0.1 level and a t-value greater than 1.65. These 11 constructs were Peer, Affiliate, Knowledge, Use, Motivation, Efficacy, Anxiety, Power, Advantage, Learning and Visibility. However, insignificant results for these constructs do not contain threats to the prediction power or R^2 values because all constructs were supported by sufficient theoretical background (as detailed in Chapters 2 and 3).

An interesting finding in Table 5.11 relates to hypothesis testing; specifically, what indicates Resistance or identifies resistance behaviour. The research hypothesised that time of adoption of OPIMS (indicator Resistance1) and average percentage of use of OPIMS daily (indicator Resistance2) could be used to measure Resistance. Based on the results, both were verified as appropriate measures to indicate Resistance, with both having t-values greater than 1.65 and reaching a significant level. Thus, the results correspond to Hypotheses 1 and 2, which claim that resistance towards OPIMS is significantly measured by time of adoption and level of use of technology. A summary of the results of the hypotheses is given in Table 5.12.

Table 5.12: Summary of results of hypothesis testing in the structural model.

Hypotheses	Results	Verification of Structural Paths		
		PLS weights	t-statistics	p-value
Time Adoption -> Resistance Hypothesis 1: Resistance towards OPIMS is significantly indicated by time of adoption.	Supported	0.81	3.50	0.00
Usage Level -> Resistance Hypothesis 2: Resistance towards OPIMS is significantly indicated by the individual usage level of the technology at work.	Supported	0.59	2.09	0.04
Leaders -> Resistance Hypothesis 3: A network that consists of support ties from leaders will have a significant influence on resistance.	Supported	0.24	2.26	0.02
Peers -> Resistance Hypothesis 4: Support from peers significantly influences resistance.	Not Supported	0.17	1.60	0.11
Affiliates -> Resistance Hypothesis 5: The support network that is formed through relationships with immediate people who are assigned to uncover new technology (i.e. technical staff) significantly influences individual resistance.	Not Supported	0.07	0.76	0.45
Knowledge on ICTs -> Resistance Hypothesis 6: General knowledge of ICT-related technologies significantly influences an individual's resistance towards OPIMS.	Not Supported	0.01	0.05	0.96
Use of ICTs -> Resistance Hypothesis 7: Experience of use of the ICT technology at work significantly influences resistance towards OPIMS.	Not Supported	-0.06	0.73	0.47
Motivation -> Resistance Hypothesis 8: Motivation will have a significant influence on resistance.	Not Supported	-0.08	0.35	0.73
Efficacy -> Resistance Hypothesis 9: Efficacy significantly influences an individual's resistance towards OPIMS.	Not Supported	0.12	1.08	0.28
Anxiety -> Resistance Hypothesis 10: Feelings of strong anxiety or uncertainties related to the use of OPIMS will significantly influence resistance.	Not Supported	0.16	1.34	0.18
Power -> Resistance Hypothesis 11: Interpersonal power will significantly influence an individual's resistance to OPIMS.	Not Supported	0.07	0.60	0.55
Advantage -> Resistance Hypothesis 12: Perceived Advantage towards use of OPIMS significantly influences an individual's resistance towards OPIMS.	Not Supported	0.17	1.47	0.14
Compatibility -> Resistance Hypothesis 13: Compatibility of the OPIMS with work tasks significantly influences resistance.	Supported	0.27	1.70	0.09
Complexity -> Resistance Hypothesis14: How complex the technology is perceived to be will significantly influence resistance towards OPIMS.	Supported	0.38	2.37	0.02
Learning -> Resistance Hypothesis15: Inadequate learning in developing competency on OPIMS significantly influences resistance behaviour.	Not Supported	-0.05	0.41	0.68
Trialling -> Resistance Hypothesis 16: Opportunities to trial the OPIMS before using it will significantly influence resistance behaviour.	Supported	0.37	1.94	0.05
Visibility -> Resistance Hypothesis 17: Visibility of the use of OPIMS at work will significantly influence resistance behaviour.	Not Supported	-0.06	0.54	0.59

As shown in Table 5.12, support from Affiliates (such as technical staff and admin staff) and Peers (such as friend and colleagues), has no significant influence on Resistance. The result is contrary to the hypotheses that Affiliates and Peers will have a significant influence on resistance behaviour. However, high-level personnel, such as supervisors and managers (Leaders), do have a significant influence on Resistance: t-value 2.26 (p-value 0.02). Thus, Hypothesis 3, a network that consists of support ties from leaders will have a significant influence on resistance, is supported.

Almost none of the hypotheses related to the knowledge and disposition factor (Hypotheses 6–11) has a significant influence on resistance towards OPIMS. None of these hypotheses is considered supported, as the relevant path coefficients are below the required value of 1.65 and do not have a significant p-value lower than 0.10. Hypotheses related to integration factors such as Compatibility and Complexity of OPIMS technology do have a significant influence on Resistance. Compatibility has a significant value at the 0.10 level, while Complexity has a significant value at the 0.05 level. Similarly, accessibility related factors such as opportunities to trial before using the OPIMS technology (Hypothesis 16) do have a significance value at the 0.05 level on the Resistance.

Overall, the PLS results suggest that the model estimates for the structural model are satisfactory. Although some constructs appeared statistically insignificant, all constructs adequately predicted the resistance factor model. In particular, four constructs significantly influence Resistance: Leaders, Compatibility, Complexity and Trialling. Each of these four constructs can be interpreted as a critical factor for the purposes of this research.

5.4.2 Effect Size (f^2)

In addition to examining the R^2 value, the PLS analysis looked at the strength of the independent construct towards the dependent construct. To investigate the strength of the independent construct for predicting the dependent construct, effect size (f^2) was calculated. In the structural model, 15 sub-models were produced by removing each of the independent constructs one at a time. Accordingly, 15 $R^2_{excluded}$ were generated for

further calculation of the effect size. $R^2_{included}$ remained the same, which was 0.484 for the dependent construct (Resistance).

Table 5.13: Effect size in the structural model.

Independent construct	$R^2_{included}$	$R^2_{excluded}$	f^2	Degree of effect
Leaders	0.48	0.44	0.09	Small effect
Peers	0.48	0.47	0.03	Small effect
Affiliates	0.48	0.48	0.01	No effect
Knowledge of ICTs	0.48	0.48	0.01	No effect
Use of ICTs	0.48	0.48	0.02	Small effect
Motivation	0.48	0.48	0.01	No effect
Efficacy	0.48	0.48	0.02	Small effect
Anxiety	0.48	0.47	0.02	Small effect
Power	0.48	0.48	0.02	Small effect
Advantage	0.48	0.47	0.03	Small effect
Compatibility	0.48	0.47	0.03	Small effect
Complexity	0.48	0.44	0.08	Small effect
Learning	0.48	0.48	0.01	No effect
Trialling	0.48	0.41	0.15	Medium effect
Visibility	0.48	0.48	0.01	No effect

Note: f^2 values 0.02 (small effect), 0.15 (medium effect), and 0.35 (large effect).

As shown in Table 5.13, all of the independent constructs, bar one, have minimal effects on Resistance, varying from no to small effect. The only exception is the one construct that had a medium effect; namely, Trialling. Trialling had a medium effect size of 0.15 and has a moderate influence on Resistance. Similarly, the $R^2_{excluded}$ values of Peers, Leaders, Use, Efficacy, Anxiety, Power, Advantage, Compatibility and Complexity also decreased slightly when omitted from the model one by one. This implies that they have a relatively small effect on Resistance. None of the independent constructs had a large effect.

It is interesting that constructs such as Immediate, Knowledge, Motivation, Learning and Visibility appeared to have almost no impact on Resistance. All of these constructs were shown to have a very weak impact on predicting Resistance, although this might be an outcome of the small sample size. In principle, effect size increases with the size of the sample, but the probability of the hypothesis being correct decreases if the effect

size rises. In this study, a weak impact size does not indicate a weak construct; rather, the strength of the effect size (f^2) is confirmed as influencing the dependent construct (Resistance). Removing independent constructs that contain almost no effect may not lessen the goodness of the prediction, but this becomes risky for medium or large effect sizes (Chin, 1998b). In this model, no large effect sizes were present.

5.5 Summary

In this chapter, the analysis of the survey data was performed using PLS, which is rooted in a regression technique (see Chapter 4). PLS is optimised to maximise the proportion of variance of the dependent construct that is explained by the independent constructs. Therefore, the major purposes of the PLS method are to investigate the predictive relations between the dependent constructs and independent construct, and to determine whether the predictive power of the proposed model is warranted.

Overall, the PLS analyses performed in this study confirm that Resistance is significantly measured by various constructs/factors; namely, Time Adoption, Usage Level, Leaders, Peers, Affiliates, Knowledge of ICTs, Use of ICTs, Motivation, Efficacy, Anxiety, Power, Advantage, Compatibility, Complexity, Learning, Trialling and Visibility. All measurement items of these constructs were tested and verified. Results of the PLS analysis show that the measurement model is reasonably valid. A very interesting result, which emerged from the R^2 analysis, is that values generated from the PLS analysis of the structural model are substantial ($R^2 = 0.484$). This implies that resistance can be predicted by the combination of all factors proposed in the IRFM. The path coefficients result (as shown in Table 5.11) and nomological analysis indicate that Leaders, Compatibility, Complexity and Trialling influence resistance more than any other factors. As the critical determinants of resistance to using OPIMS, these factors are labelled as Level 1 (see Table 5.14). The level 2 constructs include Peers, Advantage, Anxiety, Efficacy, Affiliates, Use, Power, Visibility, Learning, Motivation and Knowledge. These were the less influential factors, indicating that these constructs did not reach the significant values expected for this research.

Table 5.14: Critical factors and significant factors influencing Resistance.

Factor/Construct Name	PLS weights	t-statistics	p-value	Factor Level and Description
Complexity -> Resistance	0.38	2.37	0.02	Level 1: Critical Factor Factors at this level have path coefficient (>0.20), p-values (<0.10) and t-statistics (>1.65).
Trialling -> Resistance	0.37	1.94	0.05	
Compatibility -> Resistance	0.27	1.70	0.09	
Leaders -> Resistance	0.24	2.26	0.02	
Peers -> Resistance	0.17	1.60	0.11	Level 2: Less Influential Factor Factors at this level have path coefficient (<1.20), p-values (>0.10) and t-statistics (<1.65).
Advantage -> Resistance	0.17	1.47	0.14	
Anxiety -> Resistance	0.16	1.34	0.18	
Efficacy -> Resistance	0.12	1.08	0.28	
Affiliates -> Resistance	0.07	0.76	0.45	
Use -> Resistance	-0.06	0.73	0.47	
Power -> Resistance	0.07	0.60	0.55	
Visibility -> Resistance	-0.06	0.54	0.59	
Learning -> Resistance	-0.05	0.41	0.68	
Motivation -> Resistance	-0.08	0.35	0.73	
Knowledge -> Resistance	0.01	0.05	0.96	

The following chapter will discuss the results from the qualitative study and interviews with OPIMS users, with the aim of corroborating the findings presented in this chapter.

Chapter 6: Qualitative Data Analysis and Results

This chapter presents the qualitative findings obtained from the semi-structured interviews. This chapter explores the views and perceptions of the OPIMS users on the critical factors of resistance and the potential strategies to overcome resistance and improve the technology implementation process. The interview data were analysed using the thematic technique.

6.1 Themes and Coding

The interviews were conducted in February and March 2013. Each interview lasted 30–45 minutes and was conducted either over the telephone or face-to-face. Interviews were audio taped and transcribed verbatim. The interview data were then examined using the thematic technique and coded according to the initial codes/themes. The process of coding begins with a comparison of the initial themes, as set out in the margins, with the emerging patterns. Themes are assigned according to the terminology used by participants. Emerging themes are recognised by highlighting the transcripts and notes; and the consistency of the theme patterns is checked. Themes are reviewed and refined to ensure that the data within the theme are coherent and that they are clearly distinguishable from other themes. The transcripts or notes are evaluated according to the theme pattern that best enables the researcher to retrieve pertinent statements (Attride-Stirling, 2001). The theme is also evaluated by the number of times it is repeated, to ensure that the information contained therein is interpreted accurately (Boyatzis, 1998; Braun & Clarke, 2006).

There are three levels of themes: global themes, organising themes and basic themes (see Section 4.5.4). A global theme is a principal theme that contains a subject or a claim that generates the main ideas. Based on the interview data, two global themes were specified: (1) the critical factors to resistance and (2) strategic approaches to manage resistance. In Table 6.1, the critical factors to resistance are described by participant opinions on the research model and the factors they consider the most critical and influential in their experience with OPIMS. There are four organising areas under Global Theme 1: support network; skills, knowledge and training; attitude; and technical. Global Theme 2 refers to the strategic actions, plans and activities undertaken

by management personnel or individuals to manage the adoption process and overcome resistance behaviour. There are two organising themes under Global Theme 2: learning and training, and support and motivation.

Table 6.1: Definition of codes and themes.

Level of theme	Code or theme	Theme defined
Global Theme 1	Critical factors to resistance	This classification refers to participants' opinions on the research model that correspond with their overall experience of using OPIMS at work. Organising themes and backing statements are established around the theme and are all the factors proposed in the model; i.e. Immediate, Peers, Leaders, Knowledge, Use, Motivation, Efficacy, Anxiety, Power, Advantage, Compatibility, Complexity, Learning, Trialling and Visibility.
Organising Theme	Support network	This classification refers to the process of using one contact to gain support in using OPIMS. This allows the individual to create a support system through which an alliance can be formed.
Organising Theme	Experience and disposition	This classification refers to the driving force that initiates and directs behaviour. It is the internal energy and feeling of motivation, confidence, fear and interpersonal power that drives people to do something.
Organising Theme	Integration and technical problems	This classification refers to the participants' opinions on the useability and accessibility of the technology.
Organising Theme	Accessible learning and training	This classification refers to the aptitude to identify and execute OPIMS, proficiency and talents.
Global Theme 2	Strategy to overcome resistance	This classification refers to participants' opinions on management's actions to overcome resistance behaviour and motivate participants to use and learn for themselves, and help others in using OPIMS.
Organising Theme	Learning and training	This classification refers to participants' opinions on the importance of the availability and quality of learning and training aimed at bettering the performance of individuals in using the technology.
Organising Theme	Support and motivation	This refers to the participants' opinions about motivation building and receiving adequate support at work to help to guard against resistance to OPIMS.

The third level theme is the basic theme. The basic themes that emerged were, for example, higher management, support staff, colleagues, mentoring, independence versus dependence, and networking. Only data from the organising themes is presented for each. This is not to detract from the importance of the basic themes, but rather to provide a snapshot of the data.

6.2 Description of Interview Participants

Fourteen participants were involved in the interviews. Interview participants were identified from the 29 survey participants already in the survey database, who had

indicated their willingness to participate in this phase of the study. Invitations to participate in the interview session were sent through email with follow-up done by telephone. Table 6.2 lists the 14 participants, their code names, backgrounds and job positions.

During the interview process, the researcher first asked the participants to describe their background, job roles and tasks, the types of OPIMS software they used to complete their work tasks and the others in their organisation who help them with their jobs and the software. It is apparent from the responses that these users of OPIMS vary widely in their roles, capacity and type of software used. In particular, the variety of positions, as detailed in Table 6.2, is useful for the research, as it enables the critical resistance factors to be verified by industry practitioners from a range of different management functions. The interview participants also have varying levels of work experience in the construction industry, ranging from one to 20 years. This ensures that the research has a variety of end-user perspectives across different levels of experience and expertise.

Table 6.2: Interview participants.

