School of Information Systems

Curtin Business School

The Assimilation and Diffusion of Geophysical Information Systems in the Australian Mining Sector

Sharyn Curran

This thesis is presented for the Degree of

Doctor of Philosophy

Of

Curtin University

July 2015

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by another person except where due acknowledgement has been made.

This thesis contains no material accepted for the award of any other degree or diploma in any university.

Signature: ………………………………………….

Date: ………………………..

ABSTRACT

As industries globalize their markets, industry contexts are subject to wider dynamic influences that moderate their market capacity and profitability. Industry has looked to technological solutions to provide both strategic advantage and efficiencies in response to the factors relevant to their specific industry contexts. In many global industries, this involves adopting "high technologies", those that target specific industries and are sourced from specialist high technology providers.

The minerals mining industry of Australia, generating millions of dollars in exports typifies such an environment. It has evolved a significant Mining Technology Services sector that supplies technologies both domestically and globally to the mining industry. The adoption of such complex, specialized and changing technologies present challenges to these industries.

Previous academic studies have applied Diffusion of Innovations theory to address these problems, but this has been of limited predictive value where high technologies and supplier relationships have been involved. This research considers significant moderators of technological diffusion in a rich model to more accurately and completely reflect the mechanisms of diffusion when context is considered. This provides knowledge and understanding for both researchers and practitioners in industry for sectors where high technologies are found.

In considering the role of context the researcher takes an industry sector perspective rather than the traditional intra-organizational-only perspective. By examining a sector-wide perspective, the researcher was required not only to consider each of the three primary factors, the context itself, the high technology suppliers and the mining organizations, but critically the relationships between them and their ability to moderate diffusion and the subsequent assimilation of the technologies.

A qualitative approach using multiple case studies supported by a survey was used to determine the factors and establish a rich picture of the phenomenon. The use of multiple case studies was chosen as it is well suited to the functional end economic layering which characterizes the minerals mining industry of Australia (and globally) and, also permitted further validation through triangulation. The significant body of information that characterizes the industry sector emerged through the process of interviews, confirmed by later surveys.

A number of important determinants arose that were unaccounted for in previous Diffusion of Innovations research, and which point to the importance of context. Primary among these is the characterization of the workforce ranging from permanent invested employees to that of contract workers whose foci is themselves. This better elucidates the nature of a number of factors reported in previous Diffusion of Innovations research and includes organizational knowledge retention, assimilation, organizational culture and IT champions.

Also evident are strong professional and personal network ties that form a community that replaces organizational loyalty and acts as a source of knowledge for its members straddling both the high technology providers and the employees of mining organizations. Its membership is close-knit, informed and exclusive, thus creating a powerful entity. Reputation is also closely tied to membership of this network.

High technology providers are also found to be members of this tight-knit community and the provider's reputation is equally a reflection of its personal employees' affiliations as much as is the performance of the technology. Indeed, users of the technologies are little interested in the technology itself and regard it as a utility, where the accuracy of the data is the only criterion for value. The professional network has also historically created de facto standards for output based on the skill sets of those that comprise its membership: geologists, geophysicists, or earth scientists in the broader sense. This community also creates a power base which is able to protect its resources against the effect of political policy within Australia.

The research findings highlight the complexity of the constructs and relationships that influence technology diffusion and the outcomes confirm the limitations of intra-organizational perspective models in understanding and describing this complexity. The research takes a 21st century viewpoint of the complexity of an industry sector and has provided a new viewpoint from which to consider Diffusion of Innovation research.

Acknowledgements

To Associate Professor Paul Alexander who remained steadfast in his encouragement and support throughout the years. This thesis would have been impossible without your understanding and belief in me. Thank you for everything.

To Associate Professor John Venable who stepped in and saw me through the final days, my lasting gratitude.

To Karen Clarke, Karen Stoute and Francesca Vallini who have travelled the journey with me and made my academic days so much more. Thank You.

To Fay Davidson, my friend and confidant, who listened, advised and was my support through many years on many levels. Impossible to measure.

Table of Contents

List of Figures

List of Tables

Chapter 1 The Research Problem

1.1 Introduction

Diffusion of Innovations (DOI) theory is a conceptual paradigm for understanding the process of diffusion. As a theory, it seeks to explain the rationale for the adoption of an innovation and its spread through a social system. Everett Rogers first espoused the concept of Diffusion of Innovations in 1962 as a professor of rural sociology. Throughout the development of his theory over his lifetime, he regarded diffusion as the process by which an innovation is communicated through certain channels over time among members of a social system.

The advent of technology and its widespread consumerization has seen the application of Diffusion of Innovations to explore and explain the factors that influence the adoption, sustainability and diffusion of a technology (either hardware or software) in an increasingly technology-driven society through the perspective of personal and organizational technology and, latterly, as a network (utilized in the area of Network Science).

Diffusion of Innovation research has been adopted at both micro and macro levels of analysis. The unit of analysis was originally centered around an individual, but increasingly in the previous decades organizational research studies have focused on the organization (or sub-unit of an organization) as the unit of analysis (Attewell, 1992; Cooper & Zmud, 1990; Eveland & Tornatzky, 1990; Roman, 2003; Swanson, 1994; Wildemuth, 1992; Zaltman, Duncan, & Hobek, 1973).

The diversity of the application of technology within organizations has indicated to researchers that some variables will generalize more broadly than others and that the organizational sector represents a framework in which a technological innovation should be better understood. Fichman (2000), however, suggests that researchers should develop theories of a middle range – that is, theories tailored to a specific class of technology, and/or to a particular adoption context.Additionally, Newell et al. (2000) found that supplier-focused models of diffusion have made a significant contribution to the importance of social networks. Social networks allow communication of new ideas across organisations, in particular the links between technology suppliers and users. They noted, however, that such models may require further development if they are to provide a solution to the anomalies in the Diffusion of Innovations theory where an apparently complex product, or one that cannot be trialled, still diffuses quickly, for instance, in an environment of business process re-engineering (Grey and Mitev, 1995; Wildemuth, 1992).

The study of a unique context which examines not only organizational diffusion but is inclusive of the high technology providers and industry sector characteristics provides a research junction. Within this junction, it is possible to isolate and examine the effect of high technology providers and sector characteristics on the utilizing organization to re-examine Diffusion of Innovations anew in a highly technology-driven environment.

Such modern business environments are less likely to be one-dimensional or organizationally hierarchical. Instead, they present as layered with functional differentiation within each layer, and each of the layers interacting and contributing to the achievement of the business/industry outcomes. Examples of such layering occur in diverse environments including mining, healthcare, construction and online organizations such as Amazon.

However, in each environment, a source of information exists that represents an intrinsic layer of business/personal value. This information is interrogated, manipulated and often re-represented in an alternate format to provide additional organizational value which is then utilized throughout the environment to provide agility and benefits to the business and/or organization. The utility of the information being differentiated across the organization depends on the needs of the organizational layer. In all cases, the intrinsic source remains intact and is added to both as a result of the utility and often over a time frame which may span considerable periods. For example, in mining, the layering is evident in the exploration, feasibility and planning and finally extraction phases of the mining value chain. Regulatory requirements in Australia require that the original exploration data used for mine development be held for the lifetime of the mining operation. In some cases, this has meant decades. In the Australian healthcare sector, the proposed digital health record must represent a singular source of record utilized by health providers and associated practitioners over a patient's lifetime of care.

The concept of a context provides a boundary to the sector environment within which data is relevant and meaningful. This context not only defines the organizational environment but also provides the opportunity for a situational analysis. This includes the interacting factors external to the utilizing organization, thereby providing a richer and more complete picture as opposed to a single-dimension study unit as was previously the traditional perspective of the organizational unit of analysis.

In 2004, Fichman again urged the extension of theory by taking alternative factors into consideration. This research follows the notion expressed by Fichman, and is driven by the development of global, layered business environments in which integrated supply chains exist alongside data supply chains as knowledge becomes a strategic driver of business agility. However, just as technology has evolved, so has the 21st century business environment in which business organizational partnerships appear to have developed into a fabric of inter-related and interdependent relationships built upon the premise of achieving better returns on investments.

This research seeks to: build on knowledge from previous Diffusion of Innovations research; understand the drivers of technology diffusion in a contextualized layered environment; examine the synergies between high technology providers and the utilizing organizations; and ascertain the influence of the context itself in order to build a more complete understanding than previously demonstrated in prior research. This knowledge will provide both researchers and participants within the context with a better understanding of how to leverage new technologies and understand the dynamism and relationships which present within the context and which the singular perspective of prior research failed to provide.

1.2 Research Objectives and Questions

The objectives of this study are to investigate the effect of context and specific classes of technology on diffusion and the effect, if any, of relationships within layered business environments. The layering of the business environment introduces differentiation of function between layers and increases the likelihood of multiple applications/systems utilizing the same base data which is retained but enhanced over time by organizational usage. The differentiation may suggest that the interpretation of the factors influencing diffusion is no longer possible from a singular perspective, but must be understood from a perspective that represents a more holistic view of the industry environment.

Within this research, specific classes of technology are as defined by Fichman (2000): that is, those that are particular to the industry context and are developed for that target sector. They represent "high technology systems/applications" which are often complex and may require specific knowledge and training to achieve the required organizational objectives. Robertson and Gatignon (1986) used the term 'high technology' to indicate that the acquisition of such a technology would have significant consequences for organizational processes. Such systems are both fit for purpose and use by design and characterization. In extending the definition of Robertson and Gatignon, these technologies also enable business processes to provide value to the business and/or provide sources of information which provide benefits to those within the sector (such as in healthcare). Therefore, these may be seen as providing strategic value, as opposed to being solely utilitarian.

Fichman (2000) in suggesting that researchers should develop theories of a middle range – that is, theories tailored to a specific class of technology, and/or to a particular adoption context – recognized that diffusion is subject to influences outside of the intra-organizational perspective that effect the adoption and diffusion of any technology. Fichman (1992) in his empirical review used the concept of classes to refer to one of two types of categorization, either high knowledge burden or low knowledge burden. In this research, focus is on high technology products which are also in the high knowledge burden category. Users must be skilled in the use of the technology and interpretation of the gathered data. In using the previous examples of mining and the Australian digital health record, it may be seen that the complexity of mining data (discussed in greater detail in Section 1.3) consists of geodata gathered by various techniques requiring high skill levels to both acquire and infer from the data. Similarly, the digital health record will record data extrapolated from various medical technologies and time stamped and incorporated into the ongoing record which in turn requires interpretation by suitably qualified medical professionals.

Diffusion, therefore, cannot be considered as a linear process but one which is framed by interacting factors possibly internal but also external. Such external factors may represent those of supply chain partners, stakeholders and the industry environment itself as were discussed as early as 1986 by Robertson and Gatignon. Additionally, the research also considers the influence exerted by any particular industry sector on the high technology providers and organizations which is specific within the context and the direction of influence between these parties.

This study takes and a qualitative and exploratory approach (see Chapter 4, Research Methodology) and that seeks to explore and increase understanding with respect to the research questions shown following. These research questions are discussed in detail in Chapter 3 – Conceptual Research Model and Propositions.

1.2.1 Research Questions

1. How important is context in the diffusion of high technology products/systems?

2. How influential are supply side institutions in diffusing a technological solution or system?

3. What are the implications for understanding a diffusion model where context and supply side institutions are present?

The first two questions represent the foci of the research, each contributing to the dynamism present in agile technology-aided commercial environments where specific high technology products are utilized. Information Systems represent both the technology used and the flow of data and information that result from data acquisition and modelling that subsequently result in the support of business processes and strategic direction. Buckl et al. (2009) include both the technology and the interfaces that enable interaction that are inherent in modern information systems. The global business interaction enabled by technologies results in a complexity and layering that both extends and re-defines the very nature of information systems in a modern business environment. This re-defining of our commercial behaviour has no natural constriction of behaviour other than that imposed by context and industry, and may therefore be envisioned as either an enabler or disincentive to understanding or implementing technologies and systems in the 21st century.

The third question represents the outcome and subtleties of modelling diffusion by the inclusion of the aforementioned factors. The model will be particularly useful for both high technology providers and adopting organizations by demonstrating the impact of both rich yet hidden relationships and the trigger/response of participants to contextualized events. Gregor (2006) asserts that the creation of theory builds a repository of knowledge and “enlightens professional practice” (Gregor, 2006 p 613).

1.3 Background of the Study

1.3.1 Context

The context of this study is the minerals mining sector of Australia. This sector has been slow to adopt technologies outside those related to the extraction of ore. However, in the last two decades, global markets, Australian legislative requirements and the complexity of the information supply chain have forced consortia to deal with the complexity of the data that supports their industry sector in relation to business usage, agility, retention and value creation through knowledge extrapolation. The Oxford Dictionary of English defines context as:

> "the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood".

Bisgaard (2008), in defining the dimensions of context, states that context is the inter-relationships surrounding a particular situation or event. Fichman (1992, 2000) discusses the issue of context and asserts that theories should be tailored to a specific class of technology, and/or to a particular adoption context. As early as 1986, Robertson and Gatignon were expressing a similar view in relation to marketing and management in a much simpler technological environment. Within modern business and industry sectors, the complexity of technology within specific contexts should not be underestimated. Its role in creating business value requires that theory should reflect this complexity to enable the development of appropriate models that help to produce professional best practice.

The minerals mining sector within Australia provides a defined context and, moreover, is subject to global economic investment, political influence and differentiated by its triple layer of functional partition i.e. asset discovery (exploration), asset development (feasibility and planning – incorporating mine development) and asset mining (extraction). The technologies represented within the sector are complex, specific and tied to the previously mentioned functional partition.

Further background information about the Minerals Mining Sector of Australia is provided in Chapter 2.

1.4 Organization of the Dissertation

This dissertation has been organized into the following chapters:

Chapter 1 **Introduction**

This chapter introduces the research study and provides background to the research journey.

Chapter 2 **Literature Review**

The literature review describes the foundation theory of Diffusion of Innovations, its subsequent development and on-going contribution within the discipline of Information Systems to the development of knowledge as it pertains to organizational diffusion and assimilation. It also considers associated research that takes a supplier-focused perspective regarding the Diffusion of Innovations theory and its value in a modern global economy. Additionally, a review of the Minerals Mining Industry is provided for the reader.

Chapter 3 **Conceptualized Research Model and Propositions**

This chapter presents an initial conceptual model which was developed as a result of the literature review which demonstrated the lack of a contextualized model representative of modern business models which include specific information systems types, strategic partnerships with vendors and differentiated layering of business within specific industry contexts.

Chapter 4 **Research Methodology**

The selection of an appropriate research methodology may be a difficult process and influences the research undertaking. This chapter reviews the philosophy of research in Information Systems and the rationale behind the selection of the research methods utilized in this study and their appropriateness in achieving the research objectives.

Chapter 5 **Research Results and Discussion**

This chapter provides an overview of the five phases utilized within the research study. It discusses and describes the initial industry panel review which led to the revision of the initial conceptual model and introduces the following chapters which describe and detail the findings of the subsequent phases relevant to the revised conceptual model.

Chapter 6 **Outcomes of Research Phase 3**

This chapter presents the outcomes of Phase 3 of the research. It discusses the outcomes of the multiple case studies conducted across the minerals mining industry within Australia and focuses on the High Technology Providers and the Organizations which form the Organizational Technology Environment.

Chapter 7 **Outcomes of Research Phase 4**

This chapter presents the outcomes of Phase 4 of the research. It discusses the impact of the sector environment which includes forces which influence the industry sector and therefore influence the context to which other factors respond.

Chapter 8 **Outcomes of Research Phase 5**

Phase 5 of the research examines the themes and outcomes of the research from a sector wide perspective by use of two external surveys and an industry report. The surveys, whilst initiated by Australian government departments, have different foci but in conjunction with each other provide external validation of the research. A third document produced for the Minerals Council of Australia in 2013 showing policy analysis and trends, provides additional support for both earlier surveys and the research presented.

Chapter 9 **Discussion Post Analysis**

This chapter draws together the outcomes from each phase, placing them within a holistic contextualized perspective. A contextualized model for the minerals mining industry of Australia is presented as an outcome of this holistic perspective. It also discusses the limitations of this research and makes recommendations for further research.

1.5 Summary

Currently and historically, diffusion studies of the mining sector have primarily focused on the diffusion of technologies related to chemical extraction or advances in the physical process of mining. To date, there appears to be no significant research in the diffusion and assimilation of specialist technologies related to data discovery, analysis/feasibility or management of data in this sector. These areas, which are vital to the strategic management of any resource operation, have traditionally been overlooked or considered less important compared to the area of minerals extraction. The realization of the importance of the management of information has now been highlighted by the imposition of Australian government requirements and the overwhelming need for management of data and information over extended periods of time, e.g. decades as per Australian Government regulation. The layered differentiation of the minerals mining industry and its segmentation by organizational capacity additionally reduces the internal view of a seamless mining value chain. Instead, the three generalized activities of asset discovery, asset development and asset mining, although relying on the original set of geodata, are often viewed as quite distinct operations due to the inherent functional differentiation of the industry.

The literature review in Chapter 2 will demonstrate that there exists no model which demonstrates the relationships and constituent constructs between assimilation and diffusion of an innovative technology within an organizational framework where unique requirements and technologies interface within a specified context.

This research will therefore seek to undertake the study of not only diffusion within the layered context, but additionally the exposure of hitherto undisclosed relationships which may both inform and impact on the diffusion of information systems within such an environment.

Chapter 2 Literature Review

2.1 Introduction

This chapter provides an integrated review of the literature relating to the diffusion of information systems and its subsequent assimilation and the application of information systems from an organizational perspective. This literature review provides a conceptual underpinning for the research questions as outlined in Chapter 1 and the infrastructure for the research model development and propositions as described in Chapter 4. The topics addressed within this chapter include:

- Diffusions of Innovations Theory
- Diffusion of Innovations Theory in Information Systems/Technology
- Organizational Diffusion of Innovations in Information Systems
- Review of Assimilation research as it pertains to Diffusion of Innovations
- Supplier-focused perspectives in Diffusion of Innovations

2.2 Diffusion of Innovations Research

Diffusion of Innovations (DOI) research represents a conceptual paradigm for understanding the process of diffusion. Diffusion research has been undertaken in diverse fields of endeavor including medicine, agriculture, economics, political science and communication to explain the factors that determine the success of an innovation. Classic Diffusion of Innovations theory seeks to explain the rationale for the adoption of an innovation and its spread throughout a social system. Rogers (1962, 1983) regarded diffusion as the process by which an innovation is communicated through certain channels over time to members of a social system. He identified the four fundamental theoretical elements as innovation, communication channels, time and the nature of a social system, stating that they are identifiable in every research study.

Rogers defined these four fundamental elements as follows:

1. The Innovation: any idea, practice or object that is perceived as new by the individual or other unit of adoption. The elapsed time since the innovation's discovery is not relevant; if it is new to the unit of adoption, then it is an innovation.
2.

Table 2.1 : Innovation Characteristics of The Classic Diffusion Model

Characteristic	**Description**
Relative Advantage	The degree to which an innovation is perceived as being better than its predecessor.
Compatibility	The degree to which an innovation is perceived as being consistent with values and needs of the adopter.
Complexity	The degree to which the innovation is perceived as being difficult to implement.
Trialability	The degree to which an innovation may be tested or experimented with.
Observability	The degree to which the results are visible to potential adopters.

Rogers determined that an innovation's rate of adoption might be measured by the characteristics of relative advantage, compatibility, complexity, trialability and its observability to those within the social system.

3. Communication Channels: Communication has been defined as a process whereby participants create and share information in order to reach a mutual understanding. In the Diffusion of Innovations Theory, communication carries the additional weighted understanding that the communication message is transmitting the concept of the innovation, the sender's experience of the innovation and that this experience is being imparted to another unit or individual who has no or little experience of the innovation. Rogers (1995) also acknowledged the effect of mass communication in providing new means of communication channels, in

particular the effect of mass media in alerting individuals to the knowledge of an innovation's existence as distinct from interpersonal communications, whereby the individual beliefs or attitudes may be reshaped by the subjective attitudes of those within the same social system.

4. Time: Rogers (1983) stated that the time dimension was one of the strengths of the theory and yet one which has been frequently criticized, as measurement is dependent on the respondent's recall. Time, in the classic Diffusion of Innovations Theory is visible within three factors:

   i. The Innovation Decision Process : This is the mental process whereby an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude to the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (Rogers, 1995). This can be visualized as a five-part process as illustrated in Figure 2.1:

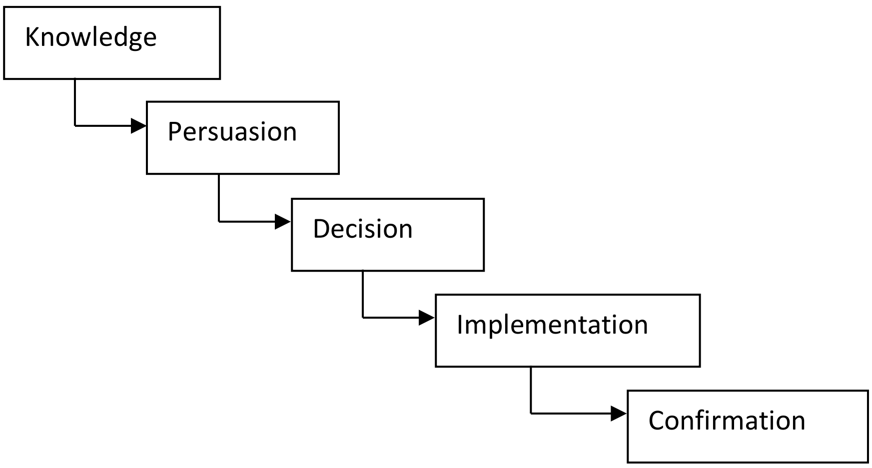


Figure 2.1 : Visualization of the Innovation Decision Process

   ii. Innovativeness or Adopter Categories : Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system (Rogers, 1995). Based upon the degree of innovativeness, five adopter categories are identified: innovators, early adopters, early majority, late majority and laggards.

Rogers and Scott (1997) found that within a social population the percentages for a technological innovation were distributed as follows:

- Innovators - 2.5%
- Early adopters - 13.5%
- Early majority – 34%
- Late majority – 34%
- Laggards – 16%

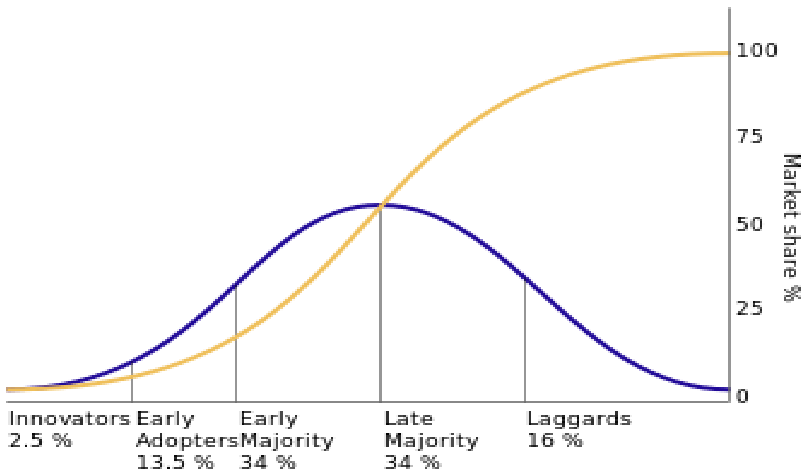


Figure 2.2 S-Curve demonstrating technology adopters <http://en.wikipedia.org/wiki/Diffusion_of_innovations>>

iii. Rate of Adoption: This is the relative speed with which an innovation is adopted by members of a social system. The rate of adoption is commonly seen as an S- shaped curve, the variation in the slope demonstrating the rapidity of adoption in some innovations as shown in Figure 2.2.

4. The Social System: A social system is a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal. Members may be individuals, organizations or sub-systems or any groups that define a boundary within which the communication network

operates. A social system will by its nature display a homophily which binds the social system and promotes free communication within that social system.

Rogers' (1962) original theory looked at individual adoption and diffusion among a homophilic social system. Since then the Diffusion of Innovations Theory has been utilized to research a range of disciplines including business, humanities and science disciplines, producing a considerable body of research.

The advent of technology and its widespread consumerization has seen the application of Diffusion of Innovations Theory to information technology and systems to explore and explain the factors that influence the adoption, sustainability and diffusion of a technology (either hardware or software) in an increasingly technology-driven society.

2.3 Diffusion of Innovations in Information Systems

Research based upon Diffusion of Innovations Theory in Information Systems/Technology continues to have currency and focus as technology expands and underlies the fabric of modern activities in contexts that are both organizational and personal (or social networks). In 1987, Pennings and Buitendam (p. xiv) stated, "The meshing of new technology with organization design, process, strategy and external relationships appears to be one of the most important issues of the next decade". Burton Swanson (1994) reiterated this as he visualized what he labeled as "the social sweep" (p. 1069) of technology which pivoted organizationally on an IS unit which itself was in flux as new technologies influenced both process and people. Fichman (1992) states that Diffusion of Innovations Theory provides a useful perspective on how to improve technology assessment, adoption and implementation; theoretically, it provides both qualitative and quantitative tools for assessing the likelihood or actual rate of diffusion of a technology, whilst identifying numerous factors that may facilitate or hinder technology adoption and implementation.

Diffusion of Innovations theory has not been without its critics. Downs and Mohr (1976) found flaws in the use of innovation characteristics, finding that studies did not distinguish between primary and secondary characteristics of innovations. Of importance were those secondary characteristics that were perceptions of the actors of the studies and were therefore subject to both external and internal influences. They concluded that studies that were based upon typologies of innovations could not be generalized across a population. They also asserted that studies resulted in a lack of cumulative findings.

Damanpour (1991), through his meta-analysis of organizational innovation determinants and moderators, acknowledged the acquiescence of other researchers (Damanpour, 1987; Meyer & Goes, 1988) to the position of Downs and Mohr. However, Damanpour also states that there is no suggestion to indicate that the results of any study are actually unstable.

Tornatzy and Klein (1982) found value in the Downs and Mohr study and stated that future researchers should conceptually address the subjectivity within their research design. Failure to do so is a methodological issue that information technology studies should explicitly address. Their meta-analysis examined seventy-five articles concerned with innovation characteristics and their relationship to the staged approach to computing. The research fell into categories of technology-specific, industry-specific or organization-specific, reflecting the use of technology within the era and the tendency for fragmentation in research which precluded commonality or generalization. They concluded that there was value in the research based upon Diffusion of Innovations Theory and suggested that studies continue to be based on both adoption and implementation stages and also across technologies and settings, thus setting a stage for further research.

2.4 Organizational Diffusion of Innovations Theory

The focus of research has historically been in the context of the commercial organization or the public sector, as the cost of computing was initially prohibitive for the personal sector, and investment encouraged and was directed to the commercial or public sector market. Academic interest can be found as early as 1978 in the work of Perry and Kraemer in the diffusion of computer applications within local governments, where they examined the characteristics of the innovations and policy. Kwon and Zmud (1987) saw information systems as an important managerial concern focusing on the effective diffusion of technologies throughout organizations, business units and work groups. Building on Zmud (1984), which defined the staged approach to computing, they saw a need for a more comprehensive framework that merged the literatures from organizational innovation research with that of information system implementation. Their framework defined the need for the contextual factors of user community, organization, technology, task and environment (Table 2.2). Of Roger's (1983) classic theory, only the original innovation characteristics of compatibility, relative advantage and complexity were retained as characteristics in the technological context, a decision based on the findings of the meta-analysis of Tornatzky and Klein (1982). Kwon and Zmud (1987) found that these three appeared to be the only characteristics providing consistent data. Arguably, the remaining characteristics of observability and trialability could be found as re-defined aspects under the task and environmental factors of the framework. Whilst Kwon and Zmud's framework took the perspective of innovation organizationally from the technologists' perspective, a significant framework for future research was also created by Robertson and Gatignon (1986) and was developed from the organizational and marketing perspective. It included specifically the forces and relationships of business drivers.

Table 2.2: Kwon & Zmud's Context Factors (Kwon & Zmud,, 1987, pages 227 – 251)

Context	Characteristics
Community	Job Tenure Cosmopolitanism Education Role Involvement
Structural	Specialization Centralization Formalization Informal Network
Technological	Compatibility Relative Advantage Complexibility
Task	Task Uncertainty Autonomy Responsibility Variety Identity Feedback
Environmental	Heterogeneity Uncertainty Competition Concentration/Dispersion Inter-organizational Dependence

Their framework sought to examine the diffusion of "high technology" among business organizations using the work of Rogers (1983) integrated with supply side and the adopter industry competitive environment. The term "high technology" was used to indicate the utilization of a technology that was perceived to have significant consequences for the organizational processes. They drew on the work of Shanklin and Ryans (1984) who described high technology products as having the capability to "create or revolutionize markets". Innovations of this type were generally regarded as complex products with which the adopting unit would be unfamiliar, costly in both terms of acquisition and organizational switching, and having organizational learning requirements implying a level of uncertainty.

In this model, the supply-side competitive environment includes structural factors and resource commitments, which both contribute directly as determinants to the rate of diffusion. In Fichman's (1992) review of adoption and assimilation research, and again later in Fichman (2000), he would cite these factors as relevant to the development of information systems research in assimilation and diffusion of innovations.

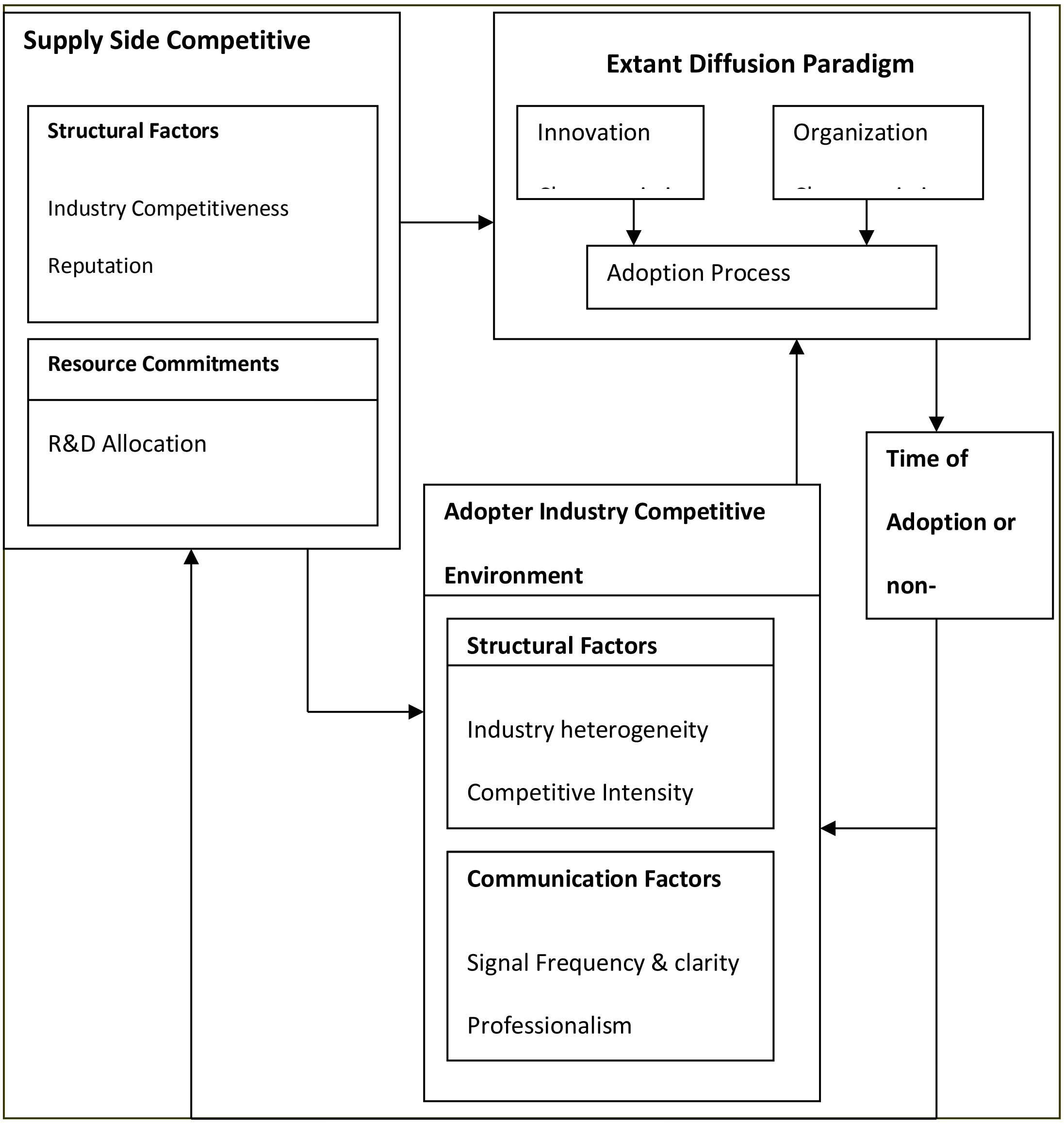


Figure 2.3: A Competitive Behaviour Paradigm for Technology Diffusion Among Organizations: Robertson & Gatignon (1986)

Figure 2.3 presents the model developed by Robertson and Gatignon describing the direction of relationships and flow of information. The authors demonstrated in 1986 that the relationship between supply-side organizations and the adopting environment were inter-connected as technology became an integral factor in organizational self-sufficiency and development.

Table 2.3 describes the factors within the Robertson & Gatignon (1986) model relating to the supply-side structural factors as affecting the rate of diffusion and the potential for market advantage. The factors are industry competitiveness, supplier reputation, technology standardization, and propensity for vertical integration.

Table 2.3: Description of Supply-side Structural factors from Robertson & Gatignon (1986)

Supply-side Structural Factors	**Description**
Industry Competitiveness	Assessed by the number of competitors, concentration ratios and barriers to entry. Higher levels of competitive intensity will lead to a faster rate of diffusion as competitors seek market advantage.
Supplier Reputation	Reputation is defined by established relationships and confidence amongst potential adopters. High reputation suppliers will have a faster initial diffusion and may sustain a lock-in arrangement with the adopter.
Technology Standardization	The speed of diffusion will be quicker if standardization of technology is common. Consumer behaviour may be hindered if there is uncertainty about the lack of compatibility.
Vertical Integration	The propensity of suppliers and customers to have a coordinating and interlocking relationship, resulting in a flow of information that is mutually beneficial.

Supply-side resource commitment, shown in Table 2.4, includes factors pertaining to the supply-side organization’s ability to provide a product that is competitive to its potential customer and allocates adequate resources to the research capability of the organization and subsequent marketing of the product.

Table 2.4 Description of Supply-side Resource Commitment factors from Robertson & Gatignon (1986)

Supply-side Resource Commitment Factors	**Description**
R & D Allocation	The greater the expenditure the more likely the development of enhanced technologies.
Marketing Support	Greater resource allocation to marketing leads to an increase in activities that promote new technologies and increase the likelihood of diffusion.

The competitive environment of the adopter industry consists of economic influences and organizational behavior factors, including those relating to communication. This environment is itself moderated by the supply-side competitive environment. Robertson and Gatignon's (1986) clear depiction of the influence of internal and external partners on the adopting organizations and information demonstrates a more holistic view of diffusion and adoption in relation to acquisitions since they incorporate all possible contributing factors within a specific context. Whilst not specifically describing the nature of the relationships between factors, the model does depict the direction of influence exerted by external factors on the adopting organization and considers these as persuasive in the organization.

Table 2.5: Description of Adopter Industry Structural factors from Robertson & Gatignon (1986)

Adopter Industry Structural Factors	**Description**
Industry heterogeneity	Transmission of information is higher within a homogenous industry, but lacking in innovative content; therefore, an intermediate level of heterogeneity is optimal.
Competitive intensity	A reasonable level of competitiveness will encourage innovation; a monopoly as an extreme will stifle innovation.
Demand uncertainty	Uncertainty is related positively to innovation as participants compete for market share.

Table 2.5 describes the structural factors within the competitive environment of the adopter industry which include industrial heterogeneity, competitive intensity and demand uncertainty.

Table 2.6 below describes the adopter industry's communication factors which are: signal frequency & clarity, professionalism and cosmopolitanism.

Table 2.6: Description of Adopter Industry Communication factors from Robertson & Gatignon(1986)

Adopter Industry Communication Factors	**Description**
Signal Frequency & clarity	Signals represent the intentions of an industry to communicate within the sector. An industry may be open or closed and is determined by its profile.
Professionalism	This is the relative technical expertise within an industry.
Cosmopolitanism	This relates to the external orientation of the industry. An industry with overseas sales will be classed as high within this scale and is more likely to innovate.

This framework also highlights the significance of post-implementation evaluation (as opposed to occurring at the point of the decision to adopt) and therefore evaluated the depth of usage. Whilst not explicit in the model shown in Figure 2.3, its inclusion as a metric for organizational success demonstrates the move by organizations to provide validation for technological expenditure and a possible measure for the level of organizational learning achieved.

The inclusion of the adopting environment at an industry level is also significant in the study to explicitly link the influences of an industry sector to diffusion of an innovation, thus creating a richer picture of the environment. The model also describes the concept of signaling as a communication factor, pre-dating the later work of Attewell (1992) which distinguishes between the concepts of signaling as indicating awareness of changes in the environment and that of knowledge transfer (implying a degree of organizational learning), and dealt with the concept of perception of the actors within the methodology of the framework.

These two studies are often cited as creating the basis for further diffusion studies, although the work of Robertson and Gatignon (1986) is located more specifically within organizational studies.

Prescott and Conger (1995) in their review of the previous ten years of research, found evidence supporting the acceptance of diffusion studies as a sound basis for the extension of theory (Bouchard, 1993; Fichman, 1992; Fichman & Kemerer, 1993; Kwon, 1990; Kwon & Zmud, 1987; Robertson & Gatignon, 1986; Wildemuth, 1992). A review of Diffusion research by Kautz et al. (2005) found that the organization as the unit of review remains dominant and that 70% of research is directed toward adoption. An empirical review of literature at the 'firm' level by Olivera and Martins (2011) covering the period 1990 to 2011 concurs with the focus not only being the organization but an inward focused perspective. This maintains the stance of Fichman (1992) who had asserted that the then-recent diffusion studies focused on extending diffusion studies to more complicated adoption scenarios. Melville & Ramirez (2007) use a differing classification of DOI as an evolved theory in information systems. They classify three stages as being: dominant, technology-organization-environment and emergent. The first two stages are in accord with the early theoretical approaches and their later development in the 1990s to include inter-organizational approaches. The emergent stage is a further development of Fichman (2004) where he further considers the concept of extending DOI by including factors from an industry perspective, thus building on his 2000 research. Melville and Ramirez (2007) suggest that theory be extended by an information processing view as the rationale for the acquisition of information systems, the foundation of the business case being the processing of data and the rationalization being the requirement for interpretation of data for business uncertainty. In the first decade of the 21st century empirical studies using frameworks of TOE and DOI (Baker, 2012, Oliveria and Martins, 2009, Zhu and Kramer, 2005, Lin and Lin, 2008) focused on e-commerce and the external drivers of new forms of competitive pressure issuing from technology. Institutional Theory was also combined with TOE to address pressures from competitors thus possibly modifying organizational structure and behaviours (Gibbs and Kraemar, 2004, Li , 2008, Soares-Aguiar and Palma-Dos-Rios, 2008)

The evolution of technology and its strategic business role continues to act as a driver for research as organizations are transformed by the opportunities unfolding as technology becomes an enabler for differentiation and economic success. The diversity of application of technology and opportunity for innovation ensuring the diversity of research in information systems will continue.

2.4.1 Focus of Research in Organizational Diffusion of Innovations

Zmud (1984) proposed two sets of activities that have come to define the systems activities of subsequent generations of researchers. The first, recognition and assessment of technological innovations, came to be identified as the adoption stage. The second, facilitation of technologies into organizational work units, was identified as the implementation stage. These sets of activities complemented the diffusion process of Rogers (1983) whose simple form Prescott and Congers (1995) adapted as the adoption stage. This stage consisted of the sub-stages of knowledge acquisition, persuasion and learning leading to a decision followed by the implementation stage which included task organization, task process and co-ordination of technology necessary for innovation deployment.

Abrahamson (1991) found that whilst much of the classic Diffusion of Innovations Theory mapped to organizations, the adoption and implementation of an innovation is part of a larger and more complex organizational goal involving a number of stakeholders. Eveland and Tornatzky (1990) concur, finding that complex technologies were "too complex to be acquired and deployed by a single discretionary authority". The infusion of technology as a business driver within organizations encouraged researchers to focus their research on either an adoption or a process implementation stream.

Attewell's (1992) theoretical review suggested two broad categories for information technology diffusion studies: adopter and macro diffusion studies. Adopter studies have dominated, being concerned with understanding the impact of potential adopters to innovate as measured by time, whilst macro diffusion studies are primarily concerned with the characterization of the rate and pattern of adoption of a technology across an organizational network (post implementation). Fichman (1992) regarded the Kwon and Zmud (1987) framework to be more relevant in studying adopter innovativeness, whilst the Robertson and Gatignon (1986)'s study was aligned with macro diffusion (post implementation). The historical value of both studies remains significant. However, the evolutionary nature of technology defines the foci of generational research. Swanson (1994) and Prescott and Conger (1995) both used the terms, "locus of impact", although each with a marginal variation in definition. Swanson found that information systems innovation was the work of the information systems department (thus implying the organization was of sufficient size to maintain a separate entity) and that the type of technology adopted fell into two categories: technical or administrative. Technical innovations were those implemented by the information systems department for their own use (even if in support of the organization). Administrative innovations were those aimed at improving internal control and coordination.

The dual typing of an innovation type was one proposed by Daft (1978) and one which Swanson used as a basis for a tri-core model, where a centralized core of information system activities acted as a mediating layer for the afore-mentioned types. He saw the need for the tri-core model as some technologies failed to be neatly categorized by the dual-core model of Daft.

The research of Prescott and Conger (1995) was based on a representative sample of seventy papers published in the preceding decade by members of the Diffusion Interest Group in Information Technology (DIGIT). In their paper, the locus of study was adapted from Swanson's tri-core model, but separated the impacts further into one of three classes: the information systems unit, intra-organizational and inter-organizational. The information systems unit is consistent with Swanson's definition; the intra-organizational class comprises those factors that impact on one or more units of the organization and include technologies such as database management systems and spreadsheets. The inter-organizational locus was one that impacted on multiple companies and typified the era in which EDI networks were introduced. A second dimension was included by the authors and defined the orientation of the study by using either a factors or staged approach. A factor approach is designed to identify variables which are related to a particular outcome and were more commonly found in adoption studies. The staged research approach was used to explain how a process, such as implementation unfolds. Fichman (2000) saw a fundamental change by the end of the previous century, where innovation was now observed as a key determinant for organizational competitiveness (Afuah, 1998) and technologies were strategic drivers to meet this goal.

Thus, technological evolution in the use of technology once again leads to an evolution in defining the foci of research. The current trends in research appear to be consistent with the definition as supplied by Attewell (1992) of either adopter or diffusion studies. Research organizationally seeks to comprehend the effect of organizational culture and context in addition to timing for adopter studies. For organizational diffusion studies, the focus should seek to understand the determinants that impact on the rate, pattern and extent of the technological diffusion.

2.4.2 Additional factors for Organizational Diffusion of Innovations.

Rogers (1995) acknowledged the relevance of factors such as change agents, opinion leaders and the structure of the organization to organizational diffusion. Change Agents are those who seek to positively influence innovation adoption. They will seek to make use of opinion leaders (those whose influence is accepted either through status or informal leadership) within an organizational structure.

Table 2.7: Internal characteristics of an organizational structure

Characteristic	Description
Centralization	The degree to which power and control is concentrated within the organization.
Complexity	The degree to which an organization's members possess a high level of knowledge and expertise, usually measured by the individual's range of specialties and formal training.
Formalization	The degree to which an organization enforces rules and procedures in role performance.
Interconnectedness	The degree to which units in the social system are linked by interpersonal networks.
Organizational slack	The degree to which uncommitted resources are available to the organization.
Size	This characteristic may in fact represent an aggregate of a combination of other characteristics. A large organization may possess slack resources and staff with expertise.

Additionally, Rogers found that the objectives of the organization determine to a large extent the structure and function of the organization. Internal characteristics of the organizational structure, shown in Table 2.7, are centralization, complexity, formalization, interconnectedness, organizational slack and size. The external characteristic is system openness which is the degree to which external influences are exchanged with individuals or sub-units of the organization.

Kwon and Zmud (1987) had foreseen the need for a more comprehensive approach to organizational adoption and diffusion and developed a framework which included the need for contextual factors. These factors were community, organizational, technological, task and environmental and were applicable to the technology of the period and was viewed as a staged implementation. This was formalized by the author's as initiation, adoption, adaptation, acceptance, routinization and infusion. See Table 2.2 for Kwon and Zmud (1987) factors. Robertson and Gatignon (1986) included additional factors that gave depth to the influences from the industry sector and from the supply-side environment. Tornatzky and Fleischer (1990) followed in this paradigm by seeking to understand diffusion within a context that describes factors in terms of the nature of the organization, technology, and an external task environment. In their model, shown in Figure 2.4, organizational and technological contexts included factors present in the previously discussed models.

However, the external task environment also included the effect of government regulation, supply-side support, and industry and market structure. The supply-side relationship was seen as a contract-only function as opposed to an integrated business model and therefore lacked relationship structure beyond the technological contractual obligation. They also envisaged the contexts as individual units which interfaced with each other and were therefore able to neither constrain nor facilitate innovation.

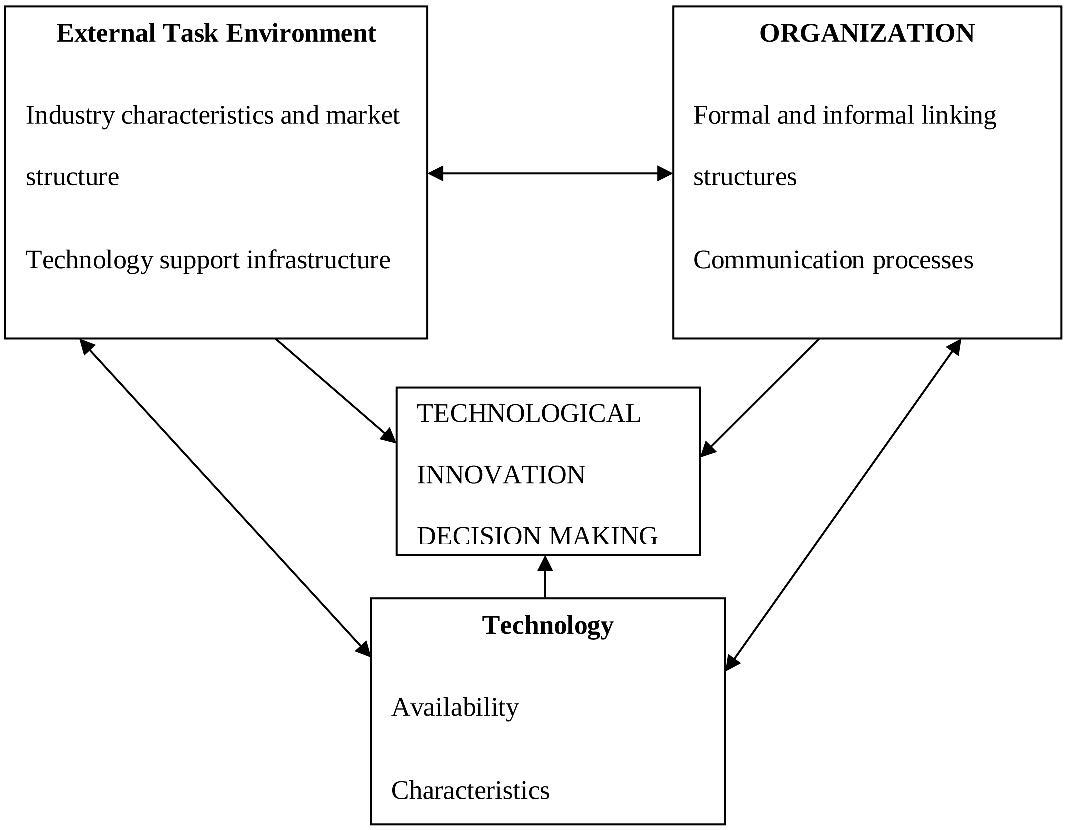


Figure 2.4 Technology, organizational and environment Framework (Tornatzky and Fleischer 1990)

The concept of separate contexts interfacing confirms their vision of distinct structured entities and isolates the interaction of individuals across the structures, thus limiting flow of information to the interface mechanism. They discussed and labeled this effect as "boundary spanning mechanisms" (built on the gatekeeper concept) and saw this as providing benefits for innovation from explicit interfaces to external and internal units.