Pseudonym	Description
Participant A	Participant A is a Project Architect. He has over 10 years of experience working in the construction industry. He uses a range of software, including CAD and OPIMS. He corresponds quickly in message/email/request for information (RFI) in OPIMS but he was not spending much time or relying heavily on that system.
Participant B	Participant B is a Document Controller. She has nearly five years of experience working in an energy company in her current position. She is a relatively heavy user of OPIMS, as it is required for her job roles.
Participant C	Participant C is a Contract Administrator. She has 10 years of experience working in construction companies. She has been a heavy user of OPIMS for five years and considers herself to have become an expert user after one year.
Participant D	Participant D is a Construction Manager. He also acts as a Managing Director of his family's own construction company. He has over 14 years of experience working in construction overseas and nationally. He is the pioneer, played a role in the implementation of several pieces of OPIMS software in the company to be used by the employees and sub-contractors for managing tendering and the project.
Participant E	Participant E is a Building Surveyor. At the same time, he is a Managing Director of his own construction company. He has over 20 years of work experience in construction. He built his own OPIMS software. The software has been used in the company for over 10 years in managing the building certification process.
Participant F	Participant F is a Strategic Procurement Manager. She has over 10 years of experience in a procurement role. She starting her first procurement career in an Army Department, and currently is working in an infrastructure company. She is a beginner user of OPIMS.
Participant G	Participant G is a Project Manager and has 15 years of experience working in construction. Although he is a regular user of OPIMS and has experience with a wide range of OPIMS software, he does not use it heavily.
Participant H	Participant H is a Construction Manager. He has 20 years of work experience in construction. He uses OPIMS extensively for managing tenders and contracts.
Participant I	Participant I is a Document Control Manager. She has over 10 years of experience working in

	a project management firm. She is an expert in project schedule software and uses OPIMS regularly.
Participant J	One of the youngest participants, Participant J is a Graduate Contract Administrator. He has previously used OPIMS but is not a regular user and he does not use it heavily.
Participant K	Participant K is an Engineer in a civil engineering firm. He has three years of work experience. He is not a heavy OPIMS user, but regularly uses OPIMS for communication, updating drawings and social interaction. He considers himself a 'moderate user' of OPIMS.
Participant L	Participant L is a Building Surveyor. He has two years of work experience in a construction company. He has used OPIMS since starting work two years ago, as it is required by the company. He is a regular OPIMS user but does not use it heavily.
Participant M	Participant M is a Sales Director for OPIMS software. He has been working with the OPIMS software company for about 13 years. He had over 20 years of experience working in the construction industry prior to joining the software company.
Participant N	Participant N is a cadet, employed as a Contract Administrator. She is currently studying for a Bachelor Degree in Engineering and expects to be finished in one year. She is not a particularly regular user, but has experience in a wide range of OPIMS software packages.

In the interview, ***Participant M***, from a software provider, stated:

> *you can have many people sign-up or log in to [the software], but, may be only few people understand better and use the software regularly. Some of people are active user and some are guest users. A person who is considered an active user may be project admin, document controller, contract admin and so on—we can call them the 'power user'. These are people who could influence others to use [the software].*

Participant B, a document controller who uses two different types of OPIMS software to manage documents for six projects, stated:

> *not all [software] users are active users—some of them are guest users. From 482 users registered in [software], only 70 of them are registered across my company nationwide. They [referred to 70 registered users] are people who deal with the software and probably use the software quite often.*

Participant D, a construction manager who is also a managing director of a small-to-medium-sized construction company, stated:

> *Our employees used this software and sub-contractors too. Employees have an obligation to use this software definitely, but for sub-contractors, we cannot 'press' that on them. Most sub-contractors are old and traditional, and they are not an internet savvy person. For example, we have a very skilful tiling contractor who offers a cheap price [tender]. He doesn't really want to use this software. We*

cannot risk our relationship with that sub-contractor just because they refuse to use this software. They offer us a reasonable price and very skilful labour. We have our procurement manager to help them upload and download drawings.

Thus, for ***Participant D***, sub-contractors' reluctance to use OPIMS was tolerable. Viewed from another perspective, adoption of OPIMS software must be flexible to accommodate sub-contractors' work preferences. For example, some businesses are still using email to send documents or drawings. For them, attaching small-sized files to an email may be more convenient than using tailored software. Tailored software might only be useful in the case of sending large drawing files, downloading the latest drawings or searching for the latest information on the project.

Based on the interviews, users were observed to fall into two groups: assigned user or guest user. The analysis indicated that assigned users use OPIMS as a prescribed part of their job role, to improve the effectiveness of their work. This group is best placed to empower others to use the software. By contrast, guest users are less implicated in, and obtain less advantage from using, the OPIMS software. Guest users may use the software for managing the overall communication process of the project, its documentation, and the transparency issues, but it appeared to be less useful overall for their specific line of work. Thus, a commitment to use the OPIMS for the guest user relates to engagement and connection more than to their job function.

6.3 Identifying Critical Factors That Influence Resistance

6.3.1 Support Network

Approximately half of the participants agreed that they were not concerned about the support they received in using OPIMS. However, the other half were of the opinion that where users are less likely to have assistance from an expert or person who has an immediate relation to the online system (such as IT staff), their use of the OPIMS software would probably be adversely affected. For example, ***Participant A***, a project architect, stated:

we have two different [OPIMS] software and recent drawings usually upload in these software for the client. Uploading or downloading a drawing with a huge

file size consumes a lot of time and sometime software crashes—it frustrates me. So I ask the IT team to deal with it. Without them, I might just as well send it through email or hard copy.

Participant D assigned one of his employees specifically to provide relevant assistance to sub-contractors.

Leaders or managers were mentioned by the participants as people who provide advice and assistance when dealing with difficult issues at work and with OPIMS. ***Participant F***, a strategic procurement manager, stated:

there are a lot of things that you probably knew that you were probably taught during training, but you forgot. And when you go to use it in real work, you have to go back and look at everything that you learned before. Sometimes it's just as easy to ask your line manager. We needed it to be solved quickly.

Participant C, a contract administrator, stated:

I work closely with the contract manager. He needs to review which documents I should pass along to someone. I need to be careful in terms of the document and the announcement that should be posted online. So, obviously all tasks require his advice and approval.

Colleagues or co-workers were also important, as expressed by the participants, with respect to the support available for use of OPIMS. ***Participant K***, an engineer and beginner with OPIMS, stated the following about colleague support:

I've got a lot of help from my colleagues. We discuss about comments and mark-up on drawing made by others through [the software]. They help me with the mark-up tools.

Participant J, a graduate contract administrator, stated:

> *when you're new, you don't get that support. It's difficult to try and get someone to help when everyone is so busy and you're still learning the ropes. Everyone is so busy in this company, especially the manager, so most of the time I learn via online and sometimes ask friends or colleagues.*

6.3.2 Experience and Disposition

Six experience and disposition factors were indicated in the model as having no influence on resistance: Knowledge of ICTs, Use of ICTs, Motivation, Efficacy, Anxiety and Power. Similar results were found from the interviews. The majority of interview participants perceived these factors as of little importance to resistance, although a few perceived them as positive. For example, ***Participant G*** stated:

> *I go to CPD (continuing professional development) programs but it is largely self-initiated. It takes the form of beginner to advanced course work, and participation regularly in off work hours, seminars, workshops and conferences.*

This participant considered certification programs as an external factor interacting with his internal need to be good at his job. His attitude is that employees are 'empowered through knowledge' and 'technology is employed within the company for employee benefits'. Being good at what he does influences the attribute of efficacy, which was the most important factor to him.

Participant C talked about beginning her contract administrator career in a company that was 'totally traditional and manual'. In that role, she witnessed inefficient practices from sub-contractors, who sent an overabundance of paperwork, tenders and drawings for the work on which they were bidding. However, this experience did not cause her to incorporate any lack of confidence or fear of loss of critical information while operating the OPIMS. Instead, she stated 'this software improved my work very much'.

Similarly, ***Participant N***'s career path had been challenging. As a cadet contracts administrator, she had found her first year difficult. She reported experiencing uncertainty and confusion. ***Participant N*** came to feel that her engineering

undergraduate degree was not grounded in the reality of practice to her job. She also mentioned that, during the first year, she had no training or assistance in using OPIMS. However, she did not feel that this negatively affected her attitude towards OPIMS. Instead, she stated, 'the technology saved my career life'. Her response to the situation was to take what she was given and adapt it to her needs as best as she could.

Power is the ability of one person to influence what another person thinks or does. When looking at power within an interpersonal relationship at work, ***Participant H*** stated:

> *you may be the only person who can run programs or software, or who can figure out the filing system. You possess knowledge that other people don't have and the top management value you. But in our office we might possess critical expertise yet not receive the promotions or raises we deserve as long as management feels we would never leave the organisation. This often makes it difficult to convince people to do things. We gain compliance when we can force someone to do something but at the price of demoralisation and resentment.*

For ***Participant H***, it is apparent that the concept of 'power' has negative connotations. In most cases, he believes that 'to push people to use the technology' and 'to get things done' requires the authority of a person with a title and high position.

6.3.3 Integration and Technical Problems

Overall, participant opinions about the integration of OPIMS at work were varied. For example, ***Participant E*** stated:

> *you need to know what you are doing. This system is designed to suit your job roles, improve your performance and efficiency. I think it is impossible for them [users] not able to understand how the system works—resistance can be avoided if the technology suits their roles and they know how to operate it within their job.*

Participant D stated:

> *to me this system is very simple, easy and intuitive. The average person would require a pretty thorough briefing, but it is not difficult for them, and it is not difficult for older people either. Employees don't have that [resistance] issue because this software works well for their job. To them it is just a normal change management issue.*

Participant G stated:

> *I need software that integrates with work and improves work process. The software updates me with the latest drawing and documents. It is quite handy and that's all I need for my job.*

Participant H stated:

> *Instead of dropping an email, they have to write up their communications and copy everyone in the email and wait two or three days to get an answer back. Here [in the software] you can manage the things like tender records, sub-contractor information in a well-organised manner. It seems to me that this software was customised according to construction management requirements.*

However, several participants reported having confronted practical and technical problems using certain software, and consequently expressed a low level of acceptance of it. For example, ***Participant B***, who has excellent skills with OPIMS software and who is currently using two different pieces of software at work, compared between two software packages (X and Y) as follows:

> *I think that software X and software Y both are easy. I didn't take so long to get used to it, but software X seems to lag a bit behind in terms of graphical interfaces. Software Y is more advanced. Frankly, I prefer software Y and I think in the future my company will use software Y only.*

Participant K said:

> *I understand why somebody would be less favourable towards this system. There is some frustration with technical aspects. Certain of them [the users] are unfamiliar with it, and they are sceptical that this software can greatly improve their working methods. The software will certainly increase efficiency in some situations, but in other circumstances it may actually slow down the process. For example, while working onsite and briefing with sub-contractors, I cannot rely on my tablet [computer] only, because it has limited views and usually the greater complexity of a project the bigger the scale of engineering details drawn for them. So A1 drawing should be in hand.*

Participant A stated:

> *this is really a superb piece of software, easy to use and well presented, keeping track of project documents. But for us [architects] this software is not really the main use. In our office, we mostly use AutoCAD for drafting, although we do own Revit as well. Other software that is normally used is SketchUp and Photoshop. There are other platforms out there that allow some really amazing 3D work but our clients generally don't request that level of visualisation.*

6.3.4 Accessible Learning and Training

From the interviews, the majority of participants used at least two different types of software in their work. Most of them agreed that without proper training, employees would not have adequate skills in using OPIMS. The training programs for each software seemed to be designed to help users learn how to master the software quickly and put it to work for themselves and their organisation. The research found the majority of participants described 'self-paced learning', with users accessing quick learning and training using a video-based tutorial approach.

Some of participants commented that training through the video-based tutorial was easy and saved both money and time. ***Participant I***, a document control manager, stated 'online training and video tutorial helps me get the most out of [software]. It is free,

easy-to-understand and effective, and saves my time'. ***Participant H***, a construction manager, stated 'we turn to online video training due to cost effective reasons'.

The online tutorial is also highly accessible and flexible, as ***Participant G***, a project manager, acknowledges. The online training video is 'easy to follow and it is accessible whether you watch it at the office or at home'. ***Participant L***, a building surveyor, stated 'with face-to-face training we usually did not get flexibility. But with online videos we can learn and progress at our own pace and watch the tutorial again and again if needed'. Online training also allowed some participants to go mobile, for example, ***Participant J*** stated, 'I can learn at home, on the job, or anywhere using a smartphone'.

Face-to-face training is also available but appears to be the less preferred approach. ***Participant L***, a building surveyor, explained:

> *that's all done online and does not rely on any human interaction, so I can start watching the tutorial videos now. I can be constantly pausing, rewinding or replaying the videos. The company prefers this style of training: the quality is good and it's a 24/7 resource. It's cheap and free and a simple process—gone are the days of sending employees off for two-days for an in-person course.*

Participant K pointed out that:

> *the results of face-to-face training and mentoring are invariably a bit disappointing, and with mounting time pressures employees need information and training at their fingertips, now. They should have access to training on-demand.*

While the importance of training in OPIMS is clear, the approach to training and facilitation of effective learning is also significant. Based on the interviews, it is evident that a traditional face-to-face approach to training is less favoured than online video-based tutorials. However, none of the participants stated that the traditional method of training should be discontinued. Online video-based tutorial-style learning does save money and time to some extent. It is also easy, accessible and has greater flexibility for users, but it is not a total solution. Video-based tutorials can better be regarded as a new context for learning processes.

6.4 Strategy to Overcome Resistance

6.4.1 Support and Motivation

In addition to verifying the critical factors to resistance, the interview participants were asked their opinions on the best strategy to overcome resistance. Most participants thought that top management and key personnel positions related to OPIMS were key to the successful adoption of OPIMS. In their view, support and motivation from managers and peers most influences effective uptake of this technology. The following statements and suggestions were made:

> *I see my manager acts as if he is part of the team, not just the boss of it. He routinely helps with the work and is always readily available to anyone who has a problem, whether it's related to work or personal.* ***(Participant C)***

> *We've not gotten much like that [motivation to use OPIMS] and not even a debrief on what we should do with it ... I think that's what management should do at the very beginning when implementing this software.* ***(Participant B)***

> *This job [project] must be managed by someone who is trustworthy, cares about people as well as the business, and acts with integrity. The manager's role in motivation is the key to employee motivation.* ***(Participant A)***

> *We need a lot of help in that area—we need to improve. It ain't about systems, and it ain't about processes. It's about interpersonal social interactions* ***(Participant I)***

> *People want careers, not jobs, and that means they want to learn and develop. The job of a manager is to actively help your staff succeed. Focus on giving your staff exciting and challenging tasks and monitor them.* ***(Participant N)***

> *Human beings are social creatures at heart. Simply talking to a colleague or manager is sometimes the best way to communicate a clear message.* ***(Participant K)***

While some participants agreed that the manager should be supportive, they also emphasised that staff should take the initiative to discuss issues with the manager, rather than waiting until the problems have developed:

> *It's not fair to expect people to read your mind when it comes to support—and it's not effective either. Just ask for what you need. The idea that the manager should simply be being more supportive is better, but it's important for you [staff/users] to open up a discussion to see what types of support are needed here.* ***(Participant E)***

6.4.2 Learning and Training

Some participants emphasised learning and training and gave the following suggestions:

> *Typically, the best way to get technology integrated into the work is to make sure people are provided with lots and lots of training. However, this cannot be the only solution. Training is one way to build skills. It doesn't need a long training, instead, training should be continuous. Learning and training support can be provided in a variety of formats. Training and technical support is usually provided by the service provider, it's freely available. They provide assistance and help the user to solve specific problems with the product. The online video tutorial is a good example.* ***(Participant H)***

> *We deal with the complexity of large projects. We are gathering and sharing information. We collaborate and team-up, yet how can we maintain a productive collaboration environment if there is too little support? Rather than telling you that you should use the technology, someone should offer you tangible support. For example, point out the strengths you're forgetting you have, or help you actively deal with the issue at hand, or help you brainstorm solutions.* ***(Participant F)***

> *The person who is considered an active user may be in project admin, a document controller, and contract admin and so on—we can call them the 'power users'. These are people who could influence others to use the [software] ... The 'power user' uses the [software] frequently. [Software] has been integrated effectively in*

their roles. So it is important to introduce the 'power user' to other users, to disseminate the advantages of [software] and persuade others to use it, and to support others when they use it. ***(Participant M)***

6.5 Summary

In a qualitative study, the central theme is expressed with regard to verification of the critical factors that predict resistance towards OPIMS. The resistance factors were grouped into four broad themes, which included support network, experience and disposition, integration and technical problems, and accessible learning and training. Another central aim of this study was to understand how organisations manage resistance, to allow for the recommendation of a strategy to overcome resistance and drive the implementation of OPIMS.