The rapidity of technological change has demanded a continuance and review of theoretical and empirical studies as information systems/technology has become a strategic enabler for organizations. Fichman (2000) suggests that researchers should develop theories of a middle range, that is, theories tailored to a specific class of technology, and/or to a particular adoption context, albeit with the understanding that some variables generalize more broadly than others.

Table 2.8 extracted from Fichman (2000) provides examples of organizational middle range theories of diffusion and their main areas of contrast (thereby providing a richer contextual model) with the classical Diffusion of Innovation Theory.

Table 2.8 Example of Middle Range Theories of Diffusion

Researcher	Innovation	Main Areas of Contrast
Markus, 1987	Communication Technologies	Includes a “critical mass” effect, e.g. highly resourced individual positing a distinctive adoption pattern
Attewell, 1992	Complex Organizational Technologies	Influences arising from the lowering of organizational knowledge barriers. This may include service arrangements or supplier side liaisons.
Swanson, 1994	Information Technologies	Characteristics of the IS unit(e.g. size, professional orientation, portfolio, innovation type.

The contextuality and functional diversity of technology, its duality as both a tool and a resource places new demands organizationally to understand the process of innovation both internally and sector wide. Fichman (2000) placed emphasis on understanding the managerial implications and clarified the terminology for Diffusion of Innovation researchers:

> “Diffusion refers to the process by which a technology spreads across a population of organizations, whilst assimilation refers to the process within organizations stretching from initial awareness of the innovation, to potentially, formal adoption and full-scale deployment”(Fichman 2000, pg 106).

Fichman's framework (see Figure 2.5) is structured around variables and relationships generalizable to the middle range of theory. In doing so, it seeks to provide a structure for research that is organizationally stable and accounts for internal and external factors and which may also be contextualized regardless of software diversity of the industry niche.

Those variables utilized by Fichman have been operationalized in previous studies, thereby providing a historical validity (Cooper & Zmud, 1990; Damanpour, 1991; Fichman & Kemerer, 1997; Kwon & Zmud, 1987; Leonard-Barton, 1988; Ramiller, 1994; Robertson & Gatignon, 1986; Rogers, 1995; Swanson, 1994; Tornatzky & Klein, 1982). A brief discussion of each environment follows, highlighting a selection of the more widely used factors within each environment.

Within the Technologies and Diffusion Environment, two sets of factors are evident: Innovation Characteristics and the Propagating Institution. With Innovation Characteristics, the classic innovation factors of Rogers (1983, 1995) are incorporated in addition to other factors such as communicability, profitability and social approval. All of the aforementioned factors are described as positive to the probability of diffusion. Factors within this set that provide a negative impact include cost and voluntariness. Propagating Institutions relates to the efforts of the propagating organization to assist in the promotion, communication and diffusion of the innovation in which they have a vested interest. These factors having been previously found in Rogers (1995) which included the effects of communication channels and mass media prior to the adoption of an innovation, and also in Robertson and Gatignons' 1986 study. This study saw as integral the influence of the supply-side organization's relationships with vendors and predicted the significance of the relationship as a means of ensuring market advantage.

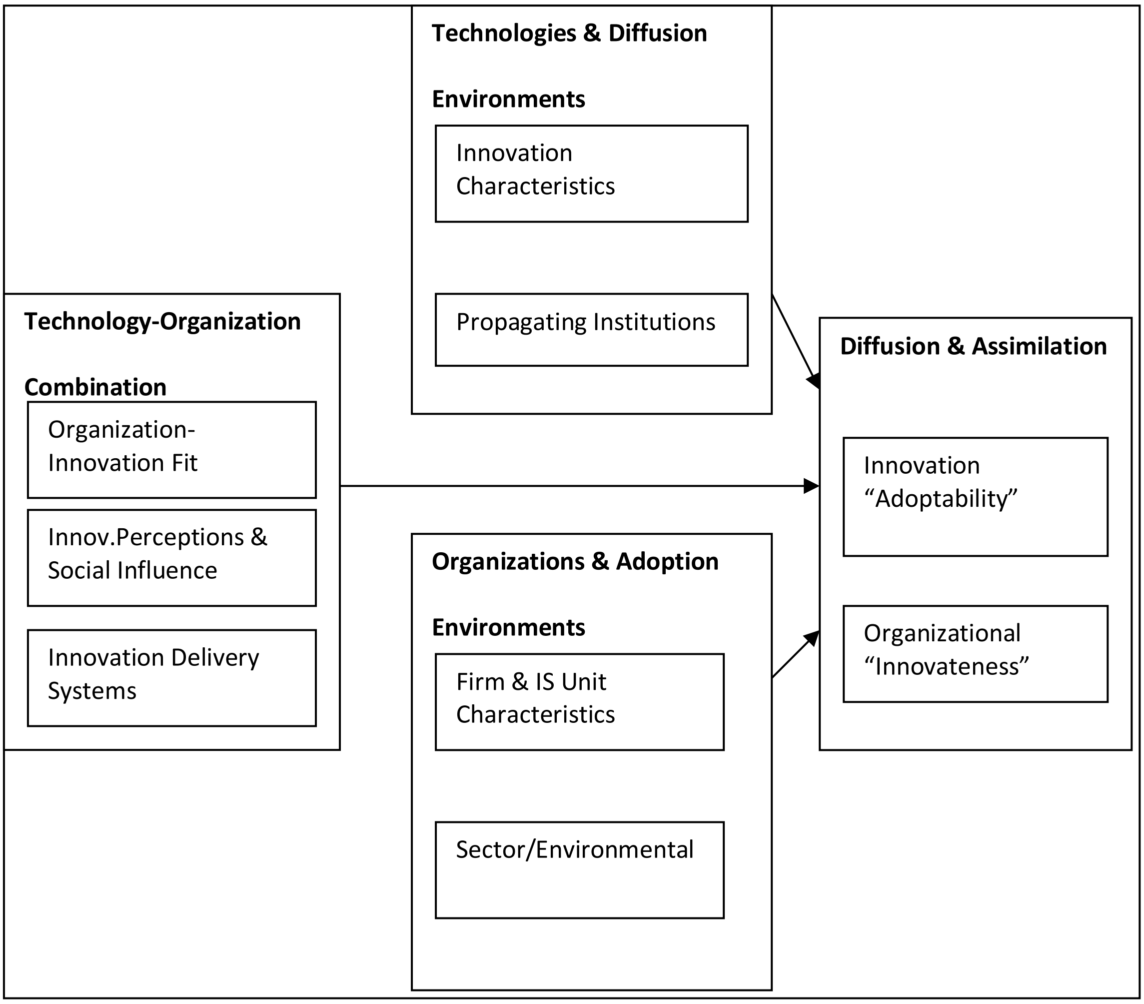


Figure 2.5: Generalizable Framework: Factors Affecting IT Innovation & Assimilation Fichman (2000)

Other factors such as promotion, industry competitiveness and technology standardization that contribute positively to the probability of diffusion of innovation are also present in Robertson and Gatignon (1986) as key supply-side characteristics.

Fichman (2000) in referring to the Organizations and Adoption Environments stated that, "a central tenet of diffusion is to understand why some organizations are more innovative than others, we must look to the characteristics of those organizations, their leaders and the environment within which they operate". Within this environment, it is important to retain the knowledge that an organization exists within a particular sector that is subject to specific industry, government and societal norms and constraints. Factors of influence within the set relating to the sector include competitive pressure, IT intensity and rate of change. Organizational studies in Information Technology have often focused on variables related either to structure or resources (Damanpour, 1991; Fichman & Kemerer, 1997; Kwon & Zmud, 1987; Swanson, 1994). However, additional factors might include communication channels and characteristics related to technical expertise and education of the employees within the organization (Attewell, 1992). Hovorka and Larsen (2005) include the use of social networks and the effect of culture created to hinder or advance the adoption and diffusion of technological innovations. Iacovou et al (1995) considered competitive pressure.

The Technology-Organization Combination seeks to understand the factors that combine to provide benefit organizationally and that appear as a juxtaposition of the technology and the organization. Fichman (2000) has positioned these as three sets: Organization-Innovation Fit, Innovation Perceptions and Social Influence and Innovation Delivery Systems. Organization-Innovation Fit describes each organization's culture in combination with strategic goals and resources creating a holistic context within which a technology will be positioned and deployed. Factors within this set are of prime importance to assimilation and the ability from the organizational unit perspective to absorb new knowledge. Significant factors include absorptive capacity, related knowledge and organizational wealth (Cooper & Zmud, 1990; Fichman & Kemerer, 1997). The Innovation Perception and Social Influence set concentrates on the perceptions of primary adopters and the influence of opinion leaders and change agents. Rogers' (1983) classic innovation characteristics can be operationalized at either the organizational or at the employee level as the unit of study. Additional factors include usefulness and ease of use which are derived from the Technology Acceptance Model of Davis (1989). The Innovation Delivery System refers to the management of the implementation process and factors within this set include management support, change leaders, training and links to propagating organizations (Leonard-Barton, 1988; Robertson & Gatignon, 1986).

An understanding of the 'generalizable' model of Fichman (2000) for a specific combination of technology and environment should provide conceptual knowledge of the assimilation and diffusion within industry sectors where specialized technologies are deployed, the cost of change is significant, and investment is high. The separation of the concepts of assimilation and diffusion additionally contributes to organizational knowledge and the prospect of amortization of costs which may be applied generically where technology transforms the business environment.

2.5 Assimilation

The Diffusion of Innovations Theory within an organizational context refers to the process by which a technology spreads across a population of organizations (Fichman, 2000). Whereas assimilation references a process of organizational learning wherein individuals and the organizations as a whole acquire the knowledge and skills necessary to effectively apply the technology (Attewell, 1992; Fichman & Kemerer, 1997).

Attewell (1992) comments on the limits of Diffusion of Innovations research within a complex organizational setting. He asserts that learning and/or communicating the technical knowledge required to use a complex innovation successfully places far greater demands on potential users and on supply-side organizations; thus, knowledge transfer and the learning process will become a shaping factor within the diffusion process. Implementing a complex new technology therefore requires both individual and organizational learning and as such, organizational learning is a product built from the members of that social system's ability to acquire skills.

The latter stages of assimilation (where a technology is institutionalized into the fabric of the organization) suggest that the intra-organizational processes are a product not only of the organizational objectives, but are also the process of technology appropriation by the individual, the work unit and ultimately the organization. The assumption inherent in the argument is that of sustaining a workforce/individuals who remain within the organization, thereby sustaining and enriching the organizational knowledge base. Levitt and March (1988) note that the link between the learning experience often becomes lost in the organization's routine as the innovation is sustained. Thus, the value of the acquired knowledge is eroded by time and organizational bureaucracy. Chong et al (2009) include the necessity for an information sharing culture that is in itself ongoing beyond the initial adoption.

Fichman (2000) suggests that the researcher would gain a more complete view of assimilation by understanding it as a process within an organization stretching from initial awareness to full-scale deployment. Although the adoption of any technology may require some degree of organizational learning, the complex technologies acquired in some sectors place additional demands on individual adopters or organizational units. Exemplars of this category of innovation include expert systems or highly context specific technologies as in exploration technologies (Fichman & Kemerer, 1999; Gill, 1995; Liker, Fleischer, & Arnsdorf, 1992) . Attewell (1992) suggests viewing the implications of knowledge barriers in organizations at a macro and micro level. At a macro level, he argues that supply-side institutions shift their focus from communicating and promoting the existence of a technology to one that demonstrates mechanisms for lowering organizational barriers. Indeed, he notes that the relationship with supply-side institutions may be restructured as they become mediators in the process of knowledge transfer, and may present opportunities for economies of scale in learning. Attewell (1992) also saw the likelihood of supply-side institutions as service agents, where a lack of in-house skills represents a barrier to technological acquisition. At a micro level, Carlson & Zmud (1999) suggests shifting the focus to development of a positive process of individual learning which should include not only the extent of learning, but also the nature and experience of the learning process.

2.5.1 Properties of Knowledge

Argote et al. (2003) state that knowledge properties affect the rate at which knowledge is accumulated, how and where it is retained, and how easily it is assimilated and diffused.

Nonaka (1991) observed that tacit knowledge is more challenging to transfer than explicit knowledge. Zander and Kogut (1995), echo a similar outcome based upon knowledge that is not codified being difficult to transfer without a rich communication channel. Argote et al. (2003) find that value is placed upon the source of the knowledge and is dependent upon the source type (internal or external to the organizational unit of learning). External knowledge is regarded more highly than knowledge transmitted internally, even though internal knowledge may be more focused and organizationally specific. Organizational dynamics and the interacting relationships provide an additional perspective with which knowledge ownership must be evaluated. Stasser and Titus (1985) found that knowledge that was held either uniquely or by a select few was less likely to be transferred amongst a wider group. Uzzi and Lancaster (2003) referred to hard knowledge versus soft knowledge. Hard knowledge is that which may be acquired though the public domain; soft knowledge is acquired through intra-organizational relationships and remains un-codified to the public domain. The value of understanding the potential impact that properties of knowledge may exert should not be underestimated. Without appropriate management, the communication of knowledge and its application becomes less effective and beneficial to the implementing organization.

2.5.2 Communication of Knowledge

The implication of organizational learning research into the diffusion or assimilation of a technological innovation carries the substantive belief that a learning process is required by the organization in order to successfully implement an innovation and maximize its potential. This process has been often been included as a factor in the communication process of Diffusion of Innovations Theory or has remained similarly grouped under emergent theory or models. Attewell (1992) states that classical studies failed to differentiate between two distinct activities: signaling and the transfer of technical knowledge. Attewell (1992) terms the type of communication referenced within classic Diffusion of Innovations Theory as signaling. Signaling implies communicating the awareness or benefits associated with an innovation as distinct from the transfer of technical knowledge. Transfer of knowledge is a much more substantial process whose outcome should be the successful and rich use of the innovation. Attewell also argues that it is impossible to transfer knowledge simply by learning by doing an activity singularly. Rather, it must be combined with a process of learning by using (Rosenberg, 1982) and, as such, it cannot therefore be simply be an event of transferring know-how from the originator to the user of a technology.

Hence, organizational learning is the process whereby individuals and the organization as a whole acquire the knowledge and skills to effectively apply a technology (Attewell, 1992). If a technological innovation is to be organizationally assimilated and possibly diffused across a sector, a conjoint issue is how to overcome the knowledge barriers and enable a process of organizational learning. Argote et al. (2003) state that for successful knowledge transfer ability, motivation and opportunity should be considered to overcome knowledge barriers. Chong et al (2009) conclude that the information sharing culture is required to act as an enabler. Wang et al (2010) perceive for this to occur that the top management support be not underestimated as a driver of culture and knowledge.

However, Levin and Cross (2004) argue that trust in two dimensions (benevolence and competence) is a significant factor in the transfer of knowledge. They discuss the influence of strong and weak ties (Granovetter, 2003) and the later work of Cross and Sproull (2004) indicates that people prefer to acquire knowledge through inter-personal contact rather than from repositories of information. The extent and type of information acquired is influenced by the level of trust found in the knowledge source and the risk of exposing themselves by revealing their need/lack of knowledge.

2.5.3 Knowledge Barriers

A knowledge barrier is the burden of organizational learning that surrounds technologies and inhibits their adoption and diffusion. Technologies that impose burdens in terms of knowledge acquisition were described by Tornatzky and Fleischer (1990) as those requiring specialist skills, possessing a scientific basis, were fragile in terms of operation, were difficult to trial or are not packaged as a unit.

Attewell (1992) considered organizational learning as the focus of diffusion for the type of technologies indicated by Tornatzky and Fleischer (1990). He suggested a Knowledge-Barrier Institutional-Network Approach that considered the current state or mechanisms that might be applied for lowering the knowledge barriers over time. To achieve this goal, he believed that it was necessary for supply-side organizations and mediating institutions to work together. However, this approach did not indicate the organizations which were likely to innovate. The fundamental assertions of his approach are the following:

- Organizational learning is partly a consequence of immobility of technical knowledge.
- The burden of organizational learning is a hurdle to adoption.
- The relationships between supply-side and user organizations as a result will go beyond a vendor-customer transaction.
- Mediating institutions exist where technical knowledge is scarce or burdensome.
- Mediating institutions capture economies of scale.
- The S-curve reflects changing knowledge barriers over time.
- Service is an alternative to adoption or non-adoption.
- Technology services are an alternative to knowledge transfer.
- A transition will occur over time from service to self-service.

Fichman and Kemerer (1997), extending the perspective of Attewell (1992) and linking organizational learning and innovation diffusion, assert that the effective assimilation of a complex technology is a product of a learning-related scale, related knowledge and diversity. Therefore, organizations must be prepared to invest in mechanisms to facilitate knowledge acquisition. Those organizations more likely to be able to reduce knowledge barriers are those that are able to amortize learning costs, have the ability to acquire knowledge more easily, and have less to learn about an innovation.

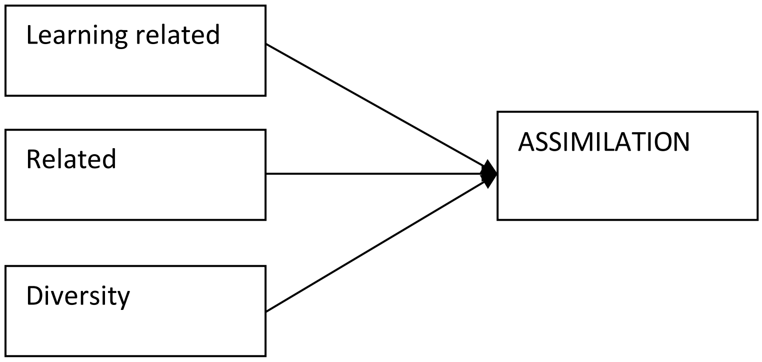


Figure 2.6 Fichman and Kemerer's Conceptual Model of Assimilation (p 1348, 1997)

Table 2.9 Description of factors utilized by Fichman and Kemerer (1997)

Factor	**Description**	**Benefit**
Learning related scale	The scale of activities over which learning cost may be spread.	Opportunity to achieve economies of scale.
Related knowledge	Pre-existing knowledge that can be applied to the desired innovation.	Reduction in organizational learning.
Diversity	Diversity of technical knowledge and activities promotes the ability to create novel associations and linkages.	Contributes to the other factors and reduction in total overall organizational learning.

Cohen and Leventhal (1990) used the term "absorptive capacity" as a combination of both related knowledge and diversity to describe the organization's ability to adopt a technology without the burden of high knowledge barriers. Existing prior knowledge provides a mental schema to which new knowledge may be appended and within which new schemas are created. Ease of organizational learning follows from ease of individual learning, because while it has been argued that individual learning is not always sufficient for organizational learning, it is necessary (Fichman & Kemerer, 1997). Roberts et al (2012) go further describing three assumptions underlying absorptive capacity. The first that existing prior knowledge exist, the second require the individual capacity to learn and thirdly that the learning is path dependant.

2.5.4 Absorptive Capacity and Diversity

The term "absorptive capacity" was first used by Cohen and Levinthal (1990) as a collective for the combination of skills that was able to recognize new information, assimilate the new knowledge and apply the learnt knowledge to a productive commercial outcome. The premise of the concept of absorptive capacity is based in behavioural and cognitive studies where a foundation or pre-existing knowledge base is required in order to use new knowledge. It is presumed that some portion of already assimilated knowledge and the new knowledge is similar for creative utilization to occur. Argote et al. (2003) use the term "ability" to comprehensively include not only the concept of pre-existing knowledge as a basis for knowledge growth, but also the individual's ability to manage the knowledge according to their needs. Roberts et al (2012) in their research review stipulate that absorptive capacity must not only be defined inclusive of prior-related knowledge, but also individual absorptive capacities and path-dependencies. They coined the term "expectation formation" as an indicator of the path reliance for acceptance of knowledge.

Diversity occurs as a result of individual learning capacity and experience. The benefit for organizations in knowledge overlap is diversity that should enhance internal communication and provide a mesh of knowledge structures leading to a reduction in knowledge barriers. Utterback (1971) concurs, finding that individuals who are able to communicate both internally and externally possess diverse and different knowledge structures and, given organizational opportunity, are able to augment the organization's capacity for innovation beyond that which any single departmental focus might provide.

2.5.5 Organizational Absorptive Capacity and Diversity

Organizational absorptive capacity is built upon the individual capacity of the organization's members, and is likely to be cumulative and a product of the prior investment by the organization in the development of its members (Cohen &

Levinthal, 1990, Roberts et al, 2012). Nelson and Winter (1982) saw an organization's absorptive capacity as not residing in any single individual, but being dependent on the links across a mosaic of individual capabilities. Teece (1996) included organizational identity and profile as an additional moderating factor to the organization's capacity. Thus, absorptive capacity is not simply a one-dimensional concept. Malhotra et al (2005) and Pavlou and El Sawy (2006) saw absorptive capacity as a dynamic capability and also as an organizational asset. The definition by Cohen and Levinthal (1990) explicitly infers the ability to learn new knowledge and to to adapt and apply the knowledge richly. Organizationally, this requires that the knowledge be transferred from the original external acquisition point within the organization by a process of structured communication by organizational members who may take on the formality of a gatekeeper/specialist role dependent upon the complexity of the knowledge or the hierarchical nature of the organization. Cohen and Levinthal also noted the roles of inward- and outward-looking absorptive capacities, stating the need for balance in order for effective organizational learning to occur. Boynton et al. (1994) saw absorptive capacity as being represented by two constructs, "Managerial IT Knowledge" and "IT-Management Process Effectiveness", both constructs directly influencing IT Use (the outcome). Boynton et al. also identified a fourth construct, "IT Management Climate" in which absorptive capacity existed and is conceived as the shared, enduring perception of salient aspects of the IT work environment. In the research model as shown in Figure 2.7, the outcome, "IT Use" is understood as the application of IT within an organization's operational and strategic activities, the definition expressed by Ives and Jarvenpaa (1991). Given this definition, the author's belief is that IT Use will encompass and achieve cost reductions, management support, strategic planning and competitive thrust through the application of IT.