The analysis concludes that OPIMS users can be classified into two groups: (1) assigned users and (2) guest users. An assigned user is a person who uses the OPIMS as a prescribed part of his or her job role. The guest user is a person who uses the OPIMS to maintain connections and engagement with a project. It is necessary for the assigned user to use OPIMS actively and heavily, but this is not crucial for the guest user.

Overall, participant attitudes were generally positive about OPIMS. Most participants stated that they were comfortable with the software. Efficacy, anxiety and power were described as not very important factors in influencing resistance to OPIMS. Participants frequently referred to different aspects of their perceptions of OPIMS (e.g. technical, ease of use and usability) when responding to the resistance question and/or expressing their positive attitudes. For example, ***Participant E*** stated 'this system is designed to suit your jobs', ***Participant D*** stated 'this system is very simple, easy and intuitive', ***Participant G*** stated 'it is quite handy and that's all I need for my job', and ***Participant B*** said 'I don't take so long to get used to it'. Most participants seemed to take what was implemented for them and adapt it as effectively as possible.

The importance of leaders and managers was the most consistent theme expressed by participants with respect to resistance and support for using OPIMS. The role of a manager, whether he or she is internal or external to the company, is important to the

support network. As ***Participant D*** stated, 'we have our procurement manager help them [sub-contractors]'. The quantity of support was not seen as critical, but the intensity (or frequency) was. As stated by ***Participant C***, 'I work closely with contract manager', and ***Participant K***, 'sometimes it's just easiest to ask your line manager'. A colleague or friend is also an important person to ask for support, as are IT staff. As ***Participant A*** stated, 'I ask the IT team to deal with it'. ***Participant J*** said, 'sometimes you ask a friend or colleagues'.

Most participants in this study agreed that training is an important factor in influencing resistance. Training has been seen to be more than just building skills and knowledge; it has personal and career benefits. For example, ***Participant N*** stated, 'People want careers, not jobs, and that means they want to learn and develop'. ***Participant C*** stated, 'this software improved my work very much', and ***Participant G*** stated, 'technology is employed within the company for employee benefits'. The study also found that training methods are being revolutionised by internet technologies. Traditional face-to-face training is being supplemented or replaced by interactive video tutorials containing information and instructions on how to operate the technology. The traditional method alone will not prepare OPIMS users for a future that requires continuous learning on the job. Face-to-face is no longer the main method for improving skills in using OPIMS. A combination of both face-to-face and online seems to offer the best overall training experience. As ***Participant L*** stated, 'with face-to-face training we usually did not get flexibility, but with online videos we can learn and progress at our own pace'. The training used must be the right fit for the learning audience. The combination of traditional and online could make people feel more connected to the training experience and thus more engaged and motivated, which in turn would optimise content retention and knowledge transfer.

In addition to the training content, participants gained the opportunity for what can be called 'self-paced training'. In self-paced training, there are no time restrictions on duration of training, and the pressure to achieve a particular outcome within a given timeframe is reduced. A key advantage of this self-direction process is that the learner develops an independence and gains access to potentially unlimited information. The learner is thus less dependent on the instructor for information about OPIMS. However,

they might require more help from the manager in interacting with the software in a meaningful way while on the job.

Regarding the strategy to overcome resistance, the majority of participants referred to most of the factors that influence resistance. The effects that these factors have on people helped to shape the strategy. Strategies suggested by participants fell into two categories: support and training. Traditionally, support has been viewed relative to individual motivation, and training has been linked with the capacity to learn. Some participants suggested that it would be more appropriate to do 'classroom' training to complement the online training program for effective overall gains. Classroom training was perceived as credible, as it is the best way to communicate a clear message, although online training was also an acceptable option and a solution to save time and money.

Participants also suggested the need for wide support from managers, peers and co-workers. This is because the way that OPIMS is operated depends on the work that is executed by managers, peers and co-workers in a project team. The nature of the work on construction projects is broadly framed in the organisational structure of such ventures, which promote interdependency and interactivity among members of the team. Leader, peer and co-worker relationships are influential on motivation and intention to use OPIMS. As ***Participant B*** said:

> *We've not gotten much like that [motivation to use OPIMS] and not even a debrief on what we should do with it ... I think that's what management should do at the very beginning when implementing this software.*

Likewise, according to ***Participant A***, 'the manager's role in motivation is employee motivation', and in the words of ***Participant I***, 'We need a lot of help in that area, we need to improve. It ain't about systems, and it ain't about process. It's about interpersonal people interactions'. Table 6.3 provides a summary of the qualitative results.

Table 6.3: Summary of qualitative results.

Constructs of IRFM	Critical factors to resistance	Less influential factors to resistance	Strategy to overcome and manage resistance
Support network (Leaders, Peers, Affiliates)	• Support from leaders, peers, co-workers and technical staff.		• Variety in learning and training experience. • Diversity in support to increase motivation.
Experience and disposition (Knowledge on ICTs, Use of ICTs, Motivation, Efficacy, Anxiety, Power)	• Motivation	• Knowledge of ICTs • Use of ICTs • Efficacy • Anxiety • Power	
Integration and accessibility (Advantages, Compatibility, Complexity, Learning, Trialling, Visibility)	• Compatibility • Learning and training	• Advantage • Complexity • Trialling • Visibility	

Chapter 7: Discussion, Implications and Conclusion

This chapter discusses the overall findings of the study; combining the key findings from the quantitative and qualitative results to verify the critical factors to resistance. The key findings and their implications for a final model of resistance are highlighted and overall conclusions are presented, including how they contribute to theory and future practice. The study limitations are also discussed and directions for future research are proposed.

7.1 Verifying the Critical Factors of Resistance towards OPIMS

7.1.1 Influence of Support Network Factors on Resistance

Three factors were indicated in the support network: Leaders, Peers and Affiliates. The Leaders factor stands out, as it has a standardised path coefficient (PLS weight) of 0.24. This path coefficient, in line with the recommendations by Chin (1998a), should be between 0.20 to 0.30 or greater for it to be taken as providing a meaningful construct. It also has an anticipated significance value (t-statistic) greater than 1.65 and a p-value below 0.10. From the combination of these results, the factor of Leaders (which includes managers and supervisors) does have a critical influence on user resistance. The significant influence of Leaders was also recognised by the majority of interview participants, as discussed in Section 6.3.1. These results confirm Hypothesis 3: A network that consists of support ties from leaders will have a significant influence on resistance.

The other indicators were Peers (path coefficient 0.17, t-statistic 1.60 and p-value 0.11) and Affiliates (path coefficient 0.07, t-statistic 0.76 and p-value 0.45). However, as previously discussed, this outcome does not necessarily mean that the factors have no significant influence on resistance. The underlying theoretical evidence is supported by the qualitative findings that Peers and Affiliates do have a significant influence on resistance. People are more likely to communicate with others if they have similar interests (Granovetter, 1973), and if a person speaks to friends, peers or co-workers about technology, such communication will reinforce the user's belief system and perceptions towards technology (Valente, 1996b). The relationship is more broadly

supported from the social network and SNT perspectives (Granovetter, 1973; Valente, 1996b). In particular, given that Peers has a path coefficient just 0.03 from the recommended minimum cut-off value (of 0.20), a t-statistic that is only 0.05 from the target value (of 1.65) and a p-value within 0.01 (of 0.10), it is reasonable to retain that factor as a significant component of the resistance model. Further, as discussed in Section 6.3.1, some of the interview participants agreed on the role of peers in providing support.

Theoretical support for Affiliates or technical staff as representing a significant factor in resistance is also evident in SNT theory (Valente, 1996b). However, the low path coefficient value (0.07), t-statistic (0.76) and p-value (0.45) measures obtained from the PLS tests are deemed insufficient to confirm Affiliates in the final model. Affiliates is thus a potential contributing factor for resistance, promoted by the theoretical literature, but was not confirmed by the current mixed methods study. Considering that research into resistance factors using as broad a palette of theories as is used to frame the current model is still in its infancy, this study can be described as exploratory in nature, and Affiliates will thus be retained as a potential factor in the model.

7.1.2 Influence of Experience and Disposition Factors on Resistance

The experience and disposition factors include Knowledge on ICTs, Use of ICTs, Motivation, Efficacy, Anxiety and Power. None of these factors obtained a statistically significant relationship to resistance in the PLS tests. Most have a path coefficient less than 0.10 (target 0.20) and none have above 0.16; most have a t-statistic well below 1.00 (target 1.65), with the highest being 1.34; and none of the p-values are anywhere close to the target (0.10). The quantitative results provide no grounds to confirm experience or disposition as providing significant factors in resistance.

Support for experience and disposition factors in the qualitative study is also poor. Perhaps the only exception is for the Motivation factor, which did receive some strong endorsement as an important indicator of resistance. Interview participants noted that people sometimes lacked motivation to use OPIMS, because they had not been informed or briefed sufficiently on why they should use it. Other participants commented on how using OPIMS is considered by some as being beyond their normal

job responsibilities. Motivation to use it is thus more about the perceived personal benefit of individual progression and skill development. This is in line with the literature on Motivation (Davis et al., 1992; Hartmann, 2006; Rogers, 2003).

The strength of support for Motivation as a significant factor in the qualitative survey and literature does suggest that it has potential as a significant factor in the model. However, the PLS test results are so poor (path coefficient of 0.08, t-statistic of 0.35 and a p-value of 0.73) that none of the experience and disposition factors justify recognition as significant factors in the final model. At best, Motivation can be regarded as a potential contributing factor for resistance, and the other factors can be deemed low-level factors.

7.1.3 Influence of Integration and Accessibility Factors on Resistance

Six factors are proposed in the research model relating to integration and accessibility: Advantage, Compatibility, Complexity, Learning, Trialling and Visibility. Of these factors, three were shown to have path coefficients greater than 0.20, t-statistics greater than 1.65 and p-values lower than 0.10; namely, Compatibility (path coefficient 0.27, t-statistic 1.70 and p-value 0.09), Complexity (path coefficient 0.38, t-statistic 2.37 and p-value 0.02) and Trialling (path coefficient 0.37, t-statistic 1.94 and p-value 0.05). These strong results support the hypothesis that Compatibility, Complexity and Trialling before use do have a significant influence on resistance. The results are also compatible with the theoretical literature, which highlights the influence of perceived usefulness to, and compatibility with, a user's job requirements on the potential for resistance (Liao & Lu, 2008; Son et al., 2012; Teo, 2011). Trialling the technology before use is also directly related to user resistance as one influencing condition of user uncertainty and discomfort with new technologies (Meutera et al., 2003; Venkatesh, 1999; Venkatesh et al. 2011).

However, the findings from the qualitative study do not support the significance of these factors. For example, despite the strong PLS test results for Trialling, only one of the participants expressed a strong opinion supporting that factor. This confounding result might have been affected by the sample size of the qualitative study. Alternatively, the strong focus on emerging learning and training opportunities may

have overshadowed the consideration of Trialling. The strength of support for Trialling as a significant factor in the PLS test and literature does provide sufficient evidence to confirm Hypothesis 16: Opportunities to trial the OPIMS before using it will significantly influence resistance behaviour. A similar case can be made to confirm Hypothesis 13: Compatibility of the OPIMS with work tasks significantly influences resistance (Compatibility), and Hypothesis14: How complex the technology is perceived to be will significantly influence resistance towards OPIMS (Complexity). However, all three hypotheses do warrant further consideration and testing.

The PLS test results for Advantage, Learning and Visibility are clearly unable to verify the significance of these factors: Advantage (path coefficient of 0.17, t-statistic 1.47 and p-value 0.14), Learning (path coefficient of -0.05, t-statistic 0.41 and p-value 0.68) and Visibility (path coefficient of -0.06, t-statistic 0.54 and p-value 0.59). Together with the lack of any support for Visibility in the qualitative study, these results indicate that Visibility should be considered as a minor influence on resistance. However, the interview participants in the qualitative study did express a relatively strong opinion that the perceived Advantage of a technology and Learning resources are significant. Advantage and Learning factors can therefore be considered as potentially significant to resistance.

7.1.4 Critical Factors and the Final IRFM

The IRFM was developed as a research model of the critical factors to resistance to OPIMS (see justification in Chapter 2). The IRFM, for the first time, seeks to integrate three previously separate theoretical perspectives: DoI, TAM and SNT. A case is also presented in Chapter 2 that resistance can be measured in terms of the time of adoption and the level of usage. Time of Adoption and Usage Level provide a measure of resistance against which the significance of the resistance factors can be assessed.

As presented in Section 5.3.1, the results of the PLS test applied to the initial measurement model indicate that a small number of the measurement items considered are not valid measures. Those few measures are therefore omitted from the structural model before application of the PLS test. Results from the structural model PLS tests, qualitative interviews and the literature identify only four causal constructs and two

measurement constructs that the research can confirm by verification of their related hypotheses. The five critical causal factors are Leaders, Peers, Compatibility, Complexity and Trialling. The two critical measurement factors are Time of adoption and Usage level. A further four causal factors are potentially critical. The four potentially critical factors are Affiliates, Motivation, Relative Advantage and Learning. The remaining six factors, Knowledge, Use, Efficacy, Anxiety, Power and Visibility to users, are deemed weak. A summary of these conclusions is presented in Table 7.1.

Table 7.1: Critical, potential and weak factors on Resistance

Factor	Strength/Level of factor on Resistance
Social Network Factor	
Leaders	Critical
Peers	Critical
Affiliates	Potential
Experience and Disposition Factor	
Knowledge	Weak
Use	Weak
Motivation	Potential
Efficacy	Weak
Anxiety	Weak
Interpersonal Power	Weak
Integration and Accessibility Factor	
Relative Advantage	Potential
Compatibility	Critical
Complexity	Critical
Learning	Potential
Trialling	Critical
Visibility	Weak

Over and above these findings, the collective strength of the IRFM structural model has an R^2 of 0.484. According to Chin (1998b), an R^2 value of 0.484 is more than sufficient to confirm the predictive capacity of a model. Given this level of predictive strength overall, and the theoretical literature that supports the inclusion of each factor in the first place, although individual factors can only be assessed as weak, for overall consistency, all factors should be retained in the model. The final IRFM model indicating the relative significance of each resistance factor is shown in Figure 7.1.

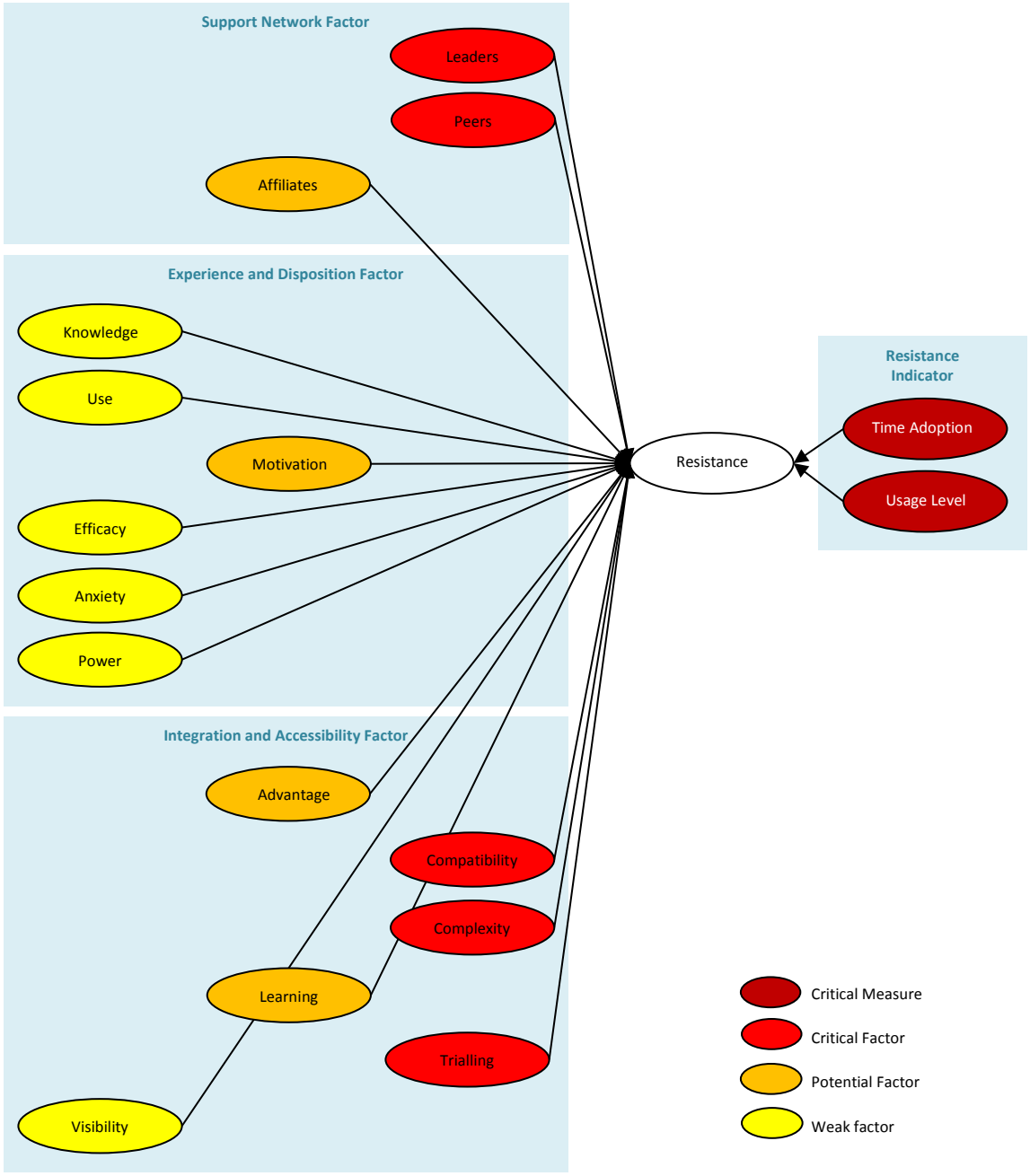

Figure 7.1: Final IRFM and critical factors of resistance towards OPIMS.

The indicators of resistance, time of adoption of technology and usage level, have not been verified in the qualitative study. However, as discussed in Section 5.4.1, the PLS tests proved that these indicators are significant and valid in the quantitative study. Time of adoption has a path coefficient of 0.81 (t-statistic 3.50 and p-value 0.00) and usage level has a path coefficient of 0.59 (t-statistic 2.09 and p-value 0.04). Based on the value of the corresponding path coefficients and significance values, time of

adoption and usage level have a great influence on resistance. These path coefficients are in line with the recommendations of Chin (1998a), who states that path coefficients should be at least 0.20 or greater than 0.30 to be considered meaningful. It could be interpreted that both indicators, time of adoption and usage level, are appropriate indicators for resistance.

In line with Figure 7.1, in total, 17 hypotheses were developed and tested in the quantitative study. Seven of the 17 hypotheses were strongly supported by both phases of this mixed methods study. These are:

Hypothesis 1: Resistance towards OPIMS is significantly indicated by time of adoption.

Hypothesis 2: Resistance towards OPIMS is significantly indicated by the individual usage level of the technology at work.

Hypothesis 3: A network that consists of support ties from leaders will have a significant influence on resistance.

Hypothesis 4: Support from peers significantly influences resistance.

Hypothesis 13: Compatibility of the OPIMS with work tasks significantly influences resistance.

Hypothesis14: How complex the technology is perceived to be will significantly influence resistance towards OPIMS.

Hypothesis 16: Opportunities to trial the OPIMS before using it will significantly influence resistance behaviour.

The following hypotheses were partially supported:

Hypothesis 5: The support network that is formed through relationships with immediate people who are assigned to uncover new technology (i.e. technical staff) significantly influences individual resistance.

Hypothesis 8: Motivation will have a significant influence on resistance.

Hypothesis 12: Perceived advantage towards use of OPIMS significantly influences an individual's resistance towards OPIMS.

Hypothesis15: Inadequate learning in developing competency on OPIMS significantly influences resistance behaviour.

The following hypotheses were NOT supported:

Hypothesis 6: General knowledge of ICT-related technologies significantly influences an individual's resistance towards OPIMS.

Hypothesis 7: General use of ICT technology at work significantly influences resistance towards OPIMS.

Hypothesis 9: Efficacy significantly influences an individual's resistance towards OPIMS.

Hypothesis 10: Feelings of strong anxiety or uncertainties related to the use of OPIMS will significantly influence resistance.

Hypothesis 11: Interpersonal power will significantly influence an individual's resistance to OPIMS.

Hypothesis 17: Visibility of the use of OPIMS at work will significantly influence resistance behaviour.

7.2 Achievement of Research Objectives

Four objectives were formulated at the beginning of this research. All objectives were achieved, as discussed below.

Objective 1: To develop a comprehensive model of the key resistance factors identified in the literature.

This research developed an IRFM based on a review of the literature, including resistance-related theory and models. Past studies showed that various social, organisational and technical elements could influence resistance; thus, this study applied a multi-theoretical perspective. To understand resistance better, aside from DoI theory

and TAM, this study added a theoretical framework derived from the social network perspective. As a result, this objective has been achieved. The literature reviews and proposed IRFM are presented in Chapters 2 and 3.

Objective 2: To test and evaluate the significance of the variables/constructs in influencing the development of resistance.

Surveys were used to measure and test the research hypotheses and constructs proposed in the IRFM. The collected data from surveys (quantitative study) were managed and statistically analysed using PLS. The PLS analysis included identifying, examining and validating the relationships of the variables/constructs proposed in the IRFM. From the analysis, the results were presented in two parts. First, the measurement model was evaluated in Section 5.3. The aim was to address the validity and reliability of the items of the individual variables/constructs. The second step, considered a priority of this analysis, was the evaluation of the whole structure of the IRFM. This was achieved using the R^2 statistic of PLS. R^2 suggests to what extent the variables/constructs help to predict, explain or influence resistance. From the analysis, the IRFM has a R^2 value of 0.484, which is sufficient to conclude that the values are substantial (Chin, 1998b). This explains a reasonably large and acceptable proportion of the variance in all of the constructs to predict the resistance factors. Based on this result, the IRFM has been verified as adequate. Therefore, this objective has also been achieved.

Objective 3: To verify the critical resistance factors using a mixture of quantitative and qualitative methods.

This research integrated qualitative with quantitative data to verify the critical factors influencing resistance. The final IRFM in Figure 7.1 shows that from 17 constructs/factors proposed in the model, two were identified as critical indicators/measures of resistance: Time of Adoption and Usage Level. Five were identified as critical causal constructs/factors: Leaders, Peers, Compatibility, Complexity and Trialling. Four (i.e. Affiliates, Motivation, Relative Advantage and Learning) are potentially critical, and the remaining six factors are weak (i.e. Knowledge, Use, Efficacy, Anxiety, Power and Visibility). Based on these results, Objective 3 has been achieved.

Objective 4: To consider the potential training and technology deployment strategies that could overcome individual resistance.

From the final model, it is clear that when construction organisations implement new technology, attention should be given to learning and training, support, motivation and ensuring active teamwork. Learning and training, for example, should be seen as a continuous process, not only for career progression, but also for personal development. Conventional face-to-face training still has a role; however, new and extended training alternatives, such as accredited training and on-the-job training, are becoming increasingly important. Based on these results, this objective has been achieved. The specific contributions of this study to the construction industry and overcoming resistance will be further discussed in Section 7.3 below.

7.3 Significant Contributions to Construction Industry and Basic Strategy to Overcome Resistance

From an industry and practical perspective, the critical factors that influence resistance and possibly hinder the technology implementation process have been determined, and a basic strategy for addressing that resistance has been outlined. The research has confirmed that leaders and peers can influence the development of resistance. Therefore, construction organisations might consider recruiting these groups into their existing implementation systems or training programs. Indeed, supportive environments from leaders and peers are robust indicators, able to break current practice in the construction industry (Kissi et al., 2012).

7.3.1 Improved Management Strategy for Learning and Training

One aim of this research was to provide basic guidelines on how resistance (resistance factors) might best be overcome. The quantitative findings of this study revealed that learning and training have a significant impact on resistance. The qualitative findings identified that learning and training for OPIMS should change. A number of participants believed that training should shift to focus on whole-person development, rather than being directed towards specific technical skills transfer and development. Skills development in the context of rapidly changing technology should not be restricted to

technical product training, but should involve anything that helps a person to make an adjustment to technological change and effectively use technology to build motivation, commitment and personal development (Luse et al., 2013; Marler et al., 2006; Piore, 1968). Training needs a broader focus than has traditionally been the case, to cover individual trainee, software, job and organisation characteristics (Compeau et al., 1995).

According to Compeau et al. (1995), training might reasonably begin with a focus on the particulars of the software, a given set of materials and specific activities designed to inform the trainee. Once the technology is more familiar to the trainee, then approaches to learning and training should move to focus on the appropriation of the software capabilities and how these can most effectively be leveraged to improve the trainee's job characteristic and/or ganisational needs. Thus, conventional product training is still required, but so are new and extended training options. The scope of possibilities for new training initiatives is quite large, and includes accredited training (Russell & Alpay, 2000) and on-the-job training (Venkatesh & Speier, 1999).

To illustrate the importance of technology training using an example from another setting, in a study on the use of IT by nurses in a primary care setting (Russell and Alpay (2000), it was evident that their low level of IT literacy was a consequence of inadequate accredited IT training. Accredited training includes formal technology qualifications, such as a Certificate or Diploma. On-the-job training is less formal, and is undertaken as the user is working, supervised and supported by appropriate peers, mentors or professional trainers (Mincer, 1962; Venkatesh & Davis, 2000). All forms of learning and training opportunities are now available well beyond the conventional classroom/workplace setting. Certainly, a number of the participants in the interviews identified online resources as currently providing strong potential for learning and training in OPIMS technologies. Online learning and training resources have the added benefit of availability and repeatability: participants can study the technology at their own pace.

It is recommended that management, in implementing new technologies, consider not just technical training, but also the broader personal, software, job and organisational training needs necessary to address a range of resistance factors. The potential of online and other non-traditional teaching methods is also an important consideration.

7.3.2 Building a Wide Support Network and Motivation

This study has confirmed that user attitudes towards technology are strongly influenced by social processes and structures (Orlikowski, 2000; Rogers, 2003; Valente, 1996b). People from inside and outside of an organisation can exert critical influence on the attitude of technology users, including by taking a key supporting role. For example, from the interviews in the qualitative study, the procurement manager of a main contractor could provide direct assistance to sub-contractors in the use of the technology for uploading and downloading project information during a construction project. The full scope of a support network can include managers, supervisors, peers and co-workers from inside and outside the organisation, project team members, IT staff inside the organisation and software providers. Therefore, with reference to OPIMS implementation, it is essential that organisations consider and help to maintain users' support networks to ensure that they are well connected, with a sufficiently broad range of others to provide them with assistance in different ways and in different situations when using the technology.

These findings resonated strongly with the findings of more generic studies on the role of leaders, peers and affiliates in fostering innovation (Jiang et al., 2000; Kissi et al., 2012; Martinko et al., 1996; Valente & Davis, 1999). A study undertaken by Kissi et al. (2012) examined the role of middle managers who have responsibility for developing the right environments to foster innovation in construction organisations. That study highlighted the fact that the support provided from middle managers to users (including technical, work and personal motivation) during the process of technology implementation helped in overcoming resistance. Similarly, Jiang et al. (2000), in a study of 66 managers in a variety of organisations, found that based on system types and key reasons for user resistance, the most favourable strategy to overcome resistance is a participative approach. Employees are at their most positive towards new technologies when managers are supportive. Being supportive in this sense involves adopting an environment of open communication, in which information on the technology is provided to users, employees participate in the decision-making process and there is a clear set of expectations for how the technology is to be used.

For some participants in the interviews, having a clear motivational target was central to improving attitudes, confidence and user performance. This is the case not just towards OPIMS, but also to the job as a whole. Salary increments or monetary rewards alone need not be the only driver of motivation. Monetary rewards do increase motivation, but they are not always sufficient in isolation. A wide range of actions and initiatives are available to improve user motivation, and this thesis recommends pursuing these. These include holding a series of workshops, conferences, meetings and events related to OPIMS, and involving as rich a mix of potential collaborators and mentors in those sessions as possible.

7.3.3 Active Role by Project Team to Achieve Successful Technology Implementation

In construction management generally, there is an assumption that clients have a role to play in driving innovation (Blayse & Manley, 2004; Brandon & Lu, 2008; Brown et al., 2006). Even though clients are not expected to invent something new, the industry does regard clients as having a role in the promotion and introduction of new initiatives that have ongoing potential benefit to the project team. However, there can be a tendency to rely too heavily on clients to drive innovation. This is the case most especially where the technology is relatively mature and already well understood by the industry, but still subject to resistance. OPIMS has existed in the industry for over a decade, but the broader implementation of the technology cannot depend solely on client initiative. Different clients and stakeholders hold different interests and gain the benefits of innovation in different ways (Sexton et al., 2009), and this can act to confound successful technology implementation.

According to Sexton et al. (2009), the role of the client can be varied during the innovation process. The client can adopt a dominant, balanced co-production and/or passive relationship to innovation at different stages of the deployment (Sexton et al., 2009). Clients are dominant when they are the lead users (Sexton et al., 2009), or what can be called a 'reformer' of the project team. The balanced co-production role is when both the client and the project team drive innovation. The passive role is where the project team drives innovation (Sexton et al., 2009). In the case of OPIMS, when the spread and progression of the technology in the construction industry has reached

maturity, the client's role in driving the technology becomes more passive. Clients do not necessarily drive the diffusion process of OPIMS in the long term, as the active role and motivation to adopt the technologies has been shared and dispersed across the industry by the project team. The focus, and expectations, then shifts to the 'technology champions' within the industry to promote further adoption. OPIMS is at a stage at which it is no longer being driven by client requirements, and rather needs to be championed and used by project teams themselves to promote wider participation across the industry (by designers, engineers, project managers, surveyors and builders).

This shift is evident in the findings of this research. The qualitative study shows how each individual organisation can adopt a more direct and active role in the implementation of OPIMS, having themselves been introduced to the technology previously by a client. The most effective way to overcome the resistance to OPIMS that remains even after the technology has reached maturity is for individual project teams to actively support the typically smaller-scale and more conservative consultant and sub-contractor organisations. Of course, not all consultancies and sub-contractors are small-scale or conservative, but where they are, the strongest motivation for change is to maintain a long-term business relationship with them based on the kind of win-win situation that OPIMS can offer.

7.4 Significant Contributions to Knowledge, Limitations and Recommendations for Future Research

Section 7.3 discussed the significant contributions of this research to the construction industry and practitioners. Another significant contribution of this research is the development of new knowledge and a model that measures resistance and provides insight into the problems encountered in implementing technology. Although the model should not be applied rigidly, it can serve as a basic guideline for organisations to prioritise technology implementation. The model can assist construction organisations to identify potential problems in the technology implementation process and make decisions about implementation strategies and plans.

7.4.1 Theoretical Background, Model and Research Case

This present study has made an original and significant contribution to knowledge and theory. It has improved and complements the theoretical technology acceptance, adoption and DoI literature. Further, this study has addressed the deficiency in the existing literature by confirming the concepts and role of resistance in the technology implementation process. This study has identified 17 factors related to resistance. Two are categorised as measures of resistance, while 15 are factors of resistance. The relationships of these factors with resistance have also been determined, revealing that Leaders, Peers, Compatibility, Complexity and Trialling are critical factors, while Affiliates, Motivation, Advantaged and Learning are potentially critical. The remaining factors: Knowledge, Use, Efficacy, Anxiety, Power and Visibility are considered weak. No previous research has integrated and categorised all these factors. This finding should enrich the construction innovation body of knowledge, especially in relation to the technology implementation process. In addition, this research has shown how resistance can be understood and managed, and how technology implementation can be improved by integrating three perspectives: DoI, TAM and SNT. From the perspective of DoI, Compatibility, Complexity and Trialling were found to be critical on resistance. From a TAM perspective, Motivation was found to be particularly important. Finally, from the third perspective, social support from Leaders and Peers was the key factor influencing individuals' resistance.