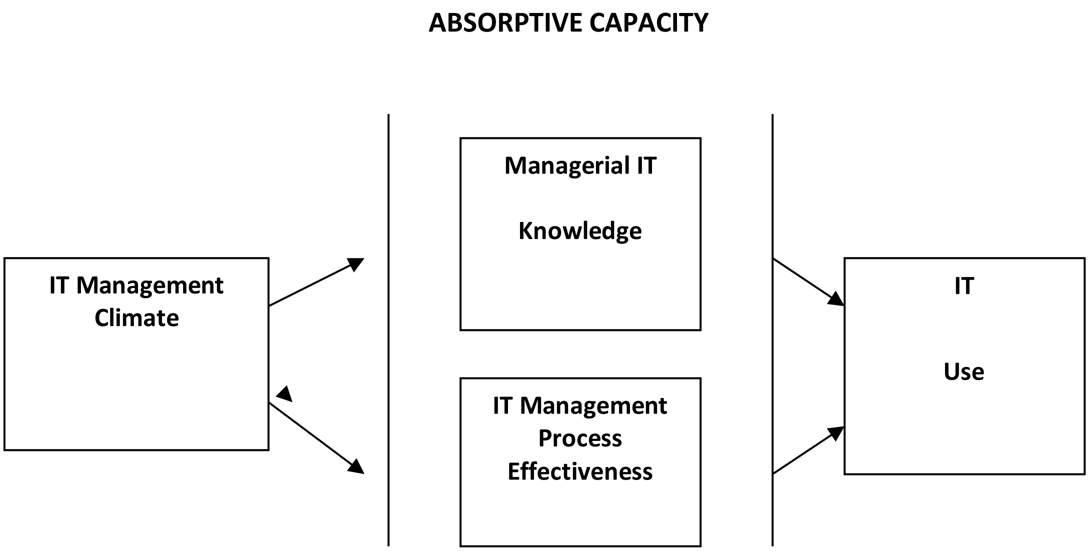


Figure 2.7: Absorptive Capacity Research Model , Boynton, Zmud & Jacobs(1994)

The two constructs that contribute to Boynton et al.'s definition of absorptive capacity are, firstly, Managerial IT Knowledge. This is represented as the conjunction of IT-related and business knowledge possessed and exchanged among IT, business and line managers within the organization. The second construct, IT-management process effectiveness, relates to how the knowledge is maintained within the organization, its structure, and the mechanisms which maintain the knowledge.

Empirical research by Boynton et al. found that although mechanisms for knowledge maintenance were an organization goal, they had little effect on IT use. More recent research in organizational learning has identified additional potential areas which may impact on the ability of the organization and its members to develop capacity; these include the individual experience of learning (Argote & Ophir, 2002; Ingram, 2002), where differing experiences should be applied dependent on the knowledge properties, the stability of the industry sector or environment (Sorenson, 2003) or how organizations manage knowledge repositories (Borgatti & Cross, 2003; Walsh & Ungson, 1991). Bassellier and Benbasat (2004) find that the demonstration of knowledge by professional competencies of executives actively impact the desire for capacity. Argote et al. (2003) note that although researchers from different disciplines use different methods in differing contexts, the vitality and diversity provide evidence of the priority and value of understanding and managing knowledge within organizations and its strategic importance for organizational growth and provision of market significance.

2.6 Supplier Side Perspectives on Diffusion of Information Systems

Research in diffusion from the supply-side perspective has historically occurred in the domains of marketing, consumer research and management. This largely reflects the historical organizational approach to suppliers and latterly the development of the supply chain as a strategic asset as opposed to external supply agencies. Hence, research in marketing and consumer research has focused on communicating and maintaining product benefits and maintaining diffusion across a market segment. In the 1980s, this approach began a period of transformation as organizations established strategic relationships with their supply chain. Robertson and Gatignon (1986), in modeling the supply-side competitive environment, included structural factors and resource commitments which they saw as part-determinants of the rate of diffusion. Structural supply-side factors affecting the rate of diffusion and the potential for market advantage include industry competitiveness, supplier reputation, technology standardization and propensity for integration. The vendors' capacity to provide research and development was also importantly represented as a factor, indicating the move to outsource high technology development to partner organizations. In addition, the industry sector itself, with its competitive drive and ability to present and communicate industry representation, was considered significant. Robertson and Gatignon (1986) argue that diffusion theory is quite incomplete unless it recognises the proactive nature of these actions and the effect of the supply-side vendor both within the market segment and with the organizations with which it partners or contracts. It strongly suggests that the factors must be viewed as an interaction so as to determine the likely success of the diffusion of a technology product and therefore its subsequent adoption by new clients within the context of the technology usage. Gatignon and Robertson (1985), in earlier work on communications in consumer research, also note the strength of the network of users and their spread across the environment as strengthening the effect of communication and indeed the appropriateness of the communication.

Frambach et al. (1998) measured the effect of supply-side variables and expressed concern that the omission of potentially powerful explanatory variables may lead to misinterpretation of empirical results. They also note the use of traditional models to evaluate intangible innovations whose characteristics will produce differing results from those of a tangible product. High technology products such as those used in the mining sector (outside of resource extraction) fall within this classification and cannot be measured against any tangible market norm.

Newell et al. (2000) found that supplier-focused models of diffusion have made an important contribution to the importance of social networks that allow communication of new ideas across organizations, in particular the links between technology suppliers and users. They also found that supplier-focused models may require further development as they may provide a solution to the contradictions in DOI theory where an apparently complex or non-trialable product still diffuses quickly as in the case of Business Process Engineering (Grey and Mitev, 1994).

Melville and Ramirez (2008), in extending diffusion of innovations research by focusing on information technology requirements as a driver, demonstrated that a supply chain structure is a positive determinant in the adoption and diffusion process and that the effect is significant in maximizing implementation success.

2.7 The Minerals Mining Sector within Australia

Australia is a major exporter of minerals resources to the world market. In 2003 – 04, Australia's mineral resources exports (excluding petroleum) were valued at AUD $43.6 billion, representing 29 per cent of Australia's total exports of goods and services (Tedesco & Curlotti, 2005). In 2011, the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) reported in its final quarterly report that twenty-two mineral resources account for 7% of Australia's GDP. As Australia's largest export (representing 46% of total exports) their reported worth approximated A$164 billion (excluding petroleum) in the 2011/12 reporting period (Senior & Huleatt, 2013). The continued development and growth not only represents a significant value to Australia, but as a sector it represents a major direct employer and supports a significant number of organizations which provide services to the mining sector (Senior & Huleatt, 2011).

Mining may be fundamentally deconstructed into three major partitions: asset discovery (exploration), asset development (feasibility/development) and asset mining (extraction) which together form the mining value chain which is seen as continuous and represents the development of a commodity.

Table 2.10 Mining Functional Partition/layers

Partition	Major Functional Activities
Asset Discovery(Exploration)	Discovery, confirmation and resource determination
Asset Development (Feasibility)	Evaluation of the asset body, analysis of mine cost against mine wastage, mining optimization
Asset Mining (Extraction)	Management of production and extraction of the ore body including environmental issues.

As can be seen in Figure 2.8 and Table 2.10, a number of functional activities comprise each partition/layer and contribute data to the overall knowledge and management of the mineral asset. Each functional partition utilizes information systems/applications for the management of the data which are particular to the context.

In addition, the Australian mining organizations and consortia that operate in the sector may also be partitioned into three participating capacity layers as shown in Table 2.11 that reflect their ability to participate in the provision of the ore body to the mining value chain.

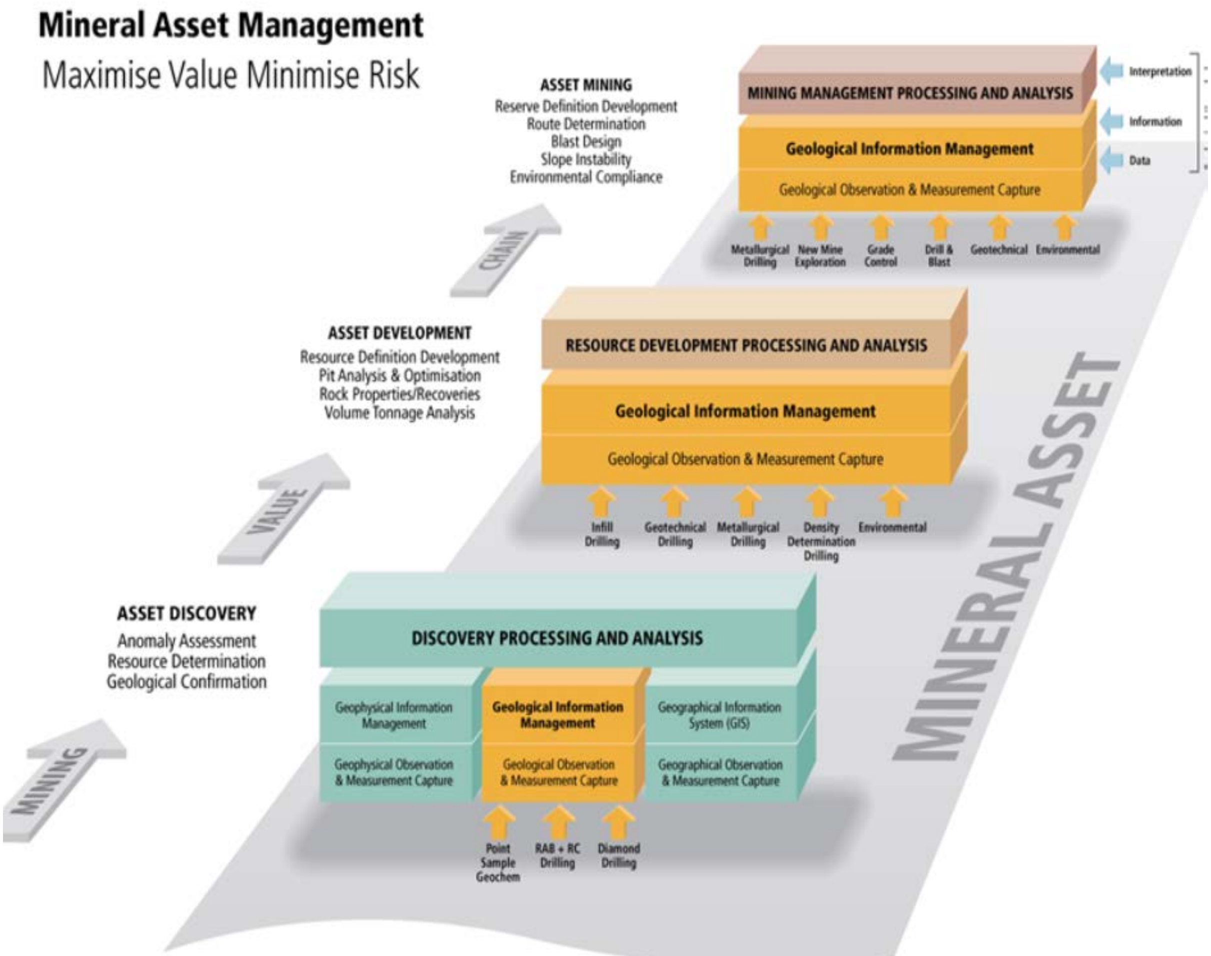


Figure 2.8. Mineral Asset Management: Source : HTP 1:

Table 2.11: Mining Organizational Capacity

Description of Organizational Mining Partition	Description of Participation
Junior	A company that is yet to generate revenue and is usually financing exploration projects via raised capital; the observations and measurements collected by this type of exploration company form the basis of a mineral reserve that will subsequently be sold, shelved or evaluated for mining.
Mid-tier	A company which is generating revenue and consequently has both exploration and mining operations.
Major	A company that has a significant exploration budget and also a large number of operations. They are involved in mining a range of commodities and often have projects in many countries

The mining organization's on-going capacity to purchase or contractually obtain high technology products is also limited by its need and position within the mining sector which also determine its ability to raise capital (Table 2.11). The utilization of information systems within each partition is therefore a determinant in the organization's ability to manage/manipulate the geodata and attract investment or on-sell the geodata and leases which ultimately result in the resource extraction (Pan and Harris, 2000).

Asset Discovery (Exploration) is an investment in the acquisition of knowledge about the location, size and quality of petroleum and mineral deposits. The decision to invest in minerals exploration depends on the probability of discovering an economic mineral deposit or extending the resource base of a known deposit. The outcome for investment is the calculated financial returns which are subject to economic and government policy factors including land access/title, prevailing and expected mineral pricing and existing and forecast technologies. In Australia, exploration is undertaken by private companies whose decision to invest is based upon the economic rent expected from the future exploitation of new discoveries.

Table 2.12 Matrix of organizational capacity and function

Organizational Capacity	Asset discovery (Exploration)	Asset Development (Feasibility and Planning)	Asset Mining (Extraction)
Junior	X		
Mid-Tier	X	X	X subject to external investment
Major	X	X	X

Economic rent refers to the surplus profits which must cover the fixed and variable costs of mineral production and required return on capital; where the time frame from discovery to production can be in excess of 10 – 15 years. In today's geologic environment, mineral deposits cannot be determined directly (i.e. by visual determination); exploration is now a process of information acquisition and reduction, where expensive techniques are applied only to areas of probable value (Pan and Harris, 2000). The process of information acquisition is based upon a wide knowledge of geology, data collection, interpretative and screening techniques.

Asset development (Feasibility) considers the value and return versus the costs of development based on a specified time usually the estimated life of the mine. The development of the asset also requires continued data gathering as the Australian Government requires accurate reporting of asset value. The management of reporting systems requires the information both in the form it was when acquired and also in its interpreted form. Development of the asset also utilizes software for pit optimization techniques and mathematical modelling as well as financial modelling.

Asset mining (Extraction) is the extraction of the mineral asset for either further refinement or provision to the market. Information systems include management of the extraction process and associated data management including geospatial modelling.

The mining value chain is therefore mirrored by a data/information supply chain. During the data discovery phase, data that is retrieved must be maintained for the duration of the lifetime of a mine. This source data, which becomes the foundation data of all subsequent asset management and decision making, must be maintained in its original format and subsequent extrapolations must be reproducible.

As shown in Figure 2.8, the mineral asset is managed by the utilization of information systems which may either interface directly with another application producing an "application landscape" (Buckl, 2009) or may extract information from a resources data management information system.

2.7.1 Information Systems in Minerals Mining

The mining of minerals is an activity dependent on specialized knowledge in the complementary areas of geology, geophysics and geochemistry. Its goal is the discovery of commercially viable ore deposits via a process of information acquisition. Nowadays, commercial success is no longer a product of traditional means; it is a combination of the aforementioned disciplines with computing technologies, information systems, geographic imaging, geostatistics and economic analysis moderated by political and legal realities. The aim of information systems within the minerals exploration domain is the synthesis of geoscience information in a target selection (where a target is one or more geologic objects). Pan and Harris (2000) state that the economic optimization of exploration requires the optimum use of diverse geodata to delineate that set of targets which is economically viable for commercial extraction. Pan (1989) asserts that the essence of information synthesis is the optimal combination of extracted information from data sets realizing a specific decision.

The following sections describe the inherent form of data utilized in the minerals mining sector of Australia. This description is intended to demonstrate the complexity of such data and to inform the reader about the specificity of high technology software and therefore the relevance and unstated interactions of context.

2.7.1.1 Geodata as Resource Information

The complexity of the geodata and its financial worth are considered primary assets of the mining companies and are reportable under Australian Government requirements. This complexity is managed by geological information systems which are unique to the minerals mining sector.

Data sets used for mineral exploration comprise information sourced from complementary activities such as geological, geochemical, geophysical, remote sensing and may also include drill hole data. The diverse data may also be combined with conceptual modelling techniques such as metallogenesis and ore genetics to produce geoscience data (Pan and Harris, 2000). Geological data comprises spatial and lithological information correlated to tectonic and mineral occurrences. There is also a temporal component in which the indicators of structure, prior, during or after mineralization occur. Geological data provides the basis for all other geoscience fields and its data's interpretation. Geochemical data provides evidence of concentrations of elements which enrich geologic areas. Concentrations are used to provide evidence of anomalous areas which may constitute a geochemical province and may be used in metallogenesis. Geophysical data is commonly provided by techniques measuring gravitational and magnetic fields and provides useful indicators for the location of deep-seated geologic structures. Remote-sensing data originates from the detection of electromagnetic energy; remote sensing systems detect the intensity of electromagnetic radiation that an object reflects, emits or scatters at a particular wavelength band. Remote sensing techniques have been widely used in regional areas, but are most strongly directed towards mapping regional lineaments, local fractures, lithological units and hydrothermally altered rocks. The acquisition of drill hole data is financially the most expensive process and is often referred to as hard data; its use may be restricted to confirming mineral presence based on data provided by other processes. Additional other data includes results obtained from assays, log information and well-logging measurements.

A mineral deposit is a geologic object and therefore, in order to be useful, each exploration datum carries two attributes: spatial location and geologic typicality. The techniques described above contribute to the datum. Pan and Harris (1992) introduced a further classification of the datum variables in order to delineate the appropriate application of data: target and explanatory variables. Target variables provide direct evidence of mineral deposits; explanatory variables provide indicators throughout a larger region. Ideally, synthesis of data would be weighted according to the variable type; however, to be of use, the different types of data must be identified and correlated.

2.7.1.2 Information Synthesis

In a brownfields area (an area previously mined), large amounts of data exist that enable analysis using statistical models. Extrapolation of models to unknown areas (greenfields) reduces the validity of models since the geological features are not consistent. Use of analogous modeling is based on a multivariate model of data extraction characterized by the use of an optimum combination of geological features in spatial variations (Pan & Harris, 2000). This modelling technique produces bias as mineralization produces variation in the endowment which analogous modelling is unable to interpret utilizing geological data which is by nature imperfect.

More recent technologies use techniques which integrate the diverse data often producing visualizations that are more useful representations of non-numerical data including lithologies and structure. The techniques for data integration rely on accurate quantification of geological observation, map visualizations, statistical pre-processing, filtering and enhancements, relations between geoscience objects and combination of the different data sets. The central task in data integration is the creation of a quantitative measure for mineral potentials (Pan & Harris, 2000). Pan & Harris describe the major components of these technologies as follows:

1. Pre-processing: this includes data capture, conversion, unification, transformation, filtering and enhancement. Common methods utilized in the transformation process include regularization, standardization and logarithmic transformation. Logarithmic transformation is vital as it reduces large contrast and skewing in numerical data. Redundant data will also be removed during this stage.

2. Information enhancement: raster and vector data sets are converted into a standard file format and interpolated on a regular grid which is then subjected to filtering and enhancement. Different interpolation methods are utilized according to the characteristics of the data.

3. Variable classification: defines geoscience features as either explanatory or target variables.

4. Information Criteria: implies the construction of models linking mineralization with geoscience data. This requires that variables be converted to information fields (dependant on the requirements of the modelling technique). Two common models are deposit and profile; the latter is particularly useful as it helps establish 3-D signatures for target prediction.

5. Defining Evidence: a critical step for data integration; where data (including qualitative) must be quantified into a form that conveys favourable/unfavourable information regarding targets.

6. Favourability measure: Following quantification, the next step is the estimation that measures mineral potentials for a given type of deposit. Potentials are those of the mineral resource descriptor, indicating number of deposits, extracted tonnage or other combination as requested.

7. Target delineation: Potentials are applied to control areas, whereas an extrapolation process is applied to an entire study area. Boundaries are established using probability or favourability estimates.

Information synthesis is a complex process that may produce multiple forms of evidence based upon diverse data. The usefulness of the evidence being dependant on the quality of the analysis and the extraction technique applied. Within Australia, the supply of appropriate services, including those described in the preceding paragraphs, are provided by the Mining Technology Services Sectors.

2.7.2 The Mining Technology Services Sector - High Technology Providers

The Mining Technology Sector hereafter referred to as 'the MTS sector' is broadly defined to include technology-based suppliers, organizations or institutions that contribute a good or service (including intellectual property) to the mining industry (excluding the petroleum industry). The providers of technology solutions comprise economically a significant investment within the resource sector and contribute to the export market within Australia as providers of technology solutions for a global market.

Haine (2006), referring to the growth in exploration within Australia, states that the ability to sustain and expand this contribution is vital to the national economic performance. This statement is echoed within the APEC community report released in January, 2007 which states that technological cooperation can play a significant role in the pursuit of sustainable development (Penney, Austin, Runley, & Curlotti, 2007). The MTS sector has emerged in a response to Australia's global position in support of the mining industry and is estimated to contribute AUD $1.9 billion in high-technology exports in mining (Martinez-Fernandez, 2005).This places the MTS sector as a decisive competitive factor underpinning the continued growth of the minerals export market and its contribution to the Australian economy. Austrade (2008) reports estimated annual sales from the Mining Technology Sector to external markets of AUD $12 billion.

In response to the lack of coordinated support and the on-going development of the minerals mining sector, an Australian government initiative, 'the Mining Technology Services Action Agenda', was established in 2001 to provide a means of dialogue between government and industry. Five focus areas were established by an action agenda, one of which directly addresses technological development and the challenge of innovation through technology. The Chair, Dr. M. Neville, Industry Issues Paper, identifies as a key issue the need to address innovation and technology transfer into and out of the MTS sector and the global impacts of MTS technologies (MTSAA, 2002). Key results of the second major review of the mining technology sector identified technical services to be the most important factor in sustained development (Tedesco & Curlotti, 2005).

There can be little doubt that the on-going expansion and sustainability of minerals export is underpinned by rapid growth enabled by technology. The need as expressed by the Mining Technology Services Agenda and its government sponsor is to understand the process of transfer (diffusion) of technology. The Australian government posits the concern for both domestic and offshore markets. The offshore markets are seen as an additional source of revenue for not only government exports, but also for suppliers of technology products.

2.7.3 The Organizational Technology Environment – The Mineral Mining Sector

The organizational technology environment represents the technology adopting/utilizing organizations within the context i.e. The Minerals Mining Sector.

The choice of mining as a context is both specific and diverse and is unique compared with the more traditional areas of study such as banking, insurance or other commercial service entities. This uniqueness derives from the segmentation of productivity with the context of mining, the longevity associated with the core data and the value and return on investment based on the value associated with core data. The mining value chain developed from Porter & Millar (1985) below, whilst showing only generic descriptions for each segment, indicates unique activities (requiring geoscientific data) exist within the mining value chain. The information systems that comprise the generically labeled 'data supply chain', represent geoscientific information systems which underpin the core processes that exist for the entire value chain. As previously stated it should be noted that whilst data is extracted for evaluation in various processes the integrity of the original data must be maintained for the duration of investment and activities. Within Australia the value of the mining asset is calculated on the data recorded for the original site, new geological data or manipulated data appends to the original data but does not replace it.

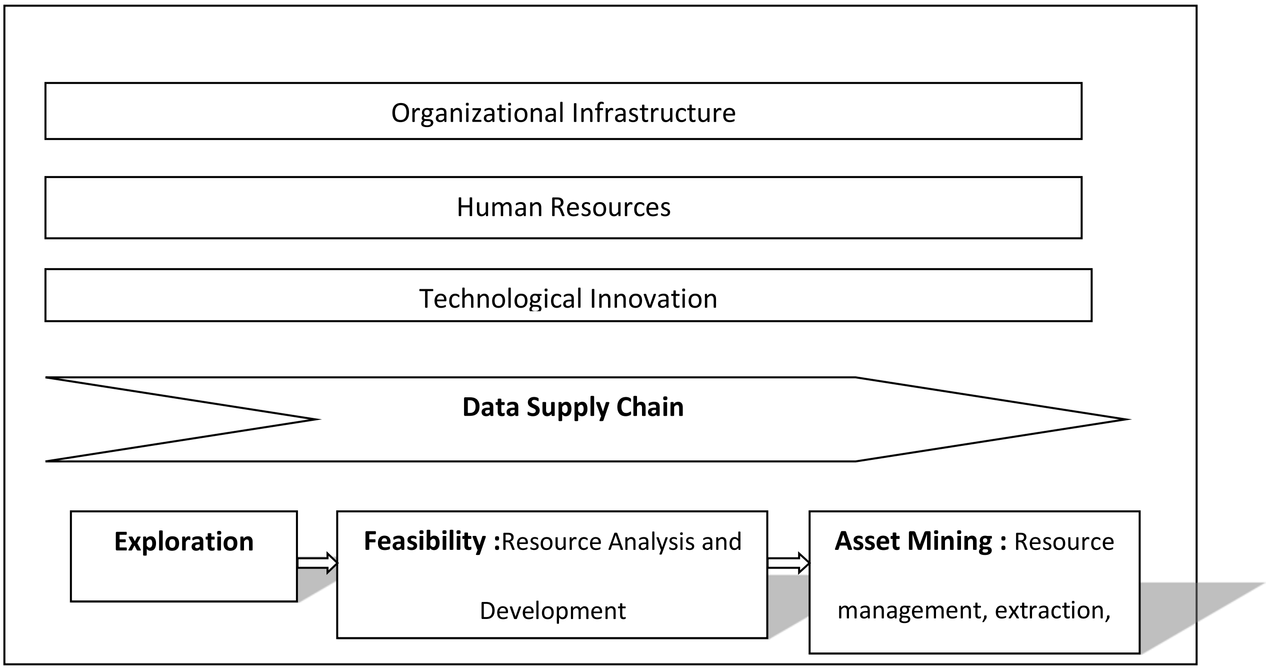


Figure 2.9: Mining Value Chain adapted from Porter & Millar (1985)

The diverse context may be visualized as previously shown in Figure 1.2 where the organizational space is represented in three segments: Junior, Mid-tier and Major.

A junior company is one that is yet to generate revenue and is usually financing exploration projects via raised capital; the observations and measurements collected by this type of exploration company form the basis of a mineral reserve that will subsequently be sold, shelved or evaluated for mining. A mid-tier company is one which is generating revenue and consequently has both exploration and mining operations. A major company is one that has a significant exploration budget and also a large number of operations. They are involved in mining a range of commodities and often have projects in many countries. Thus, the information systems and technologies which are part of the mining organizational space provide utility in addition to being of strategic importance for the lifetime of the mining operation, and therefore they determine asset value, provide feasibility information and contribute to the forwarding selling in a dynamic market. In turn, this influences the commodity price by providing optimizing information.

2.7.4 Minerals Mining Summary

The acquisition and the potential for diffusion of a high technology system thus represent a strategic decision for organizations participating within the context. This strategic decision suggests the possibility of synergies between the high technology providers and organizations in a differentiated, layered environment. Fichman (2000) suggested that further research into tailored technologies in a context-specific environment would build knowledge. As our information systems become more pervasive in a global and layered competitive environment, the creation of knowledge of such environments extends our vision towards the future.

In respect of industry sectors such as the Minerals Mining Industry of Australia, an understanding of the interaction of context and layered sector complexity should assist organizations in the strategic acquisition process of not only information systems, but also of an important synergistic relationship with the providers of high technology systems. The Australian Government has already acknowledged the value to the Australian economy engendered by maximizing efficiencies and understanding the effect of technologies in the mining sector, and recognized that this is important to the sustainability of national economy and continued prosperity. The mining technology services sector and the high technology providers are seen as vital to this prosperity and sustainability.

2.8 Outcome of Literature Review

The literature review reveals that the key focus for understanding organizational Diffusion of Innovations has been from the singular perspective of the adopting organizational unit. Early studies looked at large organizations that were able to maintain IT departments whose responsibility included the acquisition of technologies, and where knowledge in respect of information systems and technologies was centralized in the department. Later research foci took a broader organizational perspective but maintained a technical viewpoint and saw influential factors as being internal in terms of the organization. Moreover, the organizations chosen for the research were structurally hierarchical in nature and therefore maintained a top-down management approach; furthermore, they appeared to be limited to a single research location with only regional implications. These perspectives reflected the growth of information systems in the 20th century but do perceive information systems as an enabler of business or as a tool for achieving competitive advantage. With the passage of time, it is now evident that this rich history has not considered those external factors that influence commercial activity, and therefore has limitations in that it does not provide a more inclusive context-wide understanding of all the factors influencing diffusion.

From the literature review, a conceptual model was developed that incorporates factors evident in previous Diffusion of Innovations research from the perspective of the organizational unit, but also as researched by Robertson and Gatignon (1986) and latterly by Newell (2003). This conceptual model includes the external supplier factor. Additionally, the context itself is incorporated as a factor which influences and impacts on the industry sector, affecting both organizations and suppliers. The model also incorporates the relationship between the factors as a rich source of data that in previous research has been primarily assumed as meeting traditional contractual relations, or it has been ignored and has therefore remained untapped. Such relationships may provide an insight into the strength and integration of factors which may exist in a 21st century business environment where contractual alliances may be seen as strategic to the business as technology provision becomes regarded as a strategic enabler of business rather than a utility. The initial conceptual model is shown below and is discussed in detail in Chapter 3.

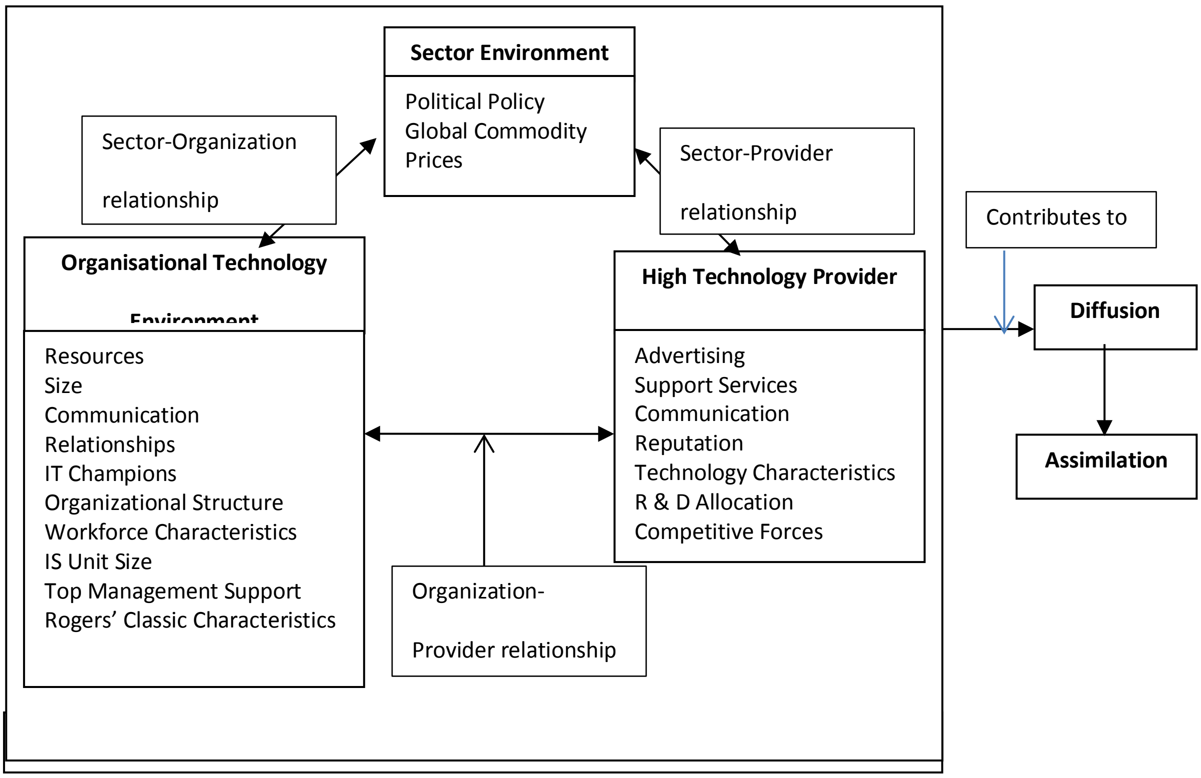


Figure 2.10: Initial Conceptual Model

2.9 Mining Sector Surveys

In Phase 5 of the research it was intended that a sector wide survey inclusive of both high technology providers and the organizations in the Organizational Technology Environment would be conducted. In the intervening period post literature review and the research phases 1-4 a number of surveys were undertaken by government departments and by the Minerals Council of Australia. The survey's together encompassed the subject matter of this research without specifically addressing the issues within the afore-mentioned survey's. The survey's high response rate made redundant the need to re-survey the sector and are examined in detail in Chapter 8 of this thesis.

ABARE (Australian Bureau of Agriculture and Resource Economics) produces quantifiable data on issues relevant to resources normally covering comparable 2 year periods. In the periods 2006-7 and 2008-9 (first reported in 2010 and subsequently published in 2011) the focus of analysis was directed to the economic contribution of the high technology providers to innovation, the economy and performance within the minerals mining sector. This report demonstrates the high level of sustained growth that contributed to the sector and a focus on integration on the business of the sector being distinct from that of being a technology provider. A latter survey (Austmine, 2013) to the research confirms that this remains valid with the technology sector contributing 6.4% to the Australian economy and ranks as a leader in Australian exports. The survey, which was funded by the Australian Federal Government, reports in financial terms $90 billion in revenue and declares the importance of a sector which identifies knowledge and skills as well as services to the mining sector. This is also supported by a publication of Austrade (2013) which re-iterates the economic findings but also lists the major high technology providers and their contribution to the growth of the technology market. The high technology providers who were participants to this research may be found in the leaders described in this document.

The second survey conducted in 2003 for the National Office for the Information Economy (NOIE) and the Department of Communications, Information Technology and the Arts (DCITA) was undertaken to understand the relationship between high technologies and the Australian mining industry. This largely qualitative survey is also latterly re-confirmed by the Austmine survey. Confirmatory of both the findings of the thesis and the earlier surveys are a continuing the following key outcomes:

1. 53% of technology providers and mining organizations collaborate directly.

2. $1.6 billion in research and development declared by 58% of providers.

3. 52% maintain competitive advantage by re-investment within the business.

4. 56% of technology providers report an increase in business growth of 56%

5. Competitive advantage is found in the relationship with customers

6. High quality differentiated products.

7. Knowledge of the mining industry

Also included in Chapter 8 was the ICT Roadmap constructed by Deloitte (2013) that examines technology-based solutions across the mining value chain which supports the need for high technology providers and an industry based knowledge component across the sector which also validates and provides external triangulation to the aforementioned survey's. PriceWaterHouseCooper's 2010 and 2014 Aussie Mine Reports also act as an independent economic analysis of the afore-mentioned data and confirm data presented within each of the survey's used within the research.

2.10 Summary

The review of the literature pertaining to the diffusion of innovations in information systems reveals several key aspects that have historical antecedents and have dominated and shaped research to date. Predominant among these are:

- Initial adoption of information systems/technologies within large organizations due to the investment required to acquire systems;
- The historical placement of Information/systems as a responsibility of a dedicated organizational unit;
- Technical focus as a key element accorded to early organizational research;
- The need for change leadership to guide technology at a non-executive level;

- The unit of study being either the intra-organizational unit or the organization itself as separate from any interacting agents or context.

The evolution of information systems/technologies has acted as an enabler of business capacity and therefore shifted the organizational placement of information systems from that of functional efficiency to that of a strategic asset. As a strategic asset, its value should be utilized across organizational silos to create a data supply chain whose value is critical to the organizational goals. Furthermore, the propensity for value may be influenced by external factors to the organization but within the industry context. Coupled with context, the literature review has revealed that little attention has been given to the significance of the impact or strength of the relationship between high technology providers and the organizations to which they provide specialized technologies within the context space. No existing model appearing in the literature that reconciles context, high technology providers and organizational needs. All organizations operate within a dynamic market contexts, often globally or policy driven, the lack of inclusion of the context therefore represents an incomplete understanding of diffusion of innovation in specialist contexts. Similarly the exclusion of the technology providers also reflects a lack of modern business practice where the supply chain act as stakeholders bringing with them integrated business solutions that are mutually beneficial.

The literature review has highlighted the need for research studies which increase our understanding of the diffusion of innovation in a dynamic business environment where context, relationships and technology type may be of increasing significance to the diffusion and assimilation of information systems. This research will seek both to inform and add to the body of knowledge regarding the Diffusion of Innovation Theory, and assist industry to incorporate into best practice an understanding of the factors which influence the diffusion of new technologies and systems in an increasingly technology-reliant marketplace.

As a result of the literature review, the following chapter presents in detail a proposed conceptual model which incorporates the concept of context, high technology providers and organizations and their relationships within the contextualized environment.

Chapter 3 Conceptualized Research Model and Propositions

3.1 Introduction

This chapter provides a summary of the initial conceptual model, its development and refinement. Key sections in this chapter are:

- Information on the development and refinement of the model;
- A summary of characteristics identified and their contribution to the conceptual model;
- Information on the development of propositions and their use in verifying and testing the conceptual model.

3.2 Initial Conceptual Model

The initial conceptual model as shown in Figure 3.1 was developed as a result of the literature review. This review included the research areas of Rogers' (1983,1995) classic Diffusion of Innovations Theory, generalized organizational diffusion, organizational diffusion in information systems, assimilation and communication of knowledge, supply chain impact and other areas deemed relevant to the study such as the effect of ties as a communication channel.

The initial conceptual model draws upon the work of Fichman (2000), Robertson and Gatignon (1986) and Tornatsky and Fleischer (1990), each of whom saw the need to contextualise diffusion of innovations research although each conducted his research in response to their particular focus in the particular research timeframe. The initial model is differentiated by its placement of the high technology vendor and organization in a context bounded by the commercial industry sector and subject to the business impacts of the particular industry in which they participate.

Thus, the relationships and events, whose significance may be otherwise less visible by research of the singular internal organizational perspective of any particular organization, may be more meaningfully represented and the extent of their influence assessed across the context. The context also enables the study of specific technologies (as suggested by Fichman (2000)) to determine whether known diffusion factors impact on high knowledge products in the same manner as the previously researched business systems/technologies; also, it removes those technologies which are now commonplace (such as word processing) and offer no significant strategic value.

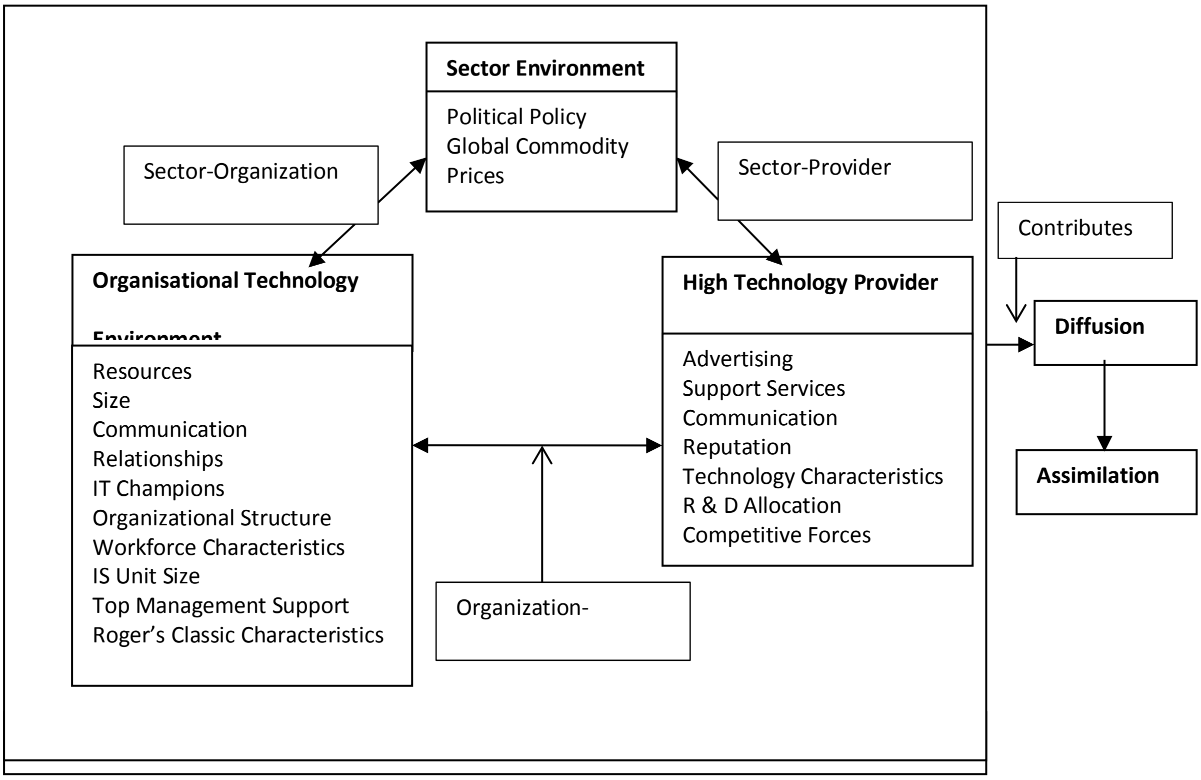


Figure 3.1 Initial Conceptual Model

The initial conceptual model shown above is bounded by its context, that is, the industry sector in which the organizations who adopt technologies and systems participate for commercial gain and wealth generation. The context relevant to research in respect of Diffusion of Innovations contains three factors, the "Sector Environment", the "Organizational Technology Environment" and the "High Technology Providers". The "Sector Environment" pertains to the context and thus the industry sector. It represents those characteristics which are external to either the organizations or suppliers, but which are business industry impacts to which the latter factors must respond.

The “Organizational Technology Environment” represents those organizations that participate within the industry sector and therefore the context. These organizations are the adopters/users of technologies and systems. Lastly, the “High Technology Providers” are the providers of systems and technologies that are unique to the context and have a high knowledge burden. Each factor has characteristics previously operationalized in past research and therefore provides a foundational validity to these characteristics and to their particular factor. Table 3.1 summarizes characteristics as categorized by Fichman (2000) within his framework, noting the originating researchers.

Additionally, the initial conceptual model proposes that the three factors demonstrate a bi-directional relationship between each pair of factors indicating that information flows in both directions between the indicated pairs within a context. These flows may also suggest that relationships exist between factors although their depth or nature remains unknown. The probability of relationships/ties beyond normal contractual obligations existing between the high technology suppliers and organizational technology environment as in a strategic business relationship may imply that networks of influence are likely to occur that have not previously been acknowledged or researched.

As demonstrated in the literature review, the effect of supply-side variables has often been under-estimated. By researching high technology products found within a context that are provided by dedicated providers, it is anticipated that a more complete understanding of the influence of suppliers may be demonstrated than previously envisioned. High technology products also remove the effect of mass market penetration techniques which often influence individual adopters and which may be commonly seen in more traditional consumer markets.

Table 3.1: Previously operationalized characteristics as categorized by Fichman (2000)

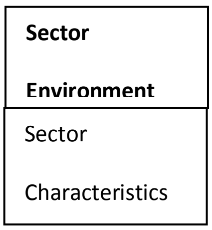
	Technology & Diffusion Environments	Organization & Adoption Environment	Technology-Organization Combination	Diffusion
Characteristic	Relative Advantage Compatibility Complexity Trialability Observability Supplier side Support Supplier side Characteristics Ease of Use	Organization Size Scale Resources Centralization Specialization Technical Specialists Communication Channels Competitive Pressure IT intensity IS unit size Top Management Support	Organizational Culture Organizational learning and support Related Knowledge Knowledge Barriers Ease of use Links to Supplier	Stage of Adoption Relative Advantage Compatibility Complexity Trialability Observability Supplier side support Communication Channels Advertising
Researchers	Rogers, 1995 Ramiller, 1994 Cooper and Zmud, 1990 Tornatzky and Klein, 1982 Leonard-Barton, 1988 Robertson and Gatigon, 1986	Damanpour, 1991 Fichman and Kemerer, 1997 Kwon and Zmud, 1990 Swanson, 1994 Zmud et al, 1990 Eveland and Tornatzky,1990 Robertson and Gatigon, 1986	Cooper and Zmud, 1990 Attewell, 1992 Fichman and Kemerer, 1999 Leonard-Barton, 1988 Robertson and Gatigon, 1986	Rogers, 1995 Ramiller, 1994 Cooper and Zmud, 1990 Tornatzky and Klein, 1982 Leonard-Barton, 1988 Robertson and Gatigon, 1986

3.2.1 Detailed Description of the Initial Conceptual Model

The initial conceptual model as described above consists of a boundary that is delineated by the commercial activity of an industry sector; this boundary provides the limitations of the context. The context as described above contains three factors (described in detail below), each of which is populated by previously operationalized characteristics. Each factor contributes to the overall effect of the context for any given technology in a given industry sector and may act as a determinant in the rate of diffusion. It is suggested that between each factor relationships exist which are bi-directional and through which networks of influence may occur.

Each factor and its characteristics are discussed in detail in the following sections. Each section is tagged by the factor icon immediately following the section heading for easy reference.

3.2.1.1 Sector Environment



Organizational IS research has previously incorporated characteristics such as industry competitiveness, profitability, rate of change and technology maturity and situated them in an environment or adoption context (Eveland and Tornatzky, 1990; Meyer and Goes, 1988, Premkumar, et al., 1994, Fichman, 2000). The perspective of such research is that of the organization looking outward; i.e. it is the organizations' view of the external influence. The perspective of a large organization may contrast significantly with that of a small or medium size enterprise. It is the author's argument that the Sector Environment should pertain to characteristics that affect the sector as a whole and should be seen to be beyond the control/perspective of any single adopting organization or interest group. The response to such events depends on each organization participating within the sector. It then becomes possible to contextualize the external effects upon the industry/sector and develop a richer picture of interaction, thereby obtaining a more meaningful view of cause and effect. The “Sector Environment” has therefore been described as consisting of a nominated characteristic, Sector Characteristics. Sector Characteristics is designed to act as a placeholder for specific characteristics once a context has been determined by the researcher. It is the intention that in the production of a generalizable model, the researcher will substitute specific context relevant characteristics pertinent to the area of study. The disadvantage of this approach is the reliance on the knowledge of the researcher when selecting appropriate characteristics. It is recommended that the researcher seek expert knowledge from industry representatives when determining likely characteristics. Once determined, these characteristics should be stated using the terminology of the selected context, thus reducing the likelihood of bias or misinterpretation possibly introduced by the researcher.

The initial conceptual model as depicted also shows that the Sector Environment possibly has relationships with both High Technology Providers and the Organizational Technology Environment. Each of these factors is provisioned to respond to the Sector Environment characteristic event/s (e.g. global financial crisis) based on the events’ impact on the factor’s characteristics to the event. Such response may be documented, thereby providing a trace/audit for future strategic management of systems and technologies.

3.2.1.2 High Technology Provider

High Technology Provider
Advertising Support Services Communication Reputation Technology Characteristics R & D Allocation Competitive Forces

The *High Technology Provider* is a service provider of an information system/technology which is unique to the context as described by the Sector Environment. The term ‘High Technology’ specifically refers to an information system/technology that addresses the needs of the Sector Environment and is unlikely to be an off-the-shelf product or product used outside the industry sector (excluding GIS products). Such information systems/technologies require training or specific skills in the operation or interpretation of the outputted data to maximize the value to the business. The initial conceptual model also suggests that the provision of specific high technology products would indicate an expected bi-directional relationship between technology providers and the organizations using their services. The goal of the providers is to profit from capabilities provided to the sector; therefore, they will be motivated to meet changing demands. They may even seek to modify client business processes (as in ERP systems) in response to the providers' perception of best practice or drive change through the introduction of new versions. The Organizational Technology Environment provides feedback in the form of needs and requirements to the provider, thus completing the bi-directional relationship. Characteristics applicable to this factor are advertising, support services, market competition, communication, relationships, technology characteristics and R&D allocations and reputation, (Robertson and Gatignon, 1986; Fichman, 2000; Frambach, 1998). These are defined in the following text.