Although a wide range of studies have addressed resistance (Hirschheim & Newman, 1988; Joshi, 2005; Kim & Kankanhalli, 2009; Laumer & Eckhardt, 2012; Martinko et al., 1996), nature of resistance (Lapointe & Rivard, 2005; Marakas & Hornik, 1996; Rivard & Lapointe, 2012) and approaches to manage (Jiang et al., 2000; Legare, 1995) and measure resistance (Davis, 2004), few have investigated, developed and tested models of factors that influence resistance. This thesis contributes to the technological innovation literature by offering a broader view on resistance. It is the first research exploring resistance factors to technologies through three different perspectives: DoI, TAM and SNT. From these theories, the research developed its IRFM. The research considers that the fundamental theoretical framework and model is successful and produces the intended result; that is, it identifies the critical factors of resistance to

OPIMS. However, future research should not be limited by the theory offered in this study.

The current testing of the IRFM has been specific to OPIMS. Further research is required to test and compare the model on other technical innovations of increasing relevance to the construction industry, such as mobile computing devices and BIM. As discussed in Section 1.2.3, BIM is currently the main agenda of BEIIC initiatives for the Australian construction industry. It has been reported that resistance to change is the key challenge facing the promotion of BIM across the industry (see Allen Consulting Group, 2010; BEIIC, 2012; buildingSMART, 2012; CRCCI, 2009). This research has highlighted the value of resistance specifically to OPIMS; however, it also offers initial evidence and support for a framework of the factors of resistance, and explains how these factors are relevant for IT innovations. Thus, this study could help BEIIC to frame and justify the existence of resistance towards BIM.

Current testing has also been confined to a particular range of generic individuals already recognised in the literature as significant members of the social network pertaining to technology resistance. Given the importance of this particular aspect of the IRFM, further investigation is recommended to identify any further support network actors not previously recognised.

7.4.2 Research Method and Analysis Techniques

This thesis employed a mixed methods research approach. This is not a novel method in the context of technology resistance or the construction industry. However, by using a combination of quantitative (survey) and qualitative (interview) data and perspectives, the research demonstrated the value of seeking to address resistance in a more comprehensive manner. The research successfully tested resistance factors by estimating the variables in the equations using a PLS technique, and it verified those factors using a systematic narrative based on thematic analysis.

The use of a mixed methods approach does raise key limitations that are inherent characteristics of that approach. For example, mixed methods can produce bias in the collection process and tends to add complexity in the analysis of the data (Cameron,

2009; Teddlie & Tashakkori, 2011). The mixed methods approach applied to this research was designed systematically and sequentially, and explicitly aimed to address key potential limitations. In the quantitative study, survey was used to explore and test the resistance factors. In the qualitative study, interview was used to deepen the understanding of critical factors of resistance and explore basic strategies to overcome resistance. This separation of the implementation and interpretation of the two main techniques helps to limit bias and reduce the complexity of the analysis.

Models that are based on a formative design process can also create bias when the validity of the measurement items and constructs is being determined (Bagozzi, 2007b; Diamantopoulos & Siguaw, 2006). Unlike reflective design, guides for ensuring the validity and reliability of formative models are under-developed and more difficult to source. In formative design, there are no established rules about the number of items required to inform or logically induct a construct. The approach in this thesis has been to capture and include as many items as possible relating to each construct based on the theory. Moreover, in this study, the objective has been to test a new model of resistance rather than to test an already well-established theoretical model. PLS is recognised as the optimum test when the purpose of the study is exploratory and aimed at theory development (Chin, 1998b). The strength of the PLS measure of the IRFM is taken as confirmation that the formative design used in this thesis has been appropriately developed and applied to predict and generate a model of resistance factors.

Until now, formal analyses of the validity of formative design have been almost exclusively limited to multicollinearity and nomological measures (Andreev et al., 2009; Diamantopoulos et al., 2008; Roberts & Thatcher, 2009). Formal validity analysis techniques for formative design have not received the broad research attention this warrants. This thesis has contributed to the field by adopting a complementary and simplified correlation procedure based on Spearman's correlation coefficient. This technique has been applied successfully once previously, in a study on e-business success factors (Haenlein, 2004). The utility of the approach in this thesis strongly recommends that future studies dealing with formative design use Spearman's correlation coefficient for validity analysis.

7.4.3 Sample Size and Composition

The sample size for any mixed method approach that relates to a difficult and sensitive business practice will be of concern since eliciting responses is more likely to be time-consuming and commercially sensitive. The sample size achieved for this research was limited for both the quantitative and qualitative aspects of the study. However, a sample size of 88 is deemed to be sufficient for the purposes of model testing using PLS (Chin, 1998b; Chin & Newsted, 1999), and taken as sufficient for this study. However, the possibility of bias in the data remains, and future research would usefully involve a larger sample for both the quantitative and qualitative studies.

The composition of the sample also places limitations on the findings. As an initial exploration of the issue, the sample in this research was comprised of as broad a mix of participants as possible. This included both professionals and students/trainees employed in different scales of organisation and in different sectors of the industry. Due to this mix, the research was not able to test a significant proportion of the population of OPIMS users, and no analysis of particular user groups was possible. Future research could complement the wide, exploratory scope of this study with a greater focus on specific professions or job positions. Such a focus in future would provide findings more specific to, for example, individual populations of architects, engineers, project managers, document controllers and/or sub-contractors. More focus on particular professions would reveal any differentiation between such groups and/or with the broader population represented in this study.

7.5 Conclusion

Section 2.2 highlighted that, in the world of technology innovation, resistance is generally considered negative and as something to be avoided rather than studied. Consequently, studies of technology acceptance dominate the literature and the outcomes inevitably hinge on emphasising the positives. Turning research attention to resistance is not just a matter of flipping the coin; it exposes a new set of variables and possibilities to improve the rate and extent of technological innovation. Resistance is a marker for user dissatisfaction and dysfunctional technology. As such, it offers a particularly helpful perspective on technology innovation where user dissatisfaction and

dysfunctional technology are evident. This is most often the case once a technology has reached maturity in an industry.

As discussed in Section 1.2.3, OPIMS technology is relevant to the construction industry, where it is a mature innovation, widely known and in use for over a decade. The established benefits of OPIMS are significant, and the capacity to move large quantities of digital information online has changed how communication and information exchange is practiced across the project team. However, despite the effectiveness of the technology as it is currently implemented, further adoption of OPIMS appears to have stalled. Attempts to promote further and broader acceptance of OPIMS have been fruitless. The purpose of this research is to consider the potential for an alternative conception to acceptance, instead based on resistance.

The literature is clear. Resistance to technology in organisations is most strongly influenced by three aspects: how well users understand the functionality and limitations of the technology; the operation and structure of the host organisation; and individual user attitudes, behaviours and biases. Never before, however, has resistance been considered through the triple lens of all three aspects. This thesis has sought to develop and test just such a model. The IRFM, as presented in Section 3.1.3, is a construct of concepts and theory derived from the DoI, TAM and SNT. The developed IRFM comprises two variables used to indicate and measure resistance (Time of Adoption and Usage Level of the technology) and 15 variables that influence resistance; specifically, support network (Leaders, Peers, and Affiliates), experience (Knowledge on ICTs, Use of ICTs), disposition (Motivation, Efficacy, Anxiety, Power), integration (Advantage, Compatibility, Complexity) and accessibility factors (Learning, Trialling, Visibility).

A mixed methods approach has been adopted for the purpose of this research, which aims to identify the fundamental factors that influence individual resistance, how the presence of resistance can be measured and to what extent individual resistance factors influence overall resistance. The mixed methods comprise quantitative (survey) and qualitative (interview) techniques to complement an extensive review of the literature. The approach has been most effective in supporting an exploratory engagement with the research questions, adopting a pragmatist paradigm to gain holistic perspectives on practical problems. Essential to the effectiveness of this approach has been the clear

delineation maintained between initial model formulation (from theory), identification of significant influences from a fixed set of candidate factors (using a survey), and further interrogation and verification of the significant factors by stakeholders (using interviews). The methodology of the research has been explained in Chapter 4.

Data collection and analysis in the quantitative and qualitative phases were conducted sequentially (as presented in Chapters 5 and 6). First, a set of surveys were distributed to the industry, generating 88 valid responses. Data from the surveys were analysed using the PLS technique, adopted from SEM. The PLS analysis showed that, collectively, all of the factors proposed in the IRFM are necessary and sufficient to predict resistance. This result confirms that the model is credible and robust overall. Individual factors were also tested using PLS, and the findings of that analysis were validated through a series of interviews with industry stakeholders. The interview data were interrogated using thematic analysis. The composition of the final IRFM was determined based on a combination and comparison of the survey, interview and literature review results. In this final chapter, the factors in the final IRFM were classified as critical (identified and fully verified), potential (identified but only partially verified) or weak (identified but not verified). The critical resistance factors are support from leaders; support from peers; compatibility of the technology; complexity of the technology; and trialling of the technology. The most effective strategies for overcoming resistance are therefore those that focus on creating a new learning and training experience, widening and increasing the accessibility of support, improving motivation and promoting a more active role from management.

The intention of this research has been to explore and gain a better, more in-depth understanding of the resistance factors that typically attend a mature technology innovation, such as OPIMS. The final IRFM is based on an extensive review of every key aspect of the resistance research, and for the first time consolidates the three key theoretical perspectives that relate to technology innovation into a triple lens. The critical resistance factors identified in the IRFM also point to the most effective strategies for overcoming resistance. From a practical standpoint, the findings of this research represent a key shift towards conceiving technology innovation more usefully in terms of resistance, especially for mature technologies. Further research should aim

to test the IRFM on other technologies, acquire a larger and more stratified sample set and consolidate the application of PLS as an analysis technique for mixed method approaches.