Advertising is seen as a mechanism to propagate or make aware the existence of a new technology (Fichman, 2000). It is also regarded as a mechanism to overcome initial reluctance toward what may be perceived by the adopting organizations as complex technologies by marketing benefits and market share possibilities (Robertson & Gatignon, 1986). Mahajan et al. (1991), however, found this to be useful only in the simplest of cases. Although Fichman (2000) rated this as a beneficial factor in communication, most researchers sought other characteristics for validation in diffusion studies.

Support Services is defined as the availability of assistance by a high technology provider to the adopting organization by the high technology provider post adoption. This may take the form of operational manuals, on-line documentation, training or vendor support via newsletters, forums and conference activities. A search of existing research in organizational diffusion of innovation in information systems finds no similar characteristic operationalized in recent research from a supply-side perspective. Leonard-Barton (1988), in her study of the use of structured systems analysis, found that access to training was important from an organizational perspective, and that users valued an informal consultant. It is arguable whether “support services “are a feature of the technology product per se. However, the definition of support services is ‘post-adoption’ and it is the belief of the high technology provider representative that the absence of this characteristic would act as a deterrent to adoption and therefore hinder the diffusion of the product throughout the sector. It should be also noted that access to these materials usually incurs a contractual cost. Additionally, other members of the preliminary review panel indicated that they perceived these services were expected from any reputable vendor.

Communication as a characteristic of the High Technology Provider represents the extent of channels of communication and the proactive nature of communicating knowledge of a technology to an organization. Frambach et al. (1998) regarded communication as an important determinant for intangible products. However, they saw communication as an awareness or outreach mechanism through the use of marketing strategies. Lind and Zmud (1991) distinguished between communication frequency and the richness of the communication channels, while Robertson and Gatignon (1986) saw communication as an openness that refers to the amount of available information. Communication in terms of the High Technology Provider is distinct from previous research where communication channels were considered to be a characteristic of the organizational environment and refer primarily to how an adopting organization becomes aware of an innovation (conceptually a pull mechanism). However, the technology provider still uses traditional channels such as telephone and email, but will also provide richer communication through the use of web-sites, conferences and outreach mechanisms such as newsletters and case studies. It may be argued that communication is a marketing tool, as suggested by Frambach et al. (1998). However, this would be over-simplistic in modern business technology which has seen a rise in the use of social media, and a variety of outreach mechanisms utilized by high technology providers. Communication may also be complemented by support type activities in the form of education programs, visualization functions or conference type activities such as workshops. Such activities promote relationship building and the formation of ties between individuals, which they in turn take with them as they move between organizations.

Reputation of the technology vendor has been reported in previous studies by Robertson and Gatignon (1986), Gatignon and Robertson (1989) and Fichman (2000) as a positive characteristic. In marketing studies, the reputation of the vendor has been seen as a significant factor, where either the product is intangible (such as with the case of technology products) or where complexity is perceived by the user. In the aforementioned situations, reputation may have a mitigating effect (Frambach et al, 1998) and acts as an assurance of quality and integrity, thereby reducing any negative perceptions. Taken in a contextualized sector environment narrowed by the specificity of the technology, reputation may become a more dominant characteristic. The dominance of a high technology provider may contribute to either the elimination of competition within the sector or may result in providers seeking market share through product diversification or further specialization depending on the nature and scope of the environment.

Technology Characteristics are those that originate in Roger's Diffusion of Innovation Theory (1983, 1995). These include ease of use, trialability, complexity, compatibility and observability. Rogers anticipated that innovations possessing favourable characteristics would be adopted and diffused more quickly. As posited by Fichman (1992), this would appear as an over-simplification, as the perception of the complexity of a technology will vary between organizations. However, a distinction should be drawn between the perception of technology characteristics by the individual (or organization) and the representation of the technology characteristics as portrayed by the high technology provider. The effectiveness of a provider's communication of features of any technology product will influence the spread of adoption (Attewell, 1992). Nevertheless it has been largely underestimated in research that has ignored the significance of supply-side variables. Technology characteristics, which are a High Technology Provider factor, represent the features of the technology as presented and communicated by the provider to potential adopters. Newell et al. (2000) warn that providers invariably present an over-simplified view of an innovation which emphasizes the benefits.

However, as this would represent a norm in terms of provider approach, it is up to the adopting organizations to take the approach of “caveat emptor” as with any significant adoption. In a contextualized environment where high technology products are considered non-core items, it is expected that the representation and effective communication of this representation would provide an effective signaling mechanism for innovative early adopters.

R & D Allocations were included by Robertson and Gatignon (1986) and Gatignon and Robertson (1989) as a supply-side variable in which they found a positive relationship between the greater investment in R & D leading to technology enhancements and a stimulation of the marketplace. This stimulation was predicted to result in a more rapid diffusion and possibly an expansion of the market as new technologies are adopted, but has been largely ignored outside of marketing studies. Information systems/technology research has also included R & D Allocation but situated it within the organizational adopting environment. It is seen as a positive characteristic in the adopting organization leading to innovation, and as an investment in a dynamic competitive environment to gain market advantage. These two viewpoints are not incompatible and together describe the impact of R & D investment in the technological diffusion process and its possible co-location in both the supply-side and adopting/diffusing organization. Cohen and Levinthal (1990) describe R & D as a significant cost in the development of knowledge, and they researched the immediate costs associated with the assimilation of innovation. In a contextualized high technology environment and an era of rapid technological change, this may be a characteristic that provides an advantage to the technology provider and also should be seen as a strategic benefit to adopting organizations within the sector. The investment in R & D, since it is situated in the High Technology Provider, displaces the larger cost incurred when the adopting organization replaces it with a smaller immediate cost of assimilating the knowledge in order to utilize the technology effectively to meet the immediate specific needs of the organization.

Competitive Forces represent the competitive intensity to provide a technology to a given context. Studies where supply-side variables are incorporated consider that the forces of competitive intensity and strategic pricing policies stimulate adoption and diffusion (Frambach, 1998; Robertson and Gatignon, 1986). As an outcome of the competitive intensity, R & D allocations are likely to be increased as a strategy to ensure market share, the outcome of which then contributes to innovation by the technology provider and to the industry sector in the form of new knowledge and potential capacity. Competitive forces located within IS diffusion studies have predominantly been focused on the adopting organization's participation in a competitive environment and innovations as a strategy for market dominance. This study unequivocally considers Competitive forces as a supply-side characteristic that drives innovation from high technology providers to the contextualized environment.

3.2.1.3 Organizational Technology Environment

Organisational Technology
Resources Size Communication Relationships IT Champions Organizational Structure Workforce Characteristics IS Unit Size Top Management Support Rogers' Classic Characteristics

The Organizational Technology Environment in the initial conceptual model represents the client organizations in the context. The major focus of organizational innovation research has been the determination of factors or characteristics that contribute to the successful adoption, implementation and diffusion of technologies. Damanpour (1991) comments on the broadness of the area and the distinctions that have been drawn by researchers to help conceptualize and differentiate various models and theories. Swanson (1994) distinguished between technological and process innovations, Damanpour and Evan (1984) discuss technical and administrative innovation, while Friedman and Cornford (1989) considered generational change as a research focus. Other researchers considered organizational factors as foci. Fichman (2000) posited that diffusion research needed to understand why organizations adopt, and this should be the central tenet of diffusion research. In doing so, one must consider the characteristics of the organization, its leaders and the environment. Attewell (1992) commented that adopter studies generate lists of characteristics that typify these studies and include organizational size and slack, specialists and innovation champions among others. More recently, Mustonen-Ollila and Lyytinen (2003) produced a table of organizational factors including opinion leaders and change agents, management hierarchy, communication and networks. These additional factors demonstrate a new focus in research and clarify the base importance of organizational factors and the inter-relationships which exist in the process of acquisition and deployment of an innovation. Emerging from the recommendation of Fichman (2000) to produce theory applicable to context or technology characteristics apposite to a context relevant model, the following characteristics (which have been operationalized in previous research) are utilized within the current theoretical model: slack resources, communication, relationships, IT champions, technical expertise, organizational culture, size and organizational fit.

Resources have been previously linked to size and wealth, although they are termed "slack resources". Tornatzky and Fleischer (1990) quite simply stated the larger the organizational size and presumed corporate wealth, the more likely it is that resources will be made available for innovative projects. Slack resources also allow an organization to absorb failure and the costs of learning (Nystrom et al., 2002) both in terms of human resource cost and organizational productivity. However, Fichman (2000) notes the contribution of Lind et al. (1989) who found mixed evidence to challenge the concept of larger organizations being more innovative. Rather, these organizations often exhibit a rigid hierarchy and appear more likely to implement rule-based management which stalls innovation (Nystrom et al., 2002). Equally, evidence may suggest that small to medium size enterprises are by necessity more ready to innovate in order to compete in a dynamic marketplace. Consideration should also be given to the structure of an industry sector and the appropriateness of the term "slack resources" across that industry sector. "Slack" may be understood to imply that the resources are idle or unallocated. It may be that resources may be made available given an appropriate business case or strategy. In the case of mining (as described in Chapter 1), there is a three-tier structure where each larger tier may include the previous tier and by implication each subsequent tier possesses greater financial capital. This tier concept finds an analogy to research by Swanson (1994) who found that IS resource allocation at a local level may have foci that are different from organizational resource allocation. Thus, the term "*Resources*" will be used in this study to represent a broader construct than that defined in previous research, that being the availability of the resources for technology innovation when it can be demonstrated that the information technology/systems provide an organizational benefit.

Size, as stated in the previous section, has been noted in earlier research as having a positive relationship to slack resources. However, Wilson et al. (Nystrom et al. 2002, page 224) saw that the consideration of size alone was being riddled with shortcomings; they proposed a multi-attribute measure which included radicalness and relative advantage. A radical innovation implies significant behavioural change in contrast to incremental innovation over time; yet no distinction was drawn between process or administrative innovation (Gopalakrishnan and Damanpour, 1997) or management or product creation (McDade et al, 2001). Despite on-going organizational diffusion research, no definitive attribute value can be assigned; rather, there is only an assertion that a positive relationship exists between size and innovateness (Nystrom et al., 2002; Germain, 1996; Boecker and Huo, 1998).

Communication Channels were a major factor recognized by Rogers (1983, 1995) and were documented by Nilikanta and Scamell (1990) who found that hypotheses linking information sources and communication channels to diffusion were not supported at an individual incremental level, but exhibit influence as complexity arises. Brancheau and Wetherbe (1990) found that different channel types were more important at differing stages, i.e. initiation, adoption, implementation. They found, as in the aforementioned study, that implications for management arise from the need to create mechanisms for knowledge transfer and the benefit of the role of the boundary spanning/gatekeeper. Contrastingly, within this research, no distinction is made between information sources and communication channels as the researcher has an *a priori* belief that given the choice, a preference is made to select a richer media source (e.g. dynamic web content) as a norm. In this manner, information is accessed immediately and may be communicated intraorganizationally either as documents or by use of the URL. The characteristic is therefore termed “communication” and is located both in this element and within the High Technology Provider as the researcher is also seeking to determine whether there is a substantial impact from a push or pull construct (Lyytinen and Damsgaard, 2001; Delhaye and Lobet-Maris, 1995; Premkumar, Ramamurthy and Nilakanta, 1994).

Relationships represent the network of associations within which individuals operate in the contextualized environment. Katz (Deroian 2002, p 835) finds it unthinkable that diffusion studies ignore the social networks, finding it analogous to studying the circulatory system without having an understanding of veins and arteries. Granovetter (1973, 1983) focused on the distinction between weak and strong ties and the implication for the transfer of information along the networks. He concluded that weak ties “are here seen as indispensable to individuals’ opportunities and to their integration into communities”. His later research in 1985 on social dimensions in economic networks, further contributed to the study of relationships in that he saw economic organizational networks as a consolidation of individuals’ preferences and opinions rather than as organizational policy in practice. Valente (1996) added the opportunity for external sources of influence in the cosmopolitan individual who is oriented to the external environment of any particular network and thus acts as a conduit for new information and experiences. The contextualized environment described in this study defines by its boundaries a social network founded on the industry experience and profile and therefore the professional attributes of those within the context. In considering minerals mining as an example, individuals within the environment in general possess skills and attributes that are unique to mining i.e. geologists, geophysicists, earth scientists who are trained to explore and extract maximum ore yields. The work context is often located in remote locations where they operate either in fly-in/fly-out transits or reside in communities that have adapted to accommodate the requirements of mining operations. Thus, the contractual nature and lifecycle of mining operations may result in weak but long-term ties that are facilitated by professional organizations in an otherwise local transient population. Additionally, external influence is affected by similar professionals whose primary occupation may move laterally to service organizations such as high technology providers, but these professionals also maintain membership of professional associations and in doing so provide a conduit for the introduction of new information.

IT Champions act as the facilitator of change within an organization, often also acting as the gatekeeper of new innovation. Rogers (1995) described the role of a change agent as one which included an ability to influence innovation decisions and to additionally possess the intent and action to change. Fichman (2000) sees a distinction between the roles of IT champions and change agents, the former acting within the delivery system of innovation implementation, the latter in exerting influence within social and management layer. Vitale and Ives (Beath 1991, page 355) also distinguish between the roles of champions and sponsors, the IT champion bringing information and knowledge, the sponsors having authority and the power to cause change. Within this research, the IT champion is defined using the definition provided by Prescott and Conger (1995), “Champion support for an innovation means that someone within the organization becomes a special advocate for the innovation, taking actions to increase the probability of successful adoption and implementation”. This research will seek to determine within the contextualized environment whether an IT Champion exists and has the ability to influence the adoption and implementation of a technology/system.

Organizational Structure in this study describes the organizational hierarchy in terms of a managerial approach to formalized acquisitions of innovative systems. Previous studies have operationalized factors in terms of centralization, formalization and vertical differentiation (Damanpour, 1991; Fichman, 2000). Table 3.2 which is an excerpt from Damanpour’s meta-analysis provides generally accepted definitions stated by researches conducting studies on innovation and diffusion studies.

Table 3.2: Description of Organizational Structure (Damanpour, 1991)

Independent Variable	Expected Relationship	Definition and Reason for Expectation
Centralization	Negative	The concentration of decision-making authority prevents innovative solutions, while dispersion of power is necessary for innovation (Thompson, 1965). Participatory work environments facilitate innovation by increasing organizational members' awareness, commitment and involvement.
Formalization	Negative	Flexibility and low emphasis on work rules facilitate innovation (Burns & Stalker, 1961; Thompson, 1965; Aiken & Hage, 1971). Low formalization permits openness which encourages new ideas and behaviours (Pierce & Delbecq, 1977).
Vertical Differentiation	Negative	Hierarchical levels increase links in communication channels, making communication between levels more difficult and inhibiting the flow of innovative ideas (Hull and Hage, 1982).

Damanpours' analysis confirmed a negative correlation between centralization and innovation and non-significant associations between formalization and vertical differentiation. Given the expected similar outcome of the variable and the confirmatory analysis of Damanpour, no significant benefit can be expected in further study at an individual level. This research will therefore seek to establish whether a centralized organizational structure inhibits the diffusion of innovations at a unit level. *Workforce Characteristics* within this study describe those primary characteristics of users of a technology/system within the contextualised sector. Damanpour (Fichman, 2000, pages 14 - 15) found within the meta-analysis that contributory factors relevant to diffusion are education level, professionalism, technical specialists and tenure. A limitation of this analysis was that previous research had stereotyped the workforce as permanent employees and individuals as having decision making ability. In current economic times, workforces in sector contexts which are subject to swings in markets prices frequently operate with contracted staff through use of specialized employment agencies. These staff, although possessing the requisite tertiary qualifications and significant experience do not have organizational permanency. The result of contractual employment is the focus of the individual is on their own continuance and this may suggest a lack of development of organizational loyalty outside of that required by professional ethics. Nor, do contracted staff experience the organizational cultural immersion process that occurs over time and that has determined the outlook of the organization historically. Historical development influencing the organizations current and future strategic direction. Rather, the importance of personal adherence to professional attributes dominate and ethical behaviour and collective professional behavioural norms operate (Valente, 1996).

IS Unit Size has previously been associated with organizational size. Swanson (1994) saw larger organizations as having the capacity for dedicated functional areas and specialized roles. These roles were seen to as act as boundary spanners and provide gateways for learning in his type 1 innovations. Tornatzky and Fleischer (1990) however saw IS unit size however as just another aspect of the overall organizational size. The reduction of dedicated Information systems units as a response to a trend to outsourcing and offshore may also suggest a reduction in capacity as a factor/characteristic to influence adoption, diffusion and therefore participate in the assimilation process.

Top Management Support was noted by Sharma & Yetton (2003) as having a rich history in Information Systems research as a significant factor in the adoption and implementation of information systems. Management support is seen as critical for successful innovation to occur due to the substantial organizational investment required for technical infrastructure and applications (Kwon & Zmud, 1987; Purvis et al, 2001). Sharma & Yetton (2003) indicate that end-users are less likely to reject innovation when top management support is clearly evident and the organizational culture is strong.

Rogers' (1995) classic diffusion characteristics are relative advantage, compatibility, complexity, trialability and observability. As stated by Fichman (2000), the basic premise suggests that innovations presenting more desirable characteristics are more likely to be adopted and subsequently diffused through a population. Extending the theory to organizations has however proved less simple. Mohr and Downs (1976) indicate the perception of what is complex is not objective but rather is a perception of the knowledge available within an organization. Further research and discussion of primary and secondary characteristics (Cooper & Zmud, 1990; Attewell, 1992; Fichman & Kemerer, 1993; Premkumar et al, 1994) still provide no consistent attestable results across organizational structures and remain still an area of on-going research.

3.3 Summary

The conceptualized model is derived from the literature review and seeks to provide a contextualized environment whereby the three factors of Sector Characteristics, High Technology Providers and Organizational Technology Environment interact within the boundaries provided by the context. This intermesh of relationship and factor thereby provides the impetus for adoption and subsequent diffusion and the technology's eventual assimilation or routinization within the context.

The following chapter discusses the research methodology and design for the move from conceptual to operational, the implementation of the paradigm and strategy for the furtherance of this research study.

Chapter 4 Research Methodology

4.1 Introduction

This chapter discusses the research methodology and the rationale behind the selection of methods used in this study. Themes addressed in this chapter include:

- Research Philosophy in Information Systems.
- Research methods utilised within the study and rationale for selection.
- Research design overview.
- A summary of the case study methodology.
- Details of ethical considerations and summary

4.2 Research Philosophy in Information Systems

Information Systems research at its most basic intent seeks to investigate and understand the interaction between information systems/ technologies and their impact (both positive and negative), outcomes and transformational abilities within business and society(that is users of technology whether individually or as a collective). As a discipline, philosophical assumptions form over time as to what constitutes valid research. These beliefs form the paradigms under which research is conducted and so define the assumptions which allow us to draw valid conclusions. These assumptions should act as guides in the acquisition of knowledge and are known as the epistemology.

Myers (2009) states that the success of a research project is dependent on the explicit understanding of the philosophical assumptions as they provide the foundations for everything else that follows. Authors in describing approaches to research frequently refer to Chua (1986) who utilized three categories in understanding research epistemology: positivist, interpretive and critical (Orlikowski and Baroudi ,1991; Myers,2009).

4.2.1 Positivist

Positivists view reality as being capable of being objectively measured and therefore described by properties which are independent of the researcher (Myers, 2009). Positivism is the approach of the natural science researcher where theoretical propositions are often expressed mathematically and the rules of logic are applied. Theory may be tested and predictions made, the results of which should be reproducible. Within the Information Systems discipline research is classified as positivist if there is evidence of formal propositions, quantifiable measures of variables and proposition testing (Myers, 2009). Orlikowski and Baroudi (1991) found that the positivist epistemology to be dominant in the time frame of their study of published research articles from 1983 to 1988. This finding is duplicated by Alavi and Carlson (1992) who in reviewing 908 MIS articles in the period 1968 to 1988 also found the positivist paradigm dominant. The positivist epistemological dominance may be historically related to the desire of early IS researchers to have Information Systems regarded as a scientific discipline area and therefore required IS practitioners to demonstrate rigour to a community of researchers from traditional scientific disciplines. It should be remarked upon that this desire was not limited to information systems. Emerging disciplines have sought the same level of acceptance from the scientific community. Lee (1991) comments that the difficulty for social science researchers is in capturing a social reality and attempting to codify it under another reality. Mumford et al. (1985) was one of a number of authors who have not only raised the issue of suitability of a positivist paradigm to social sciences, but also saw a desirability in combining the positivist and interpretive approaches (Lee, 1991).

4.2.2 Interpretive

Adherents to the interpretive paradigm assume the belief that reality is a social construction which people create, assign value to and interpret within the social context of their participation. This belief places the researcher in what Giddens (1984) describes as a subject-subject relationship, where the researcher is equally an interpreter of the social context. In so doing it has been suggested that bias is not only inevitable (Janesick, 2000) but desirable Glaser (1992).

Table 4.1: Positivism vs Interpretivism (Myers, 1991, p40)

Epistemological assumptions of positivism	**Epistemological assumptions of interpretivism**
Experience is taken to be objective, testable and independent of theoretical explanation	Data are not detachable from theory, for what counts as data is determined in the light of some theoretical interpretations, and facts themselves have to be re-constructed in the light of interpretation.
Theories are held to be artificial constructions or models, yielding explanation in the sense of a logic of hypothetico-deduction	Theories are mimetic reconstructions of the facts themselves, and the criterion of a good theory is an understanding of meanings and intentions rather than deductive explanation.
Generalizations are derived from experience and are independent of the investigator, his methods and object of study	The generalization derived from experience are dependent upon the researcher, his methods and the interactions of the subject of study. The validity of the generalizations does not depend upon statistical inference ' but on the plausibility and cogency of the logical reasoning used in describing the results from cases and in drawing conclusions from them (Walsham, 1993: 15).
The language of science can be exact. Formalizable and literal	The languages of the human sciences are irreducibly equivocal and continually adapt themselves to changing circumstances.
Meanings are separate from facts.	Meanings in human sciences are what constitute the facts, for data consists of documents, intentional behaviour, social rules, human artefacts etc and these are inseparable from their meanings for agents.

Fielden (2003) states that rather than a weakness it should be regarded as strength in qualitative research as it enriches the knowledge base in a given context. Critical to the interpretive paradigm is that the meaning must be placed within a context to be understood and is therefore bounded as a truth within that experience (Fielden, 2003).

However, Lee (1991) states that the interpretive school of thought maintains that the subjective interpretations of the participants have no meaning in a natural science perspective and therefore require radically different research methods. Kaplan and Maxwell (1994) thus see no need to pre-define variables, but rather the focus is on the human interpretation of the study context.

Myers (1991) summarises the differences between the above two approaches in Table 4.1 which itself was an adaption from Bernstein (1993).

4.2.3 Critical Research

Myers (1991) states that critical research is historically bound and that the social reality is constrained by norms within the context of research. Orlikowski and Baroudi (1991) defined critical studies as those where evidence of a critical stance towards assumptions and norms was evident. Critical research should explicate the conflicts and contradictions, thereby producing a social commentary on the research context. Neuman et al. (2006) comments that, whilst critical researchers agree with the interpretivist's criticism of the positivist paradigm, critical researchers will argue that the interpretive stance is one which ignores broader social and context issues. Despite its inclusion by Chua (1986), Orlikowski and Baroudi (1991) found nil usage in their review of paradigms in Information Systems. Alavi and Carlson (1992) in their review over a 20-year period referred only to a singular study by Smith (1988) that used the critical research paradigm.