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Appendices

Appendix A: A Summary of the Literature Specific to Construction.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Laage-Hellman and Gadde (1996)	Identified Electronic Data Interchange (EDI) implementation problems and barriers.	Information exchange and communication standardisation. Other applications support EDI. Upgrade hardware and software to use EDI.	IT skill and competence among staff.	Top management support. Change in business process. Knowledge and awareness of EDI benefits. Long-term partnership.	NA	Organisation.	Case study. Interview.
Johnson and Clayton (1998)	Investigated the impact of and potential barriers to IT implementation in design and construction organisations.	Reliability. Interoperability. Customise the technology to meet the organisation's needs.	Learning and training.	Prioritising technology to suits current needs. Assessment of return on investment (ROI) In-house support. Familiarity of senior management with the use and potential of the technology. Cost (related to operation, maintenance and staff training). Culture change.	NA	Organisation.	Survey.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Marsh and Finch (1998) and Marsh and Flanagan (2000)	Investigated the driver and barriers of automatic identification (Auto-ID) adoption.	Equipment under-developed. Vague products and component.	Employee resistance. Training.	Awareness and motivation. Conservative organisation.	Uncertainty towards measuring cost and benefits of technology investment. Unwillingness to invest.	Organisation.	Survey.
Marosszeky et al. (2000)	Investigated risk factors of IT implementation and barriers contributing to low-level adoption.	NA.	NA	Restricted vision in strategic IT use. Limited skills among top management. Financial risk. Unclear about benefits and advantages of IT investment.	Industry's fragmented nature. Low level of trust.	Organisation.	Field study. Interview.
Mitropoulos and Tatum (2000)	Investigated the forces that drive construction firms to adopt new IT such as CAD and EDI.	Process problems (supply, demand and sector growth). Technological opportunity (cost, availability skills and complementary technologies).	NA	Competitive advantage (core technology and adoption by competitors).	External requirement (owners demand, regulations, use by competitors).	Organisation.	Case study. Interview.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Love et al. (2001)	Evaluate the barriers of e-commerce implementation in small-medium size contractors.	Compatibility with other software. Integration with employees' work. Security and authentication.	Jobs lost. Reluctance to change. Concern over the requirement to undertake additional training and skill development. Fear and uncertainty. Self-respect and image. Support.	Cost and financial (maintenance cost, cost of training and education, market uncertainty, productivity and risk). Impact of e-commerce to business. Investment appraisal techniques. Organisation strategic planning. Employee knowledge. IT infrastructure. Reluctance from partners. Reluctance to change the business process.	NA	Organisation.	Interview.
Stephenson and Blaza (2001)	Investigated problems related to management information system (MIS) implementation in medium size construction organisations.	Pilot test and trial.	Employees' existing skill base. Ongoing staff training.	Cost. Culture. Top management support.	NA	Organisation.	Case study. Interview.
Weippert et al. (2002)	Studied benchmark and success factors to internet-based information and communication system (ICPM) and communication technologies (ICT) implementation.	Quality and accuracy of communication and information. Reliability and relevance. Compatibility. Ease of use. Trialling.	Ongoing learning and training. Early involvement.	Legal issues (electronic signature, requirement for hardcopies). Corporate commitment. IT support.	NA	Organisation.	Case study. Interview. Survey.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Whyte et al. (2002)	Issues and problems to implementation of virtual reality (VR).	Interoperability. Functionality. Time, quality and effectiveness. Transition strategy. System support.	User involvement.	Prior experience to similar technology. Uncertainty about projects. Work pressures. Temporal and fiscal strategy.	NA	Organisation.	Case study. Interview. Artefacts.
Alshawi and Ingirige (2003)	Investigated problems and benefits of the implementation of web-enabled project management in selected organisations.	Security of project information. Integration. Compatibility.	NA.	Culture change. Copyrights and ownership of drawings. Concern that the technology would replace face-to-face meeting. Appropriate IT staff. Cost.	Project size. Project duration. Type of contract.	Organisation.	Case study.
Mohamed and Stewart (2003)	Explored users' perceptions on web-based communication technology and potential indicators to improve implementation.	Reliability. Availability. Security. Suitability, integration and process coordination. Efficiency.	Usage level. Training. Technical support. Personal satisfaction with the technology.	Cost and benefits. Competitive advantage. Organisation image. Culture change.	NA	Individual.	Case study. Survey.
Voordijk et al. (2003)	Implementation of an enterprise resource planning (ERP) system in a construction organisation.	Technology maturity.	NA	Business strategy (cost control, free market, central planning). Implementation process and change management.	NA	Organisation.	Case study. Interview. Artefacts.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Nitithamyong and Skibniewski (2004, 2006)	Investigated success and failure factors of web-based construction project management systems (WPMS) implementation.	Ease of use. Data quality and reliability. System reliability. Output quality. Data security. Integration with team's internal systems. Integration among PM-ASP features. Integration with external software program. Number of users. Type of hosting options. Frequency of software/version update.	Internet access availability. Team attitudes towards the technology. Type of Internet service/access. Level of support from top management. Adequacy of training. Presence of champion. Adequacy of resources. Prior experience with the technology. Alignment of the implementation objectives to project objectives. Users' involvement during planning. Party who decides on use of the technology. Ability of project manager. Frequency of usage. Party who pays for use of the technology. Computer experience.	Starting stage of technology development Type of owner. Complexity related to construction tasks. Type of contract. Project size. Type of project. Project duration. Complexity related to design and engineering. Project location. Project cost.	Promptness of responses from technology provider. Technical competency of technology provider's staff. Knowledge of construction business. Attitudes of staff. Contact facilities.	Organisation and industry professionals.	Case study. Survey. Interview
Kale and Arditi (2005)	Investigated factors that influence organisation to adopt Computer-Aided Design (CAD).	NA	NA	Copying behaviours of others.	Changes in government regulations. Demand conditions. Consulting firms' suggestions. Complying with clients' requirement.	Organisation.	Survey.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Ruikar et al. (2005)	Identified end-user perspectives on possible barrier to implementation of project extranets.	Online connectivity. Technical (compatibility and interactivity) Security.	Pressure. Reluctant to change.	Cost issues. Culture change. Legal issues.	Multiple-vendor and software.	Individual.	Case study. Interview.
Peansupap and Walker (2005, 2006b)	Explored factors that influence ICT diffusion and adoption in construction organisation.	Perceived benefits and advantages. Technology characteristics.	Personal characteristics. Positive towards technology use. Tangible and intangible reward.	Supporting open discussion environment. Management support (e.g. manager, supervisor and colleagues). Technical support.	NA	Organisation.	Case study. Survey. Interview.
Aranda-Mena et al. (2006)	E-business uptake in small building organisation.	NA	Skills and training.	Influence from colleagues, family member and junior employee. Organisation awareness and readiness. Risk averse and scepticism.	NA	Organisation.	Case study. Interview.
Miller et al. (2006, 2009)	Factors influence application and diffusion of 4D CAD in project teams.	Intended benefits. Integration with request of information (RFI) system.	Learning and training. User resistance. Support.	Top management initiative, awareness and skills.	Onsite champion. Strategic planning and mutual understanding. Interest and awareness from project personnel. Sustain use.	Organisation.	Case study. Interview.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Zou and Seo (2006)	Driver and barriers influence effective implementation of e-commerce technologies in construction supply chain.	Integrated information management system. User-friendly system.	Ongoing training. Adequate time allocation for training. Support from middle manager. Stress and expectation. Proficiency. Incentives. Politics and competition among co-workers.	Reluctance to adopt. In-house technical and personnel. Culture change. Fear of business process change. Cost. Industry standard. Awareness.	NA	Organisation.	Survey. Interview.
Hjelt and Björk (2007)	Investigated end-user attitudes towards electronic document management (EDM).	System quality (functionality and usability). Information quality (up to fate, accurate, complete and well structured).	Involvement in project. Involvement in information process. IT skills. Personalities.	Support quality (training and guidelines). Management attitude. Infrastructure. Support from colleagues.	NA	Individual.	Case study. Survey. Interview.
Croker and Rowlinson (2007)	Investigated critical factors influencing temporal decision making on IT implementation and diffusion in construction project teams.	Security of information. Confidentiality between users. Software standards. Perceived benefits.	Training for collaboration work and IT application. Skills. Work task.	Culture (resistance to change and risk adverse). Technology gatekeepers and champions. Corporate strategy (resisting inertia, overcoming uncertainty, awareness).	Project team readiness (financial and technical resource availability). Project size. Project team structure (short-term alliances). Client and contractor awareness. Consultant to promote technology to clients.	Organisation.	Case study. Survey. Interview.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Hartmann and Fischer (2009)	Resistance during implementation of 4D CAD.	Ease of use. Efficient.	Learning and training. Perceived productivity.	Benefits solely for one party (i.e. client). Scepticism. Reluctant to change. Awareness.	NA	Organisation.	Case study. Interview.
Lou and Alshawi (2009)	Identified critical success factors for e-tendering system. Focussed on people and soft issues.	Process-led. In line with project team strategy. Unchanged work process to fit technology. Conduct self-evaluations before change. Conduct change through change strategies; for example, business process reengineering or change management. Alert to current research and development methods for better business processes.	Motivation of employees. Interest in IT. Job satisfaction. Prior experience with the technology. Attitude towards the system. Technology champion. Presence of top management support. Job security. Accessibility and availability of internet. Training. Adequacy of resources. Younger staff—more interest, training and focus on IT. Perceived benefits and capabilities of the technology. Improve efficiency and productivity.	NA	NA	Individual.	Case study. Interview.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Lam et al. (2009) and Wong and Lam (2010)	End-user behaviours and concerns on electronic information exchange technology.	Capacity for information transfer. Complexity. Information overload. Interactive and friendly system. Compatibility with different systems. Alert system when receiving a document. Fit with work purpose and process.	Self-discipline. Training. Worry about security. Tendency to send information to irrelevant parties. Tendency to ignore information or non-action. Compliance with current procedure. Update document. Tendency to input irrelevant information. Abuse by system.	Organisation commitment. Technical support.	Document handling. Time target. Collaboration relationship among departments. Performance targets. Work onsite. Material ordering system.	Individual.	Cross-sectional study. Survey.
Rowlinson et al. (2009)	Implementation of building information modelling (BIM) in construction.	Integration of technology and project design processes. Compatibility with other systems (e.g. procurement). Interoperability.	NA	Business success. ICT champion (e.g. senior manager). Culture change.	NA	Project team.	Case study.
Ahuja et al. (2010)	Factors affecting building project management (BPM) tools adoption.	Infrastructure maturity.	NA	Perceived benefits of the technology. Perceived barriers for adoption. Use technology for general administration. Use technology for project scheduling purposes. Cost management. Resource management.	Geographical and location of project team members.	Organisation.	Mixed methods study. Survey. Interview.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Gu and London (2010)	Key issues and factors influence BIM adoption.	Compatibility and interoperability. Integration with time sequence, cash flow modelling and simulation, and risk scenario visualisation. Integration with document management system. Integration with communication and document exchange. Data storage, security and copyright issue.	Training. New roles and responsibilities (e.g. BIM manager).	Cost and investment. Human resourcing. Project bidding and contractual arrangement. Organisation's strategic direction.	NA	Organisation.	Focus group interview.
Arayici et al. (2011)	BIM adoption and implementation strategy.	Easy and intuitive. Test and trial. Produce accurate drawings. High quality of visualisation. Information sharing and exchange. Integration with financial and cost control. Integration with building assessment tools (e.g. Codes for Sustainable Homes). Integration with project information database. Simultaneous work process.	Training. Skills and proficiency. Allow feedback from users to improve system development. Automation of project quality plan. Management support system.	Exploration of BIM tools and efficiency gains identification. Increase understanding and awareness. Piloting BIM tools on past projects. Compare BIM tools. Add value to marketing, administration and contractual information.	NA	Organisation.	Case study. Interview.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Brewer and Gajendram (2011) and Gajendran and Brewer (2012)	Impacts and effective decision making on implementation of ICT and BIM technology.	Technology availability externally to facilitate inter-firm collaboration. Technology matches business process maturity. Data security and intellectual property. Integration with work and other technologies. Interoperability. Trial.	Training. Skills and job development.	Culture change. Cost and investment (hardware, software, staff development, training, maintenance). Technology champions. Embedding own staff to train trading partners to ensure their use of the technology and for quality assurance purposes.	Project team relationships. Contractual relationships.	Organisation.	Case study. Survey. Interview.
Gambatese and Hallowell (2011)	Factors influencing the development, diffusion and implementation of technical innovations.	Increase quality of work and productivity.	Support from upper management. Support from client/owner. Fear of change. Training.	Culture. Cost. Risk of failure. Competitive advantage. Technology champion.	Communication. Marketing effort.	Organisation.	Mixed methods study. Interview. Survey.
Habets et al. (2011)	Adoption process of new and innovative equipment used for transporting asphalt from asphalt plant to construction site.	Perceived benefits. Function and capacity. Trial. Flexibility. Reliability. Velocity. Standardisation.	NA	Cost. Feasibility. Legal aspect. Top management knowledge.	NA	Organisation.	Case study. Interview. Survey.
Abrahamse and Lotriet (2012)	Investigated socio-organisational issues affecting mobile technology adoption and diffusion in a small-to-medium-size construction company.	Compatibility.	Experience and exposure. ICT literacy. Personal belief. Motivation. Stage of career. Training and technical support.	Company vision, strategic and internal policy. Politics. Management and IT support.	NA	Organisation.	Case study. Interview.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Khosrowshahi and Arayici (2012)	Factors influencing BIM adoption, and strategy to improve implementation.	Information management for building lifecycle. Efficiency of design process. Quality of visualisation, analysis modelling and documentation. Integration work flow to lean-oriented process. Hardware resource and infrastructure. Integration between design and engineering.	Education, knowledge transfer and training. Experience using 3D visualisation, modelling, analysis and dataset. Understanding and awareness. Resistance to change.	Culture change. Reluctance to initiate workflow. Cost and investment (installation and training). Intangible benefits. Demand of use. Risk management. Sustainability for design and construction. Support and collaboration for uptake and implementation between project team, including contractors. Legal aspect.	NA	Organisation.	Mixed methods study. Interview. Survey.
Kissi et al. (2012)	Investigated the role of middle manager in influencing technology adoption in an organisation; in particular, with regard to project monitoring and reporting software, new paving material and site survey systems.	NA	Supportive climate. Personal involvement. Personal responsibility. Autonomy to encourage creativity. Awareness. Championing behaviour. Network with the involvement of IT team and across company.	Financial resource.	NA	Organisation.	Case study. Interviews. Artefacts.
Son et al. (2012)	Investigated construction professionals' acceptance of mobile computing technology.	Usefulness. Ease of use. Complexity. Job relevance. Result demonstrability. Perceived performance.	Training. Personal satisfaction. Technical support.	Top management support. Social influence.	NA	Individual.	Survey.

Literature review		Potential barriers and factors for successful technology implementation and adoption				Level of investigation	Research design and methods
		Technological and process consequences	Individual consequences	Social, structural and organisational	Others		
Wong and Zhang (2013)	Limitations and critical factors to improve WPMS implementation.	Stable computer system. User access, password and security. Internet connection and web browser. Server and secure data centre. Active server and easy technology installation effort. Data integration with construction management, project management and communication. Compatibility with in-house systems.	Training. Incentives. Certificate and/or recognised qualification.	Review periodically implementation process.	Client established contractual requirement to apply the technology.	Organisation.	Case study. Interview.

Appendix B: Resistance Theory and Models.

Literature	Model	Theoretical foundation	Conjecture and supposition	Core elements of the model, reasons and factors that influence the resistance
Joshi (1991, 2005)	Equity Implementation Model (EIM).	Equity theory (Walster et al., 1978).	EIM proposes that technology change involves changes in inputs and outcomes. If individuals perceive less benefit (net gains) from the change, they are likely to be distressed and resist the change.	Increase in outcomes (pleasant work environment, less tension, job satisfaction, opportunities for advancement, customer services, recognition, visibility, salary, job grade, job level, power and influence, learning marketable skills, reduced dependence on others, usefulness of technology). Decrease in outcomes (reduced job satisfaction, reduced power, threat of loss of employment, loss of marketable skills, reduced importance and control, increased monitoring, reduced scope of advancement, conflict and ambiguity, potential failure in learning and adopting new system). Increase in inputs (more work in entering data, tension, higher level of skills, effort in learning a new system, additional tasks, more effort in performing task and monitoring, more time intensive, fear and anxiety). Decrease in inputs (ease of use, effortless, reduced information searching, reduced manual effort, cognitive effort, less rework and errors).
Marakas and Hornik (1996)	Passive Resistance Misuse (PRM).	Passive-Aggressive (P-A) behaviour theory (Fine et al., 1992). Action science's espoused theories v. theories in use (Argryis et al., 1985).	Passive resistance is identified as a covert behaviour that is not inherently criminal or motivated by personal gain. It results from fear and stress related to the intrusion of the technology into the conventional method.	Overt support for implementation strategies and objectives. Outward expressions of 'relief' that new technology is being implemented. Constantly bringing the new system into conversation. Covert procrastination. Working deliberately slowly, and outperformed. Privately protesting. Avoiding obligations by claiming to have forgotten or misunderstood. Unrealistic view of job performance compared to others' assessment. Resentment of useful suggestions of ways to be more productive. Unreasonable criticism of people in positions of authority who implement new technology.

Literature	Model	Theoretical foundation	Conjecture and supposition	Core elements of the model, reasons and factors that influence the resistance
Martinko et al. (1996)	Attributional Model of Reactions to Information Technologies (AMRIT).	Psychological attributions (Abramson et al., 1978). Organisationally induced helplessness (Martinko & Gardner, 1982). Math anxiety (Kloosterman, 1984).	User reactions to IT implementation including external influences, internal influences, reactions of behaviour and affect, attributions and expectations.	External influences (prior experience, attributional style). External influences (co-worker behaviour, technology characteristics, management support). Behaviour of reactions (acceptance, active resistance, passive resistance, reactance). Affect reactions (satisfaction, self-esteem, hostility, anger, stress, fear, apprehension, anxiety). Attributions (stability, ability, task difficulty, effort, luck/change). Expectations (efficacy, outcome).
Prasad and Prasad (2000)	Routine form of workplace resistance.	Iron Cage (Barker, 1993).	Routine resistance is covert in nature. It is less visible, unplanned and spontaneous, and recurring within the organisation.	Direct acknowledgement of intentional opposition, interruptions and questions during training sessions, working with manual methods, proxy grievances). Attributions of intentional opposition (carelessness). Attributions of non-intentional oppositions (employee reinterpretations of managerial discourses).
Cenfetelli (2004); Cenfetelli and Schwarz (2011)	Dual-factor model of IT usage.	Theory reasoned action (TRA) (Fishbein & Ajzen, 1975). Theory of planned behaviour (TPB) (Ajzen, 1991). Technology acceptance model, (TAM) (Davis et al., 1989; Venkatesh & Davis, 2000).	Rejection or resistance to use a technology may not result from the absence of an adopting perception (as theorised in TAM). Factors relevant to adoption did not contribute to rejection. Rejection refers to users' decisions to avoid a system; it is based on critical barriers such as lack of knowledge.	Information inhibitors (information overload, irrelevant request for information, deceptiveness). Information quality (timeliness, responsiveness). System quality (compatibility, reliability, relative advantage). System inhibitors (intrusiveness, effort redundancy, process uncertainty). Usage intention (perceive usefulness, perceived ease of use).

Literature	Model	Theoretical foundation	Conjecture and supposition	Core elements of the model, reasons and factors that influence the resistance
Davis (2004)	Social Architecture Factor Model (SAFM).	Change management. TRA (Fishbein & Ajzen, 1975). TPB (Ajzen, 1991).	Resistance to IT change can be indicated by type and scope and change; method and speed of introduction; demographic of individual; attitudes, beliefs and fears of individual; and demographic of organisation.	Type and scope of change (perceived changes in company, tasks requiring IT and their interdependence with other tasks). Method and speed of introduction (decision maker, training in the specific technological, resource availability, reward and punishment used). Demographic of individual (profession, age, gender, education level, member in a union, professional certification, position in the organisation, personality type, computer use). Attitude, beliefs and fear (computer anxiety, attitude towards computers and technology, computer confidence, adaptability, acceptance of uncertainty, readiness for change, locus of control, irrational idea, perceived interpersonal power, previous positive or negative technological experiences, motivation to use new technologies, disposition to innovation, perceived support for change, defence mechanism of the individual during change). Demographics of organisations (industry sector, company size).
Lapointe and Rivard (2005); Rivard and Lapointe (2012)	Multilevel model of resistance to information technology (MMRIT).	Power and politics in IT implementation (Markus, 1983). EIM (Joshi, 1991). PRM (Marakas & Hornik, 1996). AMRIT (Martinko et al., 1996).	Resistance contains elements of behaviours, object, subject, threats and initial conditions.	Resistance behaviours (speaking resentfully of the system, follow former or conventional procedures, misuse, harmful use, low-level use). Object (patterns that already exist or established routine and mode of work, political setting, individual rigidity and resentment). Subject (group, individual). Interaction (interaction between demands of the IT and established modes of work, attributional processes). Perceived threat (power loss and power gain for another, inequality, stress, fear, efficacy expectation, outcome expectations).