4.3 Research Methodology and Rationale

The choice of philosophical perspective should guide the researcher to an appropriate methodology to structure the research design. In selecting appropriate research methods, a fundamental distinction is drawn between quantitative and qualitative methods.

Quantitative research methods are associated with a positivist epistemology and therefore methods are based on the scientific tradition which produces numeric or alphanumeric data. In reaching conclusions utilising quantitative methods, a deductive approach is commonly used. A valid deductive argument is one in which the conclusion must follow from the premise and everything in a valid deductive argument must also be contained in the premise (Bluedorn, 1995). This approach therefore requires a way for the characteristics to be quantified and the generation of hypotheses which may be tested with data from quantifiable variables (Alexander, 2010).

Qualitative research methods are more commonly associated with the interpretive epistemology, the methods reflecting the incorporation of the interplay of human behaviour and response in all forms within a social context. Qualitative research may, however, utilize any of the epistemologies referred to in the previous section as pictured in Figure 4.1 below.

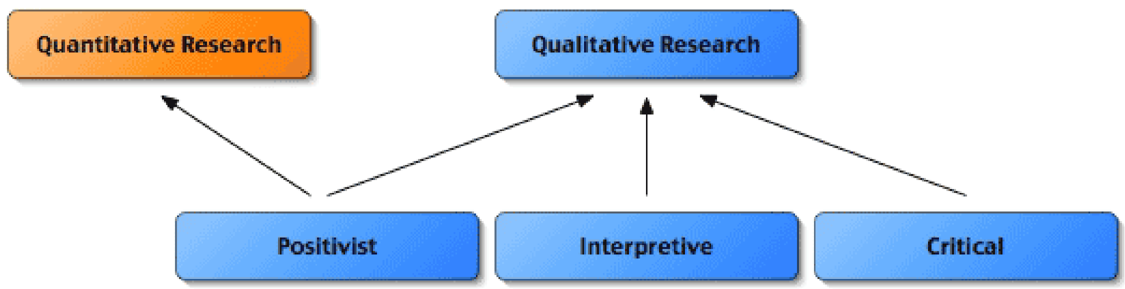


Figure 4.1 **Research Methods and Possible Epistemologies (http://dstraub.cis.gsu.edu:88/quant/2philo.asp)**

Qualitative research may often make use of inductive reasoning where the researcher gathers data/observations and moves from the particular to the general (Bluedorn, 1995). Inductive reasoning is not without its limitations; Bluedorn (1995) states that unless the evidence is exhaustive, the conclusion is only a guess. However, it does draw a general conclusion against which future observations may be tested. Landry and Banville (1992) saw the interpretive approach as being well suited to information systems where the focus is on social constructs and human behaviours.

Based upon the two dominant approaches, positivist or interpretive, Galliers (1991) produced a taxonomy of research methodologies which he saw as usefully summarising the range of approaches (see Table 4.2) utilized in information systems.

The research of Orlikowski and Baroudi (1991) confirmed the dominance of the positivist paradigm and examined the research methods utilised in the same period.

Table 4.2: Taxonomy of Research Methodologies (Galliers (1991, p149))

Scientific	**Interpretivist**
Laboratory experiments	Subjective/argumentative
Field Experiments	Reviews
Surveys	Action Research
Case Studies	Descriptive/Interpretive
Theorem Proof	
Forecasting	Futures Research
Simulation	Role/game playing

The main methods in the time frame of the study were found to be survey (49.1%), laboratory experiments (27.2%) and case studies (13.5%). However, it should be recognised that the research by Orlikowski and Baroudi (1991) was based on journals published in North America which appears to maintain a strong preference for the positivist epistemology. In subsequent research by Chen and Hirscheim (2004), the positivist epistemology still dominates despite the inclusion of European journals, although the authors note a decrease in the use of laboratory experiments and an increase in the use of case studies.

4.3.1 The Multi-method/pluralist Approach

In 1996, Benbasat and Weber in recognizing the diversity of the discipline, argued for a paradigm/s to provide coherence to information systems research, fearing that fragmentation would result from the inherent diversity. Mingers (2001), quoting Robey (1996), saw the diversity as more appropriate for a discipline that has evolved from a data processing utility than for one which now is a strategic enabler in business and is therefore similar to other business research which encompass a plurality of methods. This is not to suggest that discipline be ignored; rather the choice of paradigm and method should be based on the research aims (Robey, 1996). Mingers (2001) labelled this the “complementarist” position where “individual rationalities should be respected within the discipline as a whole”. He further suggested that the different research methods would provide a “richer understanding of a research topic”. Banville and Landry (1989) saw information systems as a pluralistic field; Cavaye (1996) states that this would seem to imply that the use of different methods is acceptable and enables the richness of the research to emerge. This viewpoint is not without support and has become known as a multi-method approach or pluralism (Mingers, 2001; Galliers, 1993: Landry and Banville, 1992). Johnson and Onwuegbuzie (2004) define multi-methods research as “the class of research where the researcher mixes or combines quantitative and qualitative research technique, methods, approaches, concepts or language into a single study”.

The benefits of a multi-method approach include richness emerging from differing aspects of reality, the ability to cross-validate data and the capacity to use additional methods which may overcome any shortcomings of using a single approach (Mingers, 2001; Johnson and Onwuegbuzie, 2004; Gable, 1994; Cavaye, 1996).

Triangulation as defined by Mingers (2001) is the method used to validate data and results from a range of sources, methods or theories. Neuman and Neuman (2006) distinguish between triangulation of theory and triangulation of method. The former occurs in the planning stages with the use of multiple theoretical perspectives or interpretation of data, while the latter term applies to the use of quantitative and qualitative methods within a single research study. Alexander (2010) states “triangulation of different data sources and types may provide convergence and corroboration” whereby one method ultimately informs another method.

Critics of the multi-method approach claim that there are a number of weaknesses associated with this style of research. Most frequently, they are said to be time-consuming and costly, and requiring a knowledge of multiple methods and the appropriate mix being beyond the skill of a single researcher (Mingers, 2001; Johnson and Onwuegbuzie, 2004).

4.4 Selection of the Research Method

The choice of a germane research method is critical to the successful outcome of a study. Factors influencing the selection of research methods are: the rationale of the research and therefore the questions to be asked, the current knowledge in regard to the research area, the involvement of the researcher within the study and the degree of focus on current events. Neuman and Neuman (2006) also consider the purpose of a study and provide three classifications: exploratory, descriptive and explanatory. Exploratory research focuses on examining a new topic whose outcome will be the formulation and focus of questions for further research. Appropriate research methods include literature reviews and case study approaches. Descriptive research provides details and can make use of an array of research methods including surveys, case studies, content analysis. Explanatory research addresses the "why" events and, whilst they often use surveys and case studies, they may also utilize experiments. This is an inductive approach for building and extending theory.

Yin (2003) identifies five major research strategies: experiments, surveys, archival analyses, histories and case studies and comments that "even though each strategy has distinctive characteristics, there are large overlaps among them". Yin (2003) further states that the choice of strategy should be guided by the three conditions: the type of research question, the extent of control over behavioural events and the degree of focus between contemporary and historical events. The type of research question is further distinguished by who, what, where, how and why. This classification scheme is designed to assist the researcher in selecting an appropriate research strategy and is depicted in Table 4.3 below.

Table 4.3: Yin's Situational Research Strategy (Yin, 2003, p 5)

Strategy	**Research Question**	**Requires control of behavioural events**	**Focus on Contemporary events.**
Experiment	how, why?	Yes	Yes
Survey	who, what, where, how many, how much?	No	Yes
Archival Analysis	who, what, where, how many, how much?	No	Yes/No
History	how, why?	No	No
Case Study	how, why?	No	Yes

4.4.1 Research Design within this study

The market viability of a product depends on the successful diffusion of that product throughout a community of users whether individual or organizational. The analysis of the literature presented in Chapter 2 indicates that whilst organizations have searched for internal understanding of factors associated with human behaviours when adopting technologies, little contextualised research has been undertaken that considers the technology, the sector in which it is implemented, and the influence of supply-side variables. One of the primary objectives of this research is to address the issue of contextualization and provide a richer, more meaningful knowledge base where the effect of both external factors and the interaction of supply side variables are considered by taking a single holistic approach. Specifically, this research is intended to identify the factors that influence the diffusion of high technology within a contextualised environment issuing from both a vendor and organizational viewpoint, and the impact of external factors within the contextualised environment, and to test and refine the conceptual model in a real-life setting.

To obtain the richness of data required to address the research question of this study, a qualitative approach using a multiple-case study approach as described by Yin (2003) was used together with the quantitative method utilizing a survey to provide cross-validation as recommended by Mingers (2001) and Alexander (2010). This approach extends that of Benbasat et al. (1987) who noted the shift in IS from "technological to managerial and organizational questions, and consequently more interest in how contexts and innovations interact".

As shown below in Table 4.4, the research design utilizes case study and archival analysis to collect research data.

Table 4.4: Research Phases

Phase	Research Design	Purpose	Paradigm
Phase 1	Literature Review and Development of Preliminary model	Exploratory	Interpretive
Phase 2	Review of the Preliminary Conceptual Model	Exploratory	Interpretive
Phase 3	Multiple Case studies	Exploratory , Explanatory & Descriptive	Interpretive and Positivist
Phase 4	Consultant Interviews	Exploratory and Explanatory	Interpretive and Positivist
Phase 5	Survey	Explanatory	Interpretive and Positivist

Figure 4.2 provides a visual representation of the research methods and procedures.

This design incorporates the three levels of understanding as described by Lee (1991) - subjective, interpretive and positivist - and therefore provides validity across the research study. Although comparable to the research design suggested by Lee (1991), this design conducts the cases studies before the survey as recommended by Gable (1994, page 118) who found that "the main disadvantage of conducting the case studies after the survey rather than before as depicted, is that they do not contribute to the model building exercise". This was later reflected by Attewell and Rule (1991, page 314) who recommend that case studies be conducted prior to surveys and that "Getting close to the phenomenon - gathering insights or discoveries about causal links, motivations, reasons why things happened - should precede verification by more objective techniques, such as surveys".

The remainder of this chapter provides a summary of each phase of the research process, the methods used and rationale for their choice.

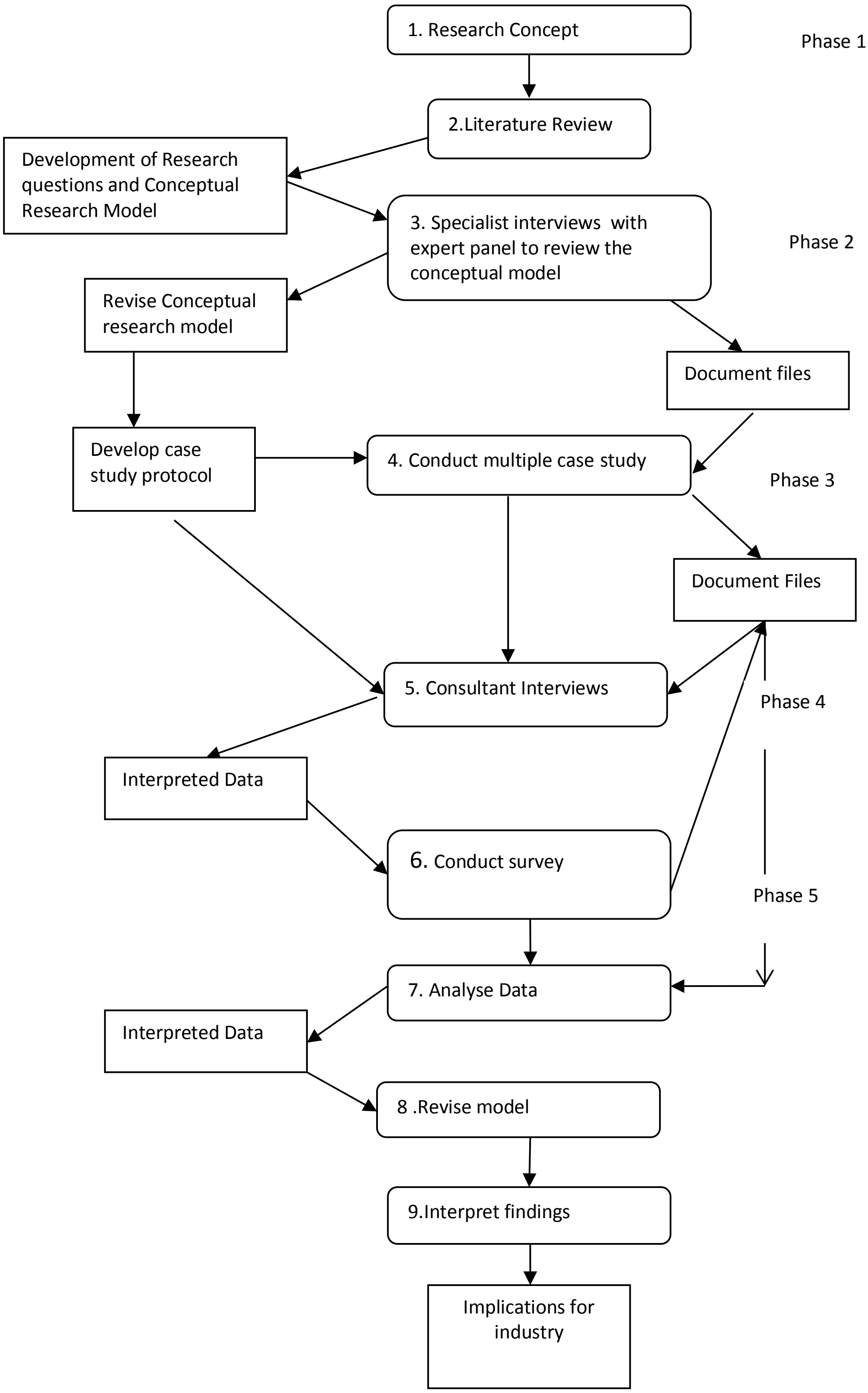


Figure 4.2: **Research Design Flowchart**

4.4.1.1 Phase One – Literature Review and Preliminary model

Phase 1 of the study comprised the literature review of relevant literature relating to diffusion, assimilation and supply-side variable impact. As an outcome of the literature review, a preliminary research model was conceptualized. The literature review helps the researcher to identify gaps in the literature, increases one's knowledge base, provides intellectual context, and identifies opposing views, to name a few of the benefits (Bourner, 1996). The aim of a critical literature review is to show how prevailing ideas fit into a conceptual model, and how such a model varies from or corresponds to known knowledge.

In developing a conceptual model, the following activities were undertaken in Phase 1:

* identify the historical development of diffusion studies from foci on the individual to that of the organizational diffusion.

* Provide a review of organizational diffusion that would contribute to the solution space for the research questions presented in this research.

* Determine the underpinning theories that would be utilized in the development and interpretation of this research.

* Detail research from contributory perspectives with organizational diffusion of innovations inclusive of assimilation of technology, the influence of supply-side factors and the contextualization of technologies within an industry sector.

* Identify factors which influence the diffusion of high technology innovations within a contextualized environment.

Based on the literature review, a preliminary research model was developed which brought together in a single context the three evident high level contributory factors of organization, supply side vendors and context external factors. Phase 1 of the study was exploratory, allowing the researcher to identify seminal works and continue to build on the existing platform of accumulated knowledge which resulted in the preliminary research model.

4.4.1.2. Phase Two – Review of the Preliminary Conceptual Model

As described in Chapter 4, preliminary interviews were conducted with a high technology vendor, a mining technology manager, a mining consultant and a technology user. The mining technology manager and the technology are both representative of the mining client organization. They are both included as their use of a product may vary with the level of responsibility attached to their roles within the organization. Each of these interviewees represents the target groups within the study. The purpose of the interview panel was to:

* Present the preliminary research model to practitioners within the industry sector.

* Refine and validate the preliminary research model in order to identify missing variables and to delete variables which were no longer relevant to the study within the current timeframe or context.

* Establish the context vocabulary as applicable to the preliminary research model.

* Be appraised of any additional contributory factors, information or guidelines utilised within the context.

The choice of participants was based on purposive sampling (Neuman et al, 2006), whereby the aim of the researcher was to select experts within the representative category to provide feedback relevant to high technology users within the mining industry of Australia. Mining technology represents specific classes of technology unlikely to be found and utilised outside of the mining environment (with the exception of GIS software).

Prior to the interview, each participant received a copy of the model and definitions of the variables as commonly suggested by the research literature. Each interview lasted approximately one hour and was recorded by the researcher to enable a free-flowing dialogue to occur.

The technology vendors interviewed for this study are the providers of a high technology to an organization and are responsible for the contractual provision of services of a high technology product and any ongoing maintenance and updates. They may or may not be the creators of the product; however, each is licensed to be the legal representative of the technology rights vendor. The technology vendor representative at the time of interview held a managerial position, however in the past had been involved in a sales capacity and also had input into research and development.

The mining technology manager was responsible for the implementation and maintenance of high technology products within a mid-tier company; his department were responsible for their own budget which was considered to be a corporate expense. The technologies were distributed at multiple operational sites although help-desk type functionality and service responsibility are centralised at a site where other corporate/managerial activities are conducted.

The mining consultant possessed significant experience within the sector and contracted his services in feasibility studies, mine management and planning and capital investment. The consultant's clients were from three functional industry groups, giving an indication of the broad scope of knowledge that a consultant is required to have. Consultants may also hold positions outside of the Australian operation, although input was limited to addressing the Australian minerals mining context.

The technology user was employed by a major mining organization and his responsibilities were classified as corporate in that they crossed mining silo operational boundaries. The technology user had previously been employed by a mining organization whose operations had been taken over by his current employer and the technical operations had been incorporated into the new organization's organizational structure.

At each interview, the theoretical model was presented and discussed. The interviewee provided feedback on the characteristics presented in the model and provided a weighted order of importance to the characteristics based upon their individual perspectives of their roles. The data gathered through the preliminary interviews indicated that a number of variables identified in the literature review were redundant. These variables included in the preliminary model are shown in Table 4.5 and were discussed in Chapter 3. No structural changes were made to the model.

Table 4.5: Previously operationalized characteristics as categorized by Fichman (2000)

	Technology & Diffusion Environments	**Organization & Adoption Environment**	**Technology-Organization Combination**	**Diffusion**
Characteristic	Relative Advantage Compatibility Complexity Trialability Observability Supplier side support Supplier side characteristics Ease of Use	Organization Size Scale Resources Centralization Specialization Technical specialists Communication channels Competitive pressure IT intensity	Organizational Culture Organizational learning support Related knowledge Knowledge barriers Ease of use Links to Supplier	Stage of Adoption Relative Advantage Compatibility Complexity Trialability Observability Supplier side support Communication Channels
Researchers	Rogers, 1995 Ramiller, 1994 Cooper and Zmud, 1990 Tornatzky and Klein, 1982 Leonard-Barton, 1988 Robertson and Gatigon, 1986	Damanpour, 1991 Fichman and Kemerer, 1997 Kwon and Zmud, 1990 Swanson, 1994 Zmud et al, 1990 Eveland and Tornatzky,1990 Robertson and Gatigon, 1986	Cooper and Zmud, 1990 Attewell, 1992 Fichman and Kemerer, 1999 Leonard-Barton, 1988 Robertson and Gatigon, 1986	Rogers, 1995 Ramiller, 1994 Cooper and Zmud, 1990 Tornatzky and Klein, 1982 Leonard-Barton, 1988 Robertson and Gatigon, 1986

All interviewees agreed with the definition of terms related to the mineral mining context. It should be noted that the terminology retained from the preliminary research model did not require modification. Specification of terminology was more significant in describing the operation of the contextualized environment.

In summary, this phase provided a valid context glossary which in turn provided a meaningful basis for a review of the preliminary research model. In addition, the case study protocol was amended to reflect the context glossary, thus clarifying the intent of questions within the interview protocol.

4.4.1.3 Phase 3 - The Case Study Approach

Darke et al. (1998), in discussing the application of rigour, relevance and pragmatism in case study research, utilize the definition provided by Yin (1994) that case study research is "an empirical enquiry that investigates a contemporary phenomenon within its real-life context" and "it relies on multiple sources of evidence". Glasser and Strauss (1967) saw the need for data to be tied to reality and stated that only in this way can theory be relevant and testable. Yin (2003, page 12) discusses definitions of case studies that focus on the rationale for the tie as previously described by Glasser and Strauss (1967) but such comments are more correctly described as topics and provide no substantive rationale for the logic of design. Instead, Yin's (2003) definition (as shown below) incorporates both scope and strategy.

1. A case study is an empirical enquiry that

   * investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.

2. The case study inquiry

* copes with the technically distinctive situation in which there will be many more variables of Interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis.

Yin (2003) makes these points to summarise that a case study "comprises an all-encompassing method" and is in fact the research strategy. Case study research may also be conducted in a positivist or interpretative manner or somewhere in between the two paradigms (Cavaye, 1996).

A multiple case study approach was selected as an appropriate strategy given the segmented nature of the mining industry within Australia. It permits the researcher to study information technology in a real-life business context in a natural setting (Benbasat et al, 1987). The mining industry in Australia is segmented not only by overall organizational size, but also by its functional participation in the mining value chain. Thus, the case study strategy optimizes the ability to make comparisons and test theoretical propositions whilst also allowing rich data collection across a more complex industry since larger organizations can be included in more than one segment.

The approach undertaken accords with an understanding of Darke et al. (1998) who state the whilst a single case study will provide findings which may be generalized by further research, multiple case studies strengthen research findings. The multi-method approach follows Cavaye (1996) who states that a positivist approach permits the definition of theoretical constructs and their empirical evaluation and that the results of the case study data collection may be compared with expected outcomes. The interpretivist approach to a research study is intended to provide a deeper understanding and takes into account the researcher's own subjectivity.

Similar to any research method, case study research has strengths and weaknesses. Cavaye (1996) states that the case method does not explicitly control variables, but studies a phenomenon in its natural context and may be a singular or multiple cases which makes use of qualitative tools and techniques. Its weaknesses exist in the possibility of a limitation of internal validity and a lack of direction in causation between variables. Lillis (1999) is concerned with the effect of bias introduced by the researcher both in conducting the interview and also in subsequent analysis. Kerlinger 's (1986) concern lies in his belief that case study does not provide a valid basis for scientific generalisation. Yin (2003) however sees case study design as similar to experiments which are generalizable to theoretical propositions (but not to populations). Yin (2003) cites four tests which are commonly used to establish quality in empirical social research. These are construct validity, internal validity, external validity and reliability.

Following the recommendations of Yin (2003) Table 4.6 shows the tests utilized in this research.

Table 4-6 Case Study Tactics (Yin, 2006,p34)

Tests	**Case Study Tactic**	**Phase of research demonstrating tactic.**
Construct Validity	Use of multiple sources of evidence Establish chain of evidence Key informants review draft report	Data Collection Data Collection Data Collection
Internal Validity	Do pattern matching Do explanation building Address rival explanations	Data analysis Data analysis
External Validity	Use replication logic in multiple case studies	Research design
Reliability	Use case study protocol	Data Collection

Case Study Protocol

Yin (2003) states that the case study protocol is essential for multiple case studies, and is considered the major method of increasing the reliability of case study research. The protocol used in this research follows Yin's recommendation and contains the following:

* An overview of the case study project

* Field procedures

* Case study questions

* A guide for the case study report.

Two protocols were used, each to represent the perspective of the groups represented: The first for high technology providers, the second for the client organization (Organizational Technology Environment). The following sample question demonstrates this approach.

Table 4.7: Protocol Perspective

High Technology Provider	**Organizational Technology Environment**
Q: What key characteristics distinguish the technology?	Q: What key characteristics does the technology provide which influenced its organizational adoption?

The keys areas that comprise the protocol are shown in Table 4.8 below.