Literature	Model	Theoretical foundation	Conjecture and supposition	Core elements of the model, reasons and factors that influence the resistance
Ferneley and Sobreperez (2006)	Compliance-Resistance-Workaround (CRW).	Resistance literature (Bhattacherjee & Hikmet, 2007; Cenfetelli, 2004; Kim & Kankanhalli, 2009; Lapointe & Rivard, 2005; Marakas & Hornik, 1996; Markus, 1983; Martinko et al., 1996).	User engagement with new technology is associated with compliance (whereby use of the technology is prescribed by a manager or stakeholder), rather than based on the merits of the technology's effectiveness or suitability. Potential impacts from compliance are resistance (positive or negative) and workaround behaviours (e.g. non-use, sabotage, avoidance at work and entering inaccurate data).	Compliance conditions (enforced procedure, discipline, non-engagement with system, organisational and personal issues). Negative resistance (compliance and acceptance by supervisors, avoid monitoring, inappropriate target, time overhead to log in and out of the system, lack of understanding, lack of knowledge, culture, peer pressure). Positive resistance (avoidance of inappropriate procedures, inflexible and unsuitable for work, not supportive of team collaboration, lack of understanding, lack of knowledge on data requirement and usage, personal judgement). Workaround: harmless, hindrance, essential (e.g. incorrect job sequencing, sub-divide tasks that are traditionally performed collectively, unreasonable target, use for reasons of friendships, non-use, balance workload, avoidance of work).
Kim and Kankanhalli (2009)	Integrated framework of resistance and status quo bias.	TAM (Davis et al., 1989; Venkatesh & Davis, 2000). EIM (Joshi, 1991). Status quo bias theory (Samuelson & Zeckhauser, 1988).	Resistance can be driven by switching cost and threats, attitude and subjective norm associated with the new technology implementation.	Switching costs: changes in cost incurred from moving from the status quo to new technology (transition costs, uncertainty costs, sunk costs). Switching benefits (increase in outcomes, decrease in inputs). Attitude (loss aversion, net benefits, equity). Subjective norm (colleague opinion, self-efficacy for change, organisational support for change).
Meissonier and Houzé (2010)	IT Conflict-Resistance Theory (IT-CRT).	Conflicts associated with IT implementation in information system literature (e.g. Besson & Rowe, 2001; Markus, 1983; Markus et al., 2000; Wagner & Newell, 2004; Walczuch et al., 2007).	Resistance can be associated with task-oriented and socio-political conflicts in the organisation.	Task-oriented conflicts: conflicts about the system, definition and execution of task, and skills required. Socio-political conflicts: cultural conflicts and loss of power.

Literature	Model	Theoretical foundation	Conjecture and supposition	Core elements of the model, reasons and factors that influence the resistance
Klaus et al. (2010)	Resistance to enterprise system implementation.	Resistance literature. TAM. Concourse theory (Stephenson, 1978).	Resistance is driven by the characteristics of resisting users and the shared communication and beliefs that exist within user groups.	User characteristics (gender, education level, years in current position, age, job position, training). Reasons for user resistance (workload, lack of fit, technical problems, changed job, complexity, environment, lack of input, communication, training, uncertainty, self-efficacy, lose control). Resistance behaviours (challenge, impatient, complain, old system, defensive, procrastinated, unmotivated, inappropriate, does not follow processes, less productivity, shadow system, avoid, hack, turnover intention, does not want to learn system, quit, refusal). Management strategies (clear plan, expertise, communication, feedback, training, customisations, provide support, incentives).
Laumer and Eckhardt (2010); Laumer and Eckhardt (2010); Laumer (2012)	Model of Resistance to IT-induced Organizational Change (MRTOC).	TRA (Fishbein & Ajzen, 1975). TPB (Ajzen, 1991). TAM (Davis et al., 1989; Venkatesh & Davis, 2000). Social influence (Eckhardt et al., 2009). Resistance literature (Bhattacherjee & Hikmet, 2007; Cenfetelli, 2004; Kim & Kankanhalli, 2009; Lapointe & Rivard, 2005; Marakas & Hornik, 1996; Markus, 1983; Martinko et al., 1996).	Resistance is caused by outcome factors, process factors, individual personality, context and social influence factors.	Individual differences and personality (age, gender, self-efficacy, experience, personality). Context (management interventions, system characteristic, process change). Social influence (private and workplace referents). Technology perceptions. Resistance to change (belief and attitudes, perceived threats, loss of power). Process and working routine perceptions. Work-related outcomes. Technology-related outcomes. Process and working routine–related outcomes.

Appendix C: Summary of indicators, factors, constructs, definitions, hypotheses and measurement items.

Indicator and Factor Name	Construct Name	Construct Definition	Hypothesis	Items and Labels
Resistance Indicator	Time of adoption	Time of adoption after period of implementation of the technology in the organisation.	Hypothesis 1: Resistance towards OPIMS is significantly indicated by time of adoption.	Indicator 1: How long has it been since you first started using the technology?
	Usage level	Percentage of use of the technology on a daily basis.	Hypothesis 2: Resistance towards OPIMS is significantly indicated by the individual's usage level of the technology at work.	Indicator 2: On average, I use the technology for _____ per cent (%) of my working day.
Support Network Factor	Leaders	Leaders include supervisors, middle managers and directors.	Hypothesis 3: A network that consists of support ties from leaders will have a significant influence on resistance.	Leaders 1: My immediate supervisor encourages me to apply OPIMS in my work. Leaders 2: On average, how often have you [received direction on how to do your job; sought or gotten technical assistance to undertake your work; discussed your personal strengths and weaknesses specific to your work; discussed the use of OPIMS] with this person?
	Peers	Peers can be friends, co-workers and other professional colleagues.	Hypothesis 4: Support from peers significantly influences resistance.	Peers 1: Colleagues in my immediate work group are able to help me make effective use of OPIMS in my work. Peers 2: On average, how often have you [received direction on how to do your job; sought or gotten technical assistance to undertake your work; discussed your personal strengths and weaknesses specific to your work; discussed the use of OPIMS] with this person?
	Affiliates	Technical staff, customer services and administrative staff.	Hypothesis 5: The support network that is formed through relationships with immediate people who are assigned to uncover new technology (i.e. technical staff) significantly influences individual resistance.	Affiliates 1: Organisational technical support (e.g. help desk, IT support) is sufficient to allow me to apply OPIMS effectively in my work. Affiliates 2: On average, how often have you received [direction on how to do your job; seek or get technical assistance to undertake your work; discussed your personal strengths and weaknesses specific to your work; discussed the use of OPIMS] with this person?

Indicator and Factor Name	Construct Name	Construct Definition	Hypothesis	Items and Labels
Experience Factor	General Knowledge of ICTs	Individuals' exposure and familiarity with ICT-related technologies in general.	Hypothesis 6: General knowledge of ICT-related technologies significantly influences an individual's resistance towards OPIMS.	Knowledge 1: I have an excellent understanding of how to use and apply ICT effectively. Knowledge 2: I can see clear advantages from using ICT in my work. Knowledge 3: My skill in using ICT at work is well above average.
	Use of ICTs	Individuals' literacy on particular use of ICT in their work for work-related purpose, specifically communication and collaboration.	Hypothesis 7: General use of ICT technology at work significantly influences resistance towards OPIMS.	Use 1: I use ICT to communicate, manage and coordinate work with my immediate work team within the organisation. Use 2: I use ICT to communicate, manage and coordinate work with external organisations (project teams, consultant, clients etc.). Use 3: How frequently would each of the following technologies be used by you at work for work-related purpose? Please refer to Attachment A (given in Section 3.4.2).
Disposition Factor	Motivation	Individual's perception on what interests and drives them to increase adoption, and that simultaneously will decrease resistance.	Hypothesis 8: Motivation will have a significant influence on resistance.	Motivation 1: I use OPIMS in my work because I believe it is a requirement of the organisation. Motivation 2: I use OPIMS in my work because I find it is a requirement of my work. Motivation 3: I use OPIMS because of the intangible rewards I get from my work (enjoyment, satisfaction, etc.). Motivation 4: I use OPIMS because of the tangible rewards I get from my work (job security, advancement, new skills, etc.).
	Efficacy	Individuals' level of confidence in the use of the technology for work.	Hypothesis 9: Efficacy significantly influences an individual's resistance towards OPIMS.	Efficacy 1: I am confident in my ability to use OPIMS to complete a range of tasks related to my work. Efficacy 2: I am confident in my ability to find useful help should a problem arise in using OPIMS for my work.
	Anxiety	Level of apprehension and hesitation in the use of OPIMS for work.	Hypothesis 10: Feelings of strong anxiety or uncertainties related to the use of OPIMS will significantly influence resistance.	Anxiety 1: It concerns me that I could lose a lot of important information using the OPIMS should I make a mistake. Anxiety 2: I try to avoid using OPIMS in my work because the information it contains is so critical to the organisation.
	Interpersonal Power	Individual subjective qualities gained from the use of OPIMS for work.	Hypothesis 11: Interpersonal power will significantly influence an individual's resistance to OPIMS.	Power 1: Using OPIMS effectively is an important factor if I want to work in this industry in the future. Power 2: Knowing how to use the OPIMS is an important factor for getting people in this organisation to take you seriously.

Indicator and Factor Name	Construct Name	Construct Definition	Hypothesis	Items and Labels
Integration Factor	Perceived Advantage	The extent to which users believe that the technology complements their work.	Hypothesis 12: Perceived advantage towards use of OPIMS significantly influences an individual's resistance towards OPIMS.	Advantage 1: Using OPIMS makes me productive. Advantage 2: Using OPIMS gives me greater control over the work I do. Advantage 3: Using OPIMS improves the quality of the work I do.
	Compatibility	The extent to which an OPIMS user believes that the technology is suited to and well integrated with the work they do.	Hypothesis 13: Compatibility of the OPIMS with work tasks significantly influences resistance.	Compatibility 1: The OPIMS provides a good fit with my current work practices and requirements. Compatibility 2: The OPIMS allows full compatibility with other systems and software required for my work.
	Complexity	The degree of difficulty involved in applying the technology at work.	Hypothesis14: How complex the technology is perceived to be will significantly influence resistance towards OPIMS.	Complexity 1: Interacting with the OPIMS is clear and intuitive. Complexity 2: Overall, I find the OPIMS easy to use.
Accessibility Factor	Learning	The adequacy of learning and training received to learn OPIMS for users at work.	Hypothesis15: Inadequate learning in developing competency in OPIMS significantly influences resistance behaviour.	Learning 1: The quality of the learning and training that I have received in OPIMS is very good. Learning 2: The time and opportunity provided for me to learn how to make effective use of the OPIMS in my work is sufficient.
	Trialling	The degree to which users have had opportunities to trial OPIMS before using it.	Hypothesis 16: Opportunities to trial the OPIMS before using it will significantly influence resistance behaviour.	Trialling 1: I was permitted to use OPIMS on a trial basis. Trialling 2: I have had ample opportunity to use OPIMS during a trial period.
	Visibility	The degree to which the OPIMS is capable of being discovered by a user to become familiar with it.	Hypothesis 17: Visibility of the use of OPIMS at work will significantly influence resistance behaviour.	Visibility 1: I have had an opportunity to see OPIMS being used by others in the construction industry. Visibility 2: I have seen that the use of OPIMS in my organisation is widespread. Visibility 3: My perception is that most of the key people in this organisation are active users of OPIMS.

Appendix D: UNSW FBE Human Resources Ethics Approval

THE UNIVERSITY OF NEW SOUTH WALES

FACULTY OF THE BUILT ENVIRONMENT

HUMAN RESEARCH ETHICS ADVISORY PANEL

Built Environment Human Research Ethics Advisory Panel

Date: *28 May 2012*

Applicant Name: Siti Salwa Mohd Ishak

Faculty of the Built Environment

Re: *Resistance Factors to the Effective Use of Online Project Information Managment Systems (OPIMSs) in Construction Organisations*

Reference Number: *125034*
Investigator: Siti Salwa Mohd Ishak

At its meeting of 22 May 2012, the Built Environment Human Research Ethics Advisory Panel was satisfied that this project, is of minimal ethical impact and meets the requirements as set out in the National Statement on Ethical Conduct in Human Research*. Please see the accompanying minutes from the panels meeting for notes regarding your research.

Having taken into account the advice of the Panel, the Deputy Vice-Chancellor (Research) has approved the project to proceed. This approval does not include interviews.

Your Head of School/Unit/Centre will be informed of this decision. This approval is valid for 12 months from the date of the meeting.

Yours sincerely

Russell Lowe
Panel Convenor
Built Environment Human Research Ethics Advisory Panel

Cc: Head, School of the Built Environment
* http:/www.nhmrc.gov.au

Appendix E: Survey Instrument (Final Questionnaires)

Part 1: Introduction and project information statement

Participant selection and focus of the study:

You are invited to participate in a study of Resistance Factors to the Effective Use of Online Project Information Management Systems (OPIMS) in Construction Organisations. You were selected as a possible participant in this study because you have been identified as a student, cadet, graduate trainee or professional from a wide variety of backgrounds/disciplines (i.e. architecture, building, surveying, engineering, and construction management) and a potential user of an online project information management system.

There are many terms used to refer to an online project information management system, for example: project web, project extranet, web based project hosting, project management platform, virtual document exchange, and so on. Broadly speaking, and for the purposes of this study, the online project information management systems are used to manage a range of information specific to a particular construction project: project information, design details, project management and financial information. Such information might include project details, project team contacts, an email directory, CAD drawings, specifications, requests for information (RFIs), contract administration information, contract status, project time and schedule, safety information, cost estimation, cash flow, and so on. To be as inclusive as possible, we use the term online project information management system to refer to any web enable software package or online system used specifically to support information exchange on a construction project.

Description and purpose of the study:

The purpose of the study is to determine the factors that contribute to users being more or less resistant to the use of OPIMS's in a construction organisation. Through this research we aim to understand better how construction practitioners relate to the online technologies and what factors most affect any resistance on their part. Through a better

understanding of the resistance factors we aim to foster more effective implementation of and training support for the use of OPIMS technologies in construction.

If you agree to participate, please complete this survey and simply click on the SUBMIT button at the end. The questionnaire should take approximately 20-30 minutes to complete. We cannot and do not guarantee or promise that you will receive any material benefits from this study.

Confidentiality and disclosure of information:

Any information that is obtained in connection with this study and that can be identified with you will remain confidential to the study and will be disclosed only with your permission, or except as required by law. If you give us your permission, we plan to publish the results of this study in the form of a PhD thesis and as scholarly journal and conference articles.

Recompense to participants:

There will be no financial compensation given to participants.

Participant consent:

Your decision to participate will not prejudice your future relations with The University of New South Wales or any other participating organisations.

If you have any questions, please feel free to ask Siti Salwa Mohd Ishak, PhD Candidate at UNSW, on z3295765@student.unsw.edu.au.

If you have any further questions at any point, Associate Professor Sidney Newton at s.newton@unsw.edu.au will be happy to discuss these with you.

Thank you for your time and participation.

Part 2: Demographic of respondent

We are interested in whether the duration of work experience, education, employment role and other demographics of the participants has any impact on the survey outcomes.

1. Your current age:
   - ○ < 20 years
   - ○ 20 < 25 years
   - ○ 25 < 30 years
   - ○ 30 < 35 years
   - ○ 35 < 45 years
   - ○ 45 < 55 years
   - ○ 55 < 60 years
   - ○ 60 < 65 years
   - ○ 65 or more years

2. Gender:
   - ○ Male
   - ○ Female

3. What is the highest level of academic qualification you have already achieved?
   - ○ High School Certificate
   - ○ Certificate I-IV
   - ○ Diploma
   - ○ Advance Diploma
   - ○ Bachelor Degree
   - ○ Undergraduate Honours
   - ○ Graduate Certificate
   - ○ Graduate Diploma
   - ○ Masters
   - ○ PhD
   - ○ None of the above (Please specify: _____)

4. Are you a current student employed in the construction industry as a cadet, intern or graduate trainee?

- ○ Yes
- ○ No (I am experienced employee / professional)

If you answer "No" to this question, please skip to Question 8.

5. What is your current enrolment status in study?

- ○ High School Certificate
- ○ Certificate I-IV
- ○ Diploma
- ○ Advance Diploma
- ○ Bachelor Degree
- ○ Undergraduate Honours
- ○ Graduate Certificate
- ○ Graduate Diploma
- ○ Masters
- ○ PhD
- ○ None of the above (Please specify: _____)

6. What is the general field of your current study?

- ○ Building and Construction
- ○ Engineering
- ○ Architecture
- ○ Property Development
- ○ Facilities Management
- ○ Quantity Surveying
- ○ None of the above (Please specify: _____)

7. How much longer do you expect to be enrolled in the current program of study?

- ○ <6 months
- ○ 6 months < 1 year
- ○ 1 < 2 years
- ○ 2 < 3 years
- ○ 3 < 4 years
- ○ 4 or more years

8. How long have you been working with your current employer?

- ○ < 6 months
- ○ 6 months < 1 year
- ○ 1 < 2 years
- ○ 2 < 3 years
- ○ 4 < 5 years
- ○ 5 or more years

9. Which of the following is closest to your current job title?

- ○ Architect
- ○ Building Surveyor
- ○ CAD Operator
- ○ Contract Administrator
- ○ Construction Manager
- ○ Engineer
- ○ Estimator
- ○ Facilities Manager
- ○ Foreman/Builder
- ○ Project Manager
- ○ Property Development
- ○ Quantity Surveyor
- ○ Site Supervisor
- ○ None of the above (Please specify: _____)

10. What is your total duration of relevant industry work experience to date?

- ○ < 6 months
- ○ 6 months < 1 year
- ○ 1 < 2 years
- ○ 2 < 3 years
- ○ 4 < 5 years
- ○ 5 or more years

Part 3: General knowledge and use about ICTs

We are interested in your exposure and familiarity with ICT in general.

Please select from each of the lists below, whichever term best suits you to complete the sentence.

Note: ICT refers to information and communication technologies such as desktop and laptop computers and intelligent handheld devices such as the iPad and iPhone. It also includes applications such as the worldwide web, Facebook and Google.

11. Does your job require you to use any information and communication technologies (ICTs)?

- ○ Yes
- ○ No

If you answer "No" to this question, please skip to Question 48.

12. I believe that I have _____ understanding of how to use and apply ICT effectively.

- ○ an excellent
- ○ a better than average
- ○ an average
- ○ a less than average
- ○ a minimal

13. I can see clear advantages from using ICT in my work _____.

- ○ a clear majority of the times I use it
- ○ most of the times I use it
- ○ some of the times I use it
- ○ only a few of the times I use it
- ○ none of the times I use it

14. Compared to my fellow workers, I would describe the level of my skill in using ICT at work as _____.

- ○ well above average (top 20%)
- ○ above average (top 20-40%)
- ○ average (middle 40-60%)
- ○ below average (lowest 20-40%)
- ○ well below average (lowest 20%)

We are interested in the particular ICT you use in your work.

Please select from each of the lists below, whichever term best suits you to complete the sentence.

15. I use ICT to communicate, manage and coordinate work with my immediate work team within the organisation _____.

- ○ all the time (several times a day)
- ○ most of the time (daily)
- ○ some of the time (once or twice a week)
- ○ rarely (once or twice a month)
- ○ very rarely
- ○ never

16. I use ICT to communicate, manage and coordinate work with external organisations (project teams, consultants, clients etc.) _____.

- ○ all the time (several times a day)
- ○ most of the time (daily)
- ○ some of the time (once or twice a week)
- ○ rarely (once or twice a month)
- ○ very rarely
- ○ never

17. In your experience, how frequently would each of the following technologies be used by you at work for work related purposes?

ICT Tools' Name	5 = Several times a day	4 = Daily	3 = Once or twice a week	2 = Once or twice a month	1 = Very rarely	0 = Never
Electronic Calendar (e.g. MS Outlook Agenda)						
Email						
Facsimile						
Instant Messenger Service (IMS)						
Mobile Computing (PDA/Smart Phone/PC tablet)						
Mobile Phone						
Organisations Own Intranet System						
Pager						
Radio Transceiver (Walkie Talkie)						
Short Message Service (SMS/Text)						
Telephone (Landline)						
Telephone-conferencing						
Video-conferencing (e.g. Skype)						
World-Wide Web in General						

We are interested in the particular online project information management system (OPIMS) that you may or may not use in your work.

Note: There are many terms used to refer to an online project information management system (OPIMS), for example: project web, project extranet, web based project hosting, project management platform, virtual document exchange, and so on. Broadly speaking, and for the purposes of this study, the online project information management systems are used to manage a range of information specific to a particular construction project: project information, design details, project management and financial information. Such information might include project details, project team contacts, an email directory, CAD drawings, specifications, requests for information (RFIs), contract administration information, contract status, project time and schedule, safety information, cost estimation, cash flow, and so on. To be as inclusive as possible, we use the term online project information management system to refer to any web enable software package or online system used specifically to support information exchange on a construction project.

18. Have you ever used an online project information management system (OPIMS) at work?

- ○ Yes
- ○ No

If you answer "No" to this question, please skip to Question 48.

19. Please list the name(s) of the online project information management system(s) you use at work currently.

- ○ Software Name 1: _____
- ○ Software Name 2: _____
- ○ Software Name 3: _____
- ○ Software Name 4: _____
- ○ Software Name 5: _____

20. Who first introduced you to the importance of this kind of software for your work?

- ○ Organisation (manager, supervisor, IT technical staffs)
- ○ University (program courses, tutorials)
- ○ Software Provider (software company)
- ○ Others (Please specify: _____)

21. How long has it been since you first started using any of the OPIMS's mentioned above?

- ○ < 6 months
- ○ 6 months < 1 year
- ○ 1 < 2 years
- ○ 2 < 3 years
- ○ 4 < 5 years
- ○ 5 or more years

22. On average, I use OPIMS for _____ percent (%) of my working day.

- ○ <100
- ○ <80
- ○ <60
- ○ <40
- ○ <20

Part 4: Attitude and disposition towards OPIMS

We are interested in your attitude towards online project information management system (OPIMS).

Please select from each of the lists below, whichever term best suits you to complete the sentence.

23. I use online project information management systems (OPIMSs) in my work because I believe it is _____ requirement of the organisation.
    - ○ a critical
    - ○ a very important
    - ○ an important
    - ○ a somewhat important
    - ○ not an important

24. I use OPIMS in my work because I find it _____ requirement of my work.
    - ○ a critical
    - ○ a very important
    - ○ an important
    - ○ a somewhat important
    - ○ not an important

25. I use OPIMS because it is _____ factor in the tangible rewards I get from my work (job security, advancement, new skills, etc.).
    - ○ a critical
    - ○ a very important
    - ○ an important
    - ○ a somewhat important
    - ○ not an important

26. I use OPIMS because it is _____ factor in the intangible rewards I get from my work (enjoyment, satisfaction, etc.).

- ○ a critical
- ○ a very important
- ○ an important
- ○ a somewhat important
- ○ not an important

We are interested in your level of confidence in the use online project information management system (OPIMS) for your work.

Please use the following scale to indicate your response to the following statements.

27. I am confident in my ability to use online project information management system (OPIMS) to complete a range of tasks related to my work.

- ○ strongly agree
- ○ agree
- ○ neither agree nor disagree
- ○ disagree
- ○ strongly disagree

28. I am confident in my ability to find useful help should a problem arise in using OPIMS for my work.

- ○ strongly agree
- ○ agree
- ○ neither agree nor disagree
- ○ disagree
- ○ strongly disagree

We are interested in your level of anxiety in the use online project information management system (OPIMS) for your work.

Please use the following scale to indicate your response to the following statements.

29. It concerns me that I could lose a lot of important information using the online project information management system (OPIMS) should I make a mistake.
    - O strongly agree
    - O agree
    - O neither agree nor disagree
    - O disagree
    - O strongly disagree

30. I try to avoid using OPIMS in my work because the information it contains is so critical to the organisation.
    - O strongly agree
    - O agree
    - O neither agree nor disagree
    - O disagree
    - O strongly disagree

We are interested in any power issues associated with the use of online project information management system (OPIMS) for your work.

Please select from each of the lists below, whichever term best suits you to complete the sentence.

31. Using online project information management system (OPIMS) effectively is _____ factor if I want to work in this industry in the future.
    - O a critical
    - O a very important
    - O an important
    - O a somewhat important
    - O not an important

32. Knowing how to use the OPIMS is _____ factor for getting people in this organisation to take you seriously.

- ○ a critical
- ○ a very important
- ○ an important
- ○ a somewhat important
- ○ not an important

Part 5: Integration and accessibility OPIMS to work

We are interested in the extent to which online project information management system (OPIMS) complements your work.

Please use the following scale to indicate your response to the following statements.

33. Using online project information management system (OPIMS) makes me productive.

- ○ strongly agree
- ○ agree
- ○ neither agree nor disagree
- ○ disagree
- ○ strongly disagree

34. Using OPIMS gives me greater control over the work I do.

- ○ strongly agree
- ○ agree
- ○ neither agree nor disagree
- ○ disagree
- ○ strongly disagree

35. Using OPIMS improves the quality of the work I do.

- O strongly agree
- O agree
- O neither agree nor disagree
- O disagree
- O strongly disagree

We are interested in how compatible online project information management system (OPIMS) is to the work you do.

Please use the following scale to indicate your response to the following statements.

36. The online project information management system (OPIMS) provides a good fit with my current work practices and requirements.

- O strongly agree
- O agree
- O neither agree nor disagree
- O disagree
- O strongly disagree

37. The OPIMS allows full compatibility with other systems and software required for my work.

- O strongly agree
- O agree
- O neither agree nor disagree
- O disagree
- O strongly disagree

We are interested in how difficult you find it to apply the online project information management system (OPIMS) to the work you do.

Please use the following scale to indicate your response to the following statements.

38. Interacting with the online project information management system (OPIMS) is clear and intuitive.
    - ○ strongly agree
    - ○ agree
    - ○ neither agree nor disagree
    - ○ disagree
    - ○ strongly disagree

39. Overall, I find the OPIMS _____ to use.
    - ○ extremely easy
    - ○ moderately easy
    - ○ neither easy or difficult
    - ○ moderately difficult
    - ○ Extremely difficult

We are interested in the quality of training you receive to learn online project information management system (OPIMS) for your work.

Please use the following scale to indicate your response to the following statements.

40. The quality of the learning and training that I have received in online project information management system (OPIMS) is _____.
    - ○ very good
    - ○ good
    - ○ reasonable
    - ○ poor
    - ○ very poor
    - ○ not applicable / no training given

41. The time and opportunity provided for me to learn how to make effective use the OPIMS in my work is sufficient.

- O strongly agree
- O agree
- O neither agree nor disagree
- O disagree
- O strongly disagree
- O not applicable / no training given

We are interested in what opportunities you have had to trial the on line project information management system (OPIMS) before using it.

Please use the following scale to indicate your response to the following statements.

42. I was permitted to use an online project information management system (OPIMS) on a trial basis period to see what it could do.

- O strongly agree
- O agree
- O neither agree nor disagree
- O disagree
- O strongly disagree
- O not applicable / no trial given

43. I've had ample opportunity to use various OPIMS applications during the trial period.

- O strongly agree
- O agree
- O neither agree nor disagree
- O disagree
- O strongly disagree
- O not applicable / no trial given

We are interested in visible the use of online project information management software is in your organisation.

Please use the following scale to indicate your response to the following statements.

44. I have had opportunity to see the online project information management system (OPIMS) being used by others in construction industry.
    - ○ strongly agree
    - ○ agree
    - ○ neither agree nor disagree
    - ○ disagree
    - ○ strongly disagree

45. I have seen that the use of OPIMS in my organisation is widespread.
    - ○ strongly agree
    - ○ agree
    - ○ neither agree nor disagree
    - ○ disagree
    - ○ strongly disagree

46. My perception is that most of the key people in this organisation are _____ users of OPIMS.
    - ○ highly active
    - ○ active
    - ○ neither active nor passive
    - ○ passive
    - ○ very passive

Part 6: Support Network

We are interested in the people in your work environment network (broadly speaking) who provide you with direction, support and/or encouragement to undertake your work. We also want to see whether they help you specifically with the use of online project information management system (OPIMS) in your current employment role and how you view that support.

47. List all of people with who you have significant communication related to your current work.

Please specify at least seven (7) people with whom you have relatively frequent or significant communications.	Job Position	On average, how often have you received direction on how to do your job from this person?	On average, how often would you seek or get technical assistance to undertake your work from this person?	On average, how often would you have discussed your personal strengths and weaknesses specific to your work with this person?	On average, how often would you have discussed the use of online project information management system (OPIMS) with this person?
Person 1					
Person 2					
Person 3					
Person 4					
Person 5					
Person 6					
Person 7					
Person 8					
Person 9					
Person 10					

Categories of Job Position:
1 = Management (those with higher-level management responsibilities)
2 = Immediate Supervisor/Manager
3 = Related Professional (e.g. Architect, Project Manager, Engineer, QS)
4 = Technical Colleague (e.g. CAD Operator, ICT Support Person)
5 = Construction Worker (e.g. Onsite tradesperson, Foremen, Sub-contractor)
6 = Administrative Staff (e.g. Office Assistance, Secretary, HR person)
7 = Local Peers (Other students/cadets/graduates in a similar role WITHIN the same organisation)
8 = Other Peers (Other students/cadets/graduates in different organisation)
9 = None of the above

Scales for frequency of communication:
5 = All the time (several times a day)
4 = Most of the time (daily)
3 = Some of the time (once or twice a week)
2 = Rarely (once or twice a month)
1 = Very rarely
0 = Never

Part 7: Closing

Thank you for participating in the survey.

48. If you interested in receiving feedback on the result of this survey and be involved with the research work In the future, please leave your contact details below.

Name: _____

Email: _____

Appendix F: Spearman's correlation coefficient analysis results

Table C-1: Spearman's correlation coefficient among items measuring Leaders.

	Leaders1	Leaders2
Leaders1	1.000	.169
Leaders2	.169	1.000

Table C-2: Spearman's correlation coefficient among items measuring Peers.

	Peers1	Peers2
Peers1	1.000	-.058
Peers2	-.058	1.000

Table C-3: Spearman's correlation coefficient among items measuring Affiliates.

	Affiliates1	Affiliates2
Affiliates1	1.000	.088
Affiliates2	.088	1.000

Table C-4: Spearman's correlation coefficient among items measuring Knowledge on ICTs.

	Knowledge1	Knowledge2	Knowledge3
Knowledge1	1.000	.336	.612
Knowledge2	.336	1.000	.425
Knowledge3	.612	.425	1.000

Table C-5: Spearman's correlation coefficient among items measuring Use of ICTs.

	Use1	Use2	Use3
Use1	1.000	.123	.586
Use2	.123	1.000	.381
Use3	.586	.381	1.000

Table C-6: Spearman's correlation coefficient among items measuring Motivation.

	Motivation1	Motivation2	Motivation3	Motivation4
Motivation1	1.000	0.794	.775	.548
Motivation2	.794	1.000	.707	.647
Motivation3	.775	.707	1.000	.714
Motivation4	.548	.647	.714	1.000

Table C-7: Spearman's correlation coefficient among items measuring Efficacy.

	Efficacy1	Efficacy2
Efficacy1	1.000	0.726
Efficacy2	0.726	1.000

Table C-8: Spearman's correlation coefficient among items measuring Anxiety.

	Anxiety1	Anxiety2
Anxiety1	1.000	.741
Anxiety2	.741	1.000

Table C-9: Spearman's correlation coefficient among items measuring Power.

	Power1	Power2
Power1	1.000	.458
Power2	.458	1.000

Table C-10: Spearman's correlation coefficient among items measuring Advantage.

	Advantage1	Advantage2	Advantage3
Advantage1	1.000	.718	.713
Advantage2	.718	1.000	.707
Advantage3	.713	.707	1.000

Table C-11: Spearman's correlation coefficient among items measuring Compatibility.

	Compatibility1	Compatibility2
Compatibility1	1.000	.640
Compatibility2	.640	1.000

Table C-12: Spearman's correlation coefficient among items measuring Complexity.

	Complexity1	Complexity2
Complexity1	1.000	.474
Complexity2	.474	1.000

Table C-13: Spearman's correlation coefficient among items measuring Learning.

	Learning1	Learning2
Learning1	1.000	.545
Learning2	.545	1.000

Table C-14: Spearman's correlation coefficient among items measuring Trialling.

	Trialling1	Trialling2
Trialling1	1.000	.961
Trialling2	.961	1.000

Table C-15: Spearman's correlation coefficient among items measuring Trialling.

	Visibility1	Visibility2	Visibility3
Visibility1	1.000	.455	.280
Visibility2	.455	1.000	.718
Visibility3	.280	.718	1.000