Table 4.8: Comparison of protocol sections

High Technology Provider	**Organizational Technology Environment**
Respondent Details	Respondent Details
Understanding the Technology	Background to Technology Acquisition
Vendor – Client Relationship	The Technology Organizationally
Positioning the Technology –Mining Sector	The Technology and the Mining Sector

Influence of External Factors	Influence of External factors in Technology Acquisition
Other Issues	Issues in Technology Usage

Case Selection

Eisenhardt (1989, p. 537) states that in the selection of cases, "it makes sense to choose cases such as extreme situations and polar types in which the process of interest is transparently observable".

Yin (2003) asks researchers to consider "multiple case studies as one would consider multiple experiments – that is, to follow 'replication logic'". He suggests that replication logic using multiple cases to confirm or disprove initial propositions, Szanton (1981) terms this "literal replication", using across-group cases providing theoretical replication.

Yin's research design, which he considers potent is well suited to the segmented nature of the mining sector and provides the opportunity for both literal and theoretical replication. Table 4.9 provides a visual representation of cases within this research study.

Table 4.9: Mining Sector by function and size used in this research.

	Junior	**Mid -Tier**	**Major**
Exploration	Technology Provider Client Organization x 1	Technology Provider x2 Client Organization x1	Technology Provider x2 Client Organization x2
Feasibility/Analysis	X	Technology Provider x2 Client Organizationx1	Technology Providerx2 Client Organizationx3
Extraction	X	Technology Providerx2 Client Organizationx1	Technology Providerx3 Client Organizationx3

At the same time, it also meets Eisenhardt's (1989) requirement for theoretical sampling allowing for a range of cases.

Case Selection and Procedures

A number of leading high technology providers who provide global services to the worldwide mining community have their origins in Perth, Western Australia. In addition, other major technology providers pertinent to the mining sector provide sales offices to the Western Australia mining community.

Benbasat et al. (1987) indicate that the initial approach to potential case study participants is critical. The importance of an appropriate approach was confirmed by previous contact with the mining sector and discussion with the Western Australian School of Mines in regard to potential candidates. The mining community is insular in general and views outside interest with caution. The preliminary interview panel also provided feedback on potential high technology providers in addition to potential contacts within adopting organizations.

Selection of High Technology Vendors

In developing a primary list of possible candidate cases, a major consideration was in ensuring validity and adhering to the research design to provide both literal and theoretical replication. It was therefore deemed necessary to have representation by technology vendors wherever technology was utilised within each segment. A triple approach was adopted to develop a primary list of vendors. An initial list was constructed based on the recommendations from the preliminary panel and was considered vital in establishing the reputation of the vendor within the members of the mining community. A second list was created based upon the participation of a number of High Technology Vendors in a federal government initiative to raise the profile of the Mining Technology Services Sector. Vendors who expressed a willingness to participate in a government initiative was thought to indicate a predisposition to develop their knowledge base and therefore the likelihood that they would participate in external research. Thirdly, vendors were sought who were seen to be participating in industry representation for the benefit of the industry group. The three lists were cross-referenced and the primary contact group was created. Contact was initially attempted by telephone and, where meetings were arranged, interviewees were subsequently provided with an overview of the research, its purpose and a protocol of conduct that included privacy protection for participants.

The interviewees were contacted in accordance with instructions of the participating vendor and were provided with the interview protocol prior to the interview being conducted. Interviews were semi-structured and were conducted at the business premises of the technology vendor. Interviews were recorded to ensure accuracy. In addition to the interview, other materials including support material and marketing material provided to clients were collected on the day to provide alternate sources of data.

Selection of Organizations in Organization Technology Environment

The development of an initial organizational contact list followed a similar approach to that used for the High Technology Providers. The first contact list was developed from the recommendations of the preliminary panel. The second list focused on organizations that are active in the development of the mining industry profile. The third approach was the most significant and involved an introduction to a client organization from the high technology vendor. In these cases, the vendor was asked to contact the client organization for confirmation that this would be acceptable, and then subsequently provide the details of the contact to the researcher. The contact was telephoned and, as with the High Technology Vendor, was provided with an overview of the research and protocols. Where organizations were willing to participate, an interview protocol was provided to interviewees prior to the meeting and followed the process established in interviews with the High Technology Vendor. Once again all interviews were conducted at the business premises of the organization and lasted an average of approximately 90 minutes. The interviews were taped with the permission of the contact and organization.

Organizations were made aware of the desirability of additional materials in regard to the operation of the company within the mining segment. All companies provided general information; two organizations provided significant archival information regarding a recent technology adoption.

Case Study Analysis

Data analysis techniques follow those of Huberman and Miles (1994) who describe the focus of analysis “as words”. To analyse these words, we must process them. This processing involves three concurrent flows of activity (Miles and Huberman, 1994): data reduction, data display and the drawing of conclusions/verification.

Data Reduction is an approach that allows the researcher to focus, organize data and discard data. This process assists the researcher in the process of visualizing outcomes. Miles and Huberman (1984) describe the technique as a reduction and transformation by means such as selection, summary, paraphrasing, or by being subsumed in a larger pattern.

Data Display takes the data from the data reduction process and displays it as a table.Data Verification and Conclusion Drawing are the final analytical activities for the qualitative researcher. It is here that the researcher begins to interpret the data. S/he does this by noting regularities, patterns (differences/similarities), explanations, possible configurations, causal flows, and propositions.

The benefit of these three interactive activities is that a uniform and therefore consistent approach can be followed.

After the conclusion of each interview, an Interview Summary Sheet was completed. It included key points of the interview and any additional issues either stemming from the interview process or as raised by the participating vendor/organization for follow-up.

4.4.1.4 Phase 4 - Consultant Interviews

Principal mining consultants (hereafter referred to as consultants) within the mining sector of Western Australia are contract employees utilized for mine feasibility, resource and reserve evaluation, asset evaluation, mine reviews among other advisory services including technology evaluation and recommendation. Contracts may be over an extended time frame or for a specific task. Additionally, a single consultant may be contracted to multiple companies at any one time.

To meet the definition of principal mining consultant as required by the 2004 edition of the Australian Code for Exploration Results, Mineral Resources and Ore Reserves, a person must be a qualified mining engineer with in excess of 15 years continuous experience dealing with a range of commodities and operations, and having undertaken a wide range of activities including feasibility studies, resource evaluations, mine design and scheduling, and operational improvements. Moreover, they should have experience in software usage. Only then will they been deemed competent to report to the Australian Securities Exchange (ASX) to enable a mine/commodity to participate in a global market space. Thus, the consultant was deemed a suitable person as a source of knowledge about the contextualized environment and the independent influences which affect the environment beyond the scope of any individual influence.

A leading consultant who participated in the initial phase provided a list of possible candidates whom he believed were appropriately qualified to comment on the research being undertaken in respect of the sector environment. This consultant was asked to contact those candidates to advise them of his participation in the research and to gauge their inclination to participate. Those who indicated some interest in the study were provided with a research summary and protocol. Would-be participants or those requiring additional information were invited to contact the researcher by email or telephone. Those consultants who responded were contacted by the preferred method indicated. In all cases, the consultants who responded were prepared to provide data by means of a structured questionnaire.

Due to work constraints, not all consultants were available for a face-to face interview. All participants were asked the same questions.

4.4.1.5 Phase 5 – Survey

Yin (2003) suggests that a formal survey may also be used for case study research since it gives further weight to and confirmation of the data subsequent to the interview process. Gable (1994) views the case study and survey as complementary, providing a synergy between the interpretive and positivist approaches.

Details of ICT providers within Australia are available from ABARE (Australian Bureau of Agriculture and Resource Economics). Details of mining firms with mineral resources within Australia may be obtained from the Australian Bureau of Statistics, affiliated mining websites, professional associations and the Western Australian School of Mines.

The survey instrument is intended to capture the perception of the contribution of high technology providers and their role in the modern minerals mining industry as seen from both the perspective of the mining industry and the providers themselves. Additionally, the provision of economic data lends sector and context validation to the qualitative outcomes.

The preceding description of the intent of Phase 5 was subsequently replaced with the inclusion of two comprehensive surveys completed by Australian Government authorities. These surveys drew on economic periods ranging from 2003 – 2010 and captured the intent of this author in respect of the intended surveys. Due to the origin of the survey, the response rates were high and indicated a fortuitous synergy in respect to this research. The interest of the Australian Government in accumulating data in respect of mining technology services, its impact both on internal markets and as an export item highlights the value of such services and the need for increased knowledge of diffusion mechanisms for domestic growth.

The following chapter provides a comparative analysis of all the data obtained through the multi-method approach.

4.5 Summary

This chapter provides an understanding of the research methodologies and their prevalence within the field of information systems research. The assumptions that underlie each paradigm inform the researcher of the appropriateness of the research methods in achieving the aims of the research.

The research design was then decided and developed from an understanding of the appropriateness of the paradigm to the research question and goals of the research.

This research seeks to understand the importance of context and relationships in a complex layered environment and in doing so develop a richer model of diffusion than previous research has revealed. To capture the complexity and inter-relationships, it was necessary to select a paradigm and methodology that would disclose the depth of complexity and the hidden richness of inter-relationships not revealed through quantitative studies alone. The qualitative and case study approach was selected as it allowed for the disclosure of differing perspectives within a context and across the environmental context. Multiple case studies not only provide strength to the study but as suggested by Yin (2003) provides for both theoretical and literal replication, the latter ensuring that dynamism is represented in a developed model. The subsequent use of a survey provides cross validation, thereby strengthening the study.

The following chapter commences an analysis and discussion of the research data from each research phase outlined in this chapter.

Chapter 5 Research Results and Discussion

As described in the previous chapter, the research design consists of five phases. Chapters 5-8 describe and discuss the outcomes for each phase of research followed by an integrating chapter which draws together the data and findings. Chapter 5 includes Phases 1 and 2 which are inclusive of the literature review and development of the preliminary model which was then the subject of Phase 2 the initial interviews.

Table 5.1 below, shown previously in Chapter 4 (Table 4.4), depicts this study's research phases.

Table 5.1 Research Phases (Table 4.4)

Phase and Chapter	Research Design	Purpose	Paradigm
Phase 1 Chapter 5	Literature Review and Development of Preliminary model	Exploratory	Interpretive
Phase 2 Chapter 5	Review of the Preliminary Conceptual Model	Exploratory	Interpretive
Phase 3 Chapter 6	Multiple Case studies	Exploratory , Explanatory & Descriptive	Interpretive and Positivist
Phase 4 Chapter7	Consultant Interviews	Exploratory and Explanatory	Interpretive and Positivist
Phase 5 Chapter 8	Survey	Explanatory	Interpretive and Positivist
Chapter 9 Integrating Chapter and summary			

5.1 Phase 1 – Literature Review and Development of Preliminary Model

Phase 1, as previously described in Chapter 4, utilized the literature review to synthesize previous research in the area of diffusion and assimilation in order to develop a conceptual model of contextualized diffusion. This model not only situates the high technology vendor and organizational technology environment within a meaningful contextual environment, but includes the effects on the sector of the environment itself. Thus, the relationships which exist between the primary factors are included in the research framework so as to provide a richer picture and explore the primary factors in depth; hence, this approach differs from the internal-only organizational perspective taken by previous research. In doing so, the relationships and events whose significance may otherwise be lost, may be meaningfully represented and their impact assessed in terms of their context. The contextualised environment also enables the study of specific technologies which are pertinent to the sector and equally removes those technologies which are now commonplace (such as word processing) and therefore offer no significant strategic value or process improvement.

5.2 Phase 2 – Review of the Proposed Conceptual Model

To validate the initial conceptual model in the context of minerals mining within Australia, interviews were conducted with representatives of the sector. The purpose of the interviews was to present the conceptual model whereby the model may be refined and validated in terms of the context and time and timeframe.

5.2.1 Initial Interviews

Initial interviews were conducted with a high technology vendor, mining technology manager, a mining consultant and a technology user, each of whom represented the target groups of the study. Individually, all interviewees had more than ten years of industry experience within the minerals mining sector, although not within the same organization in the case of the latter two.

For the purposes of this study, the technology vendors are the providers of a high technology to an organization and are responsible for the contractual provision of services of a high technology product and any ongoing maintenance and updates. They may or may not be the creators of the product; however, they are licensed as the legal representatives of the technology rights vendor. The technology vendor representative at the time of interview held a managerial position, but in the past had been involved in a sales capacity and also had input into research and development.

The mining technology manager was responsible for the implementation and maintenance of high technology products in a mid-tier company; his department had its own budget which was considered a corporate expense. The technologies were distributed at multiple operational sites although help-desk type functionality and service responsibility is centralised at a site where other corporate/managerial activities take place.

The mining consultant possessed significant experience within the sector and contracted his services in feasibility studies, mine management and planning and capital investment. Clients of the consultant were represented across the three functional industry partitions, indicating the scope of knowledge required of consultants. Consultants may also hold positions outside of Australian operations, although their input in this study was limited to the Australian minerals mining context.

The technology user was employed by a major mining organization and his responsibilities were classified as corporate in that they crossed the operational boundaries of the mining silo. The technology user had previously been employed by a mining organization whose operations had been taken over by his current employer and the technical operations had been incorporated into the new organization's organizational structure.

Each exploratory interview lasted for approximately one hour and was conducted at the interviewee's workplace. At each interview, the full initial conceptual model was presented and discussed. The interviewee providing feedback on the characteristics presented within the model and gave a weighted order of importance to the characteristics based upon their individual perspective. All interviewees agreed to the definitions of terms related to the mineral mining context.

5.2.2 Outcomes of the initial interviews

As a consequence of the interviews the initial conceptual model was refined to produce the model shown in Figure 5.1.

Some structural changes were made to the model previously shown in Figure 3.1. These included the removal of the bi-directional arrow between the Sector Environment and the High Technology Provider. Whilst major mining organizations undoubtedly possess the ability to lobby, influence public opinion through advertising or other activities that may influence local government policy, it was felt by the interviewees that the ability of the high technology providers to manifest any concerted influence or impact was unlikely. Therefore the direction of effect between the 'Sector Characteristics' and 'High Technology Providers' becomes a directed edge from Sector Characteristics to High Technology Providers.

An additional route to direct assimilation of complex high technology products was proposed based on the sector requirements and the contract nature of the highly skilled workforce.

Some characteristics found in earlier research were removed primarily because they were either irrelevant or outdated since the research is based on contextualized systems which are therefore by definition only of interest to a specific population of users. Those characteristics and the rationale for removal from the model are shown in the Table 5.2.

Table 5.2: Characteristics and rationale for removal from initial conceptual model

Characteristics	Rationale for non-inclusion
Advertising	Redundant in a contextualised environment. All vendors advertise however primary information is thought to be communicated by alternate means.
Technology Sponsorship	Not evident in contextualised environment.
IS Unit size	Not evident in contextualised environment.
IT Intensity	Not required for contextualized environment as adoption is directed towards specific technologies.
Rate of Technological Change	Not evident in contextualised environment
Usefulness, Ease of use, complexity (these are grouped as they belong to Roger(1983,1995) DOI theory)	Contextualised Environment tend to produce specific technologies which are focused and training is specific to the task. These are considered a non-optional requirement. Considered therefore not relevant and incorporated into technology characteristics within the High Technology Provider.
Top Management Support	Redundant. Acquisition in industry specific contexts are unlikely to occur without management authorization and support.

.

It should be noted that the terminology retained from the initial conceptual model did not require modification. Specific terminology was more significant when describing the operation of the contextualized environment which would be a probable feature of any complex sector/industry.

The refinement of the initial conceptual model by agreement of representative participants of the context of study accords with the research of Gable (1994) and Lee (1991) whereby the likelihood of the researcher's subjectivity is reduced by the application of industry participation. The model discussed in the following section is based on both the subjective and interpretive understanding of participants.

5.2.3. The Revised Conceptual Model

Figure 5.1 presents the revised conceptual model and is generalised to the perspective of high technology products. It views the contextualized environment as an aggregate of three factors. Each factor comprises characteristics which together uniquely identify the factor and in doing so also define the specific context. Together they provide a determinant effect which acts as an indicator of the likelihood of diffusion and/or assimilation. It should be observed that two equally valid pathways are available from the Contextualized Environment to Diffusion within this model based on the adopting organizations rationale for adopting the technology.

The first and perhaps more traditional diffusion mechanism does not perceive assimilation (or routinization). The organization adopts the technology based upon the perceived benefits largely evident from the Contextualized Environment. For example, an organization entering the industry sector may perceive an advantage in adopting a technology that is commonly deployed in the dominant organizations within the sector without considering alternatives or organizational costs in the adoption of the technology.

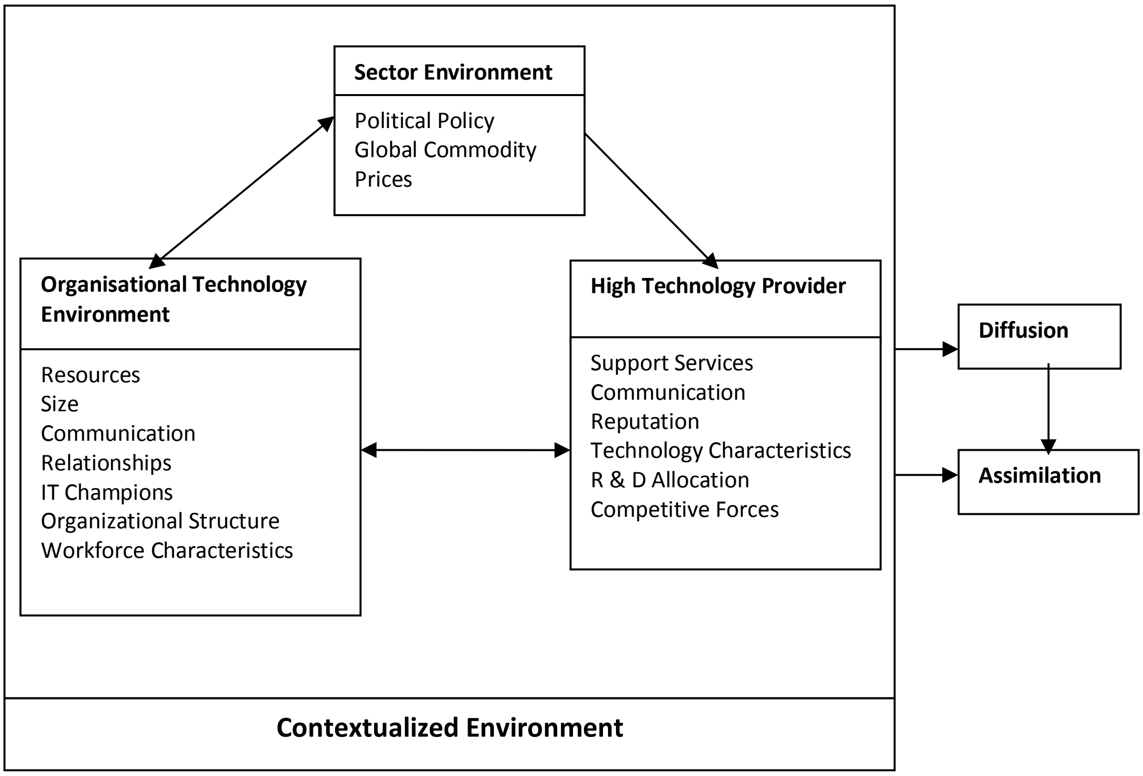


***Figure 5.1*: Revised Conceptual model**

This pathway is supported by the research of Frambach et al. (1998) who observed that the presence of a dominant opinion leader within an organization can mimic the individual adoption context. In the current research, a major organization itself may act as a dominant opinion leader. A junior organization may acquire a particular system in order to be compatible with the major organization which is the likely purchaser of the data belonging to the junior organization. The second pathway considers that the introduction of the technology has produced observable/reportable benefits and that the technology is adopted based on the belief that the effect is reproducible upon adoption of the technology. This pathway would be observed the innovation is either a process or administrative type. A distinction is made between a process (versus product) (Ettlie, 1983; Damanpour, 1991) or administrative (versus technological) innovation (Damanpour and Evan, 1984; Damanpour, 1991) and the purpose for which the innovation is adopted and implemented. Tabak and Barr (1999) indicate that these types of innovation are unlikely to require significant behavioural change and are designed more for efficiencies rather than radical or strategic change.

In the minerals mining context being researched, all interviewees who participated in the effective focus group found it difficult to distinguish between the concepts of diffusion and assimilation. Diffusion as a singular concept was well understood; however, the concept of assimilation (routinization) remains problematic. This was felt to be a result of the non-optional usage requirement of high technology systems within the minerals mining case. Given that the data acquired during the exploration phase of a resource represents the assessable value of the asset; therefore, its subsequent storage, manipulation, viability and integrity must be ensured through the use of high technology systems which are often found as integrated modules. Staff, both permanent and contractual, are expected to have acquired the relevant skills as part of their professional identity and to be work ready when employed. The exception being those who specialize in GIS software and are technologists as opposed to geophysicists, mining engineers or any other category of earth scientist found within the context.

As the aim is to consider a generalizable model to the definition suggested by Fichman (2000) that is technologies of a specific type/class of technology or context specific, the researcher has retained the concept of assimilation within the revised model.

The following section describes the revised conceptual model and propositions significant to the aims of the research. These are shown detailed relevant to the factor which they characterize. The propositions are developed from the body of existing research on Diffusion of Innovations and assimilation established through the literature review. Baxter and Jack (2008, page 551) state "the more a study contains specific propositions, the more it will stay in feasible limits". They agree with Yin (2003) that propositions will guide and focus the study and with Miles and Huberman (1994) that propositions lay a foundation for a conceptual model. Both Yin (2003) and Stake (1995) suggest that propositions are necessary elements of case study research. The propositions which follow aid with the goal of exploring the research questions thus building knowledge.

5.2.3.1 The Contextualized Environment – The Sector Environment

Sector Environment
Sector Characteristics

The Minerals Mining Context

The mining context was selected due to its significant contribution to the Australian economy, its use of high technology products (found globally) and the reliance on the accuracy and longevity of the geodata represented and manipulated by the technology products. Characteristics substituted for the placeholder 'Sector Characteristics', applicable in this study are 'Political Policy' and 'Global Commodity Price'.

Political Policy reflects decisions made by governments located at the point of the resource that directly affect the viability of a mineral resource and that are not a characteristic of the resource itself. The proposed introduction of a mining super tax in Australia and the industry response to suspend projects is a current manifest example (ABC, 2010; Tasker, 2010). The rapid response to the super tax announcement of project suspension was reflected immediately afterwards in share values, union response and state politics (ABC, 2010; Stevens, 2010). The mining sector's immediate threat to suspend projects flows backwards through the mining value chain to its suppliers, including high technology providers. The siloed organization of mining (see chapter 1) provides benefits in the isolation of any outbound detrimental effect from one mining operation to another, but provides no cost benefit in a corporate technology adoption of high technology. Nor does it provide a lock-in effect to a technology vendor when a new mining operation is commenced. Thus, the suspension of new mining projects has an immediate impact on high technology providers as all further licensing arrangements also cease.

The second characteristic '*Global Commodity Price'* represents the return on investment based upon the resource and is subject to market forces. The higher the commodity export prices, the higher the potential investment and likelihood of new projects. Commodity prices fluctuate and are affected by supply and demand fluctuations globally, forward selling and macro-economic forces. Additionally variability is subject to exchange rates against the U.S. dollar which is the standard global price denominator (Kirchner, 2008-09) for the minerals commodity market. Figure 5.2 demonstrated the forces within the mining context.

The figure describes for mineral resources (the mineral ore body) two states, indicated and measured. Indicated represents a probable ore body suitable for mining but without any certainty of quality or quantity. The mineral reserve (its asset value) is therefore unconfirmed.

A measured ore body has yielded exploration data that may be used in feasibility studies to provide more accurate information for investment and development.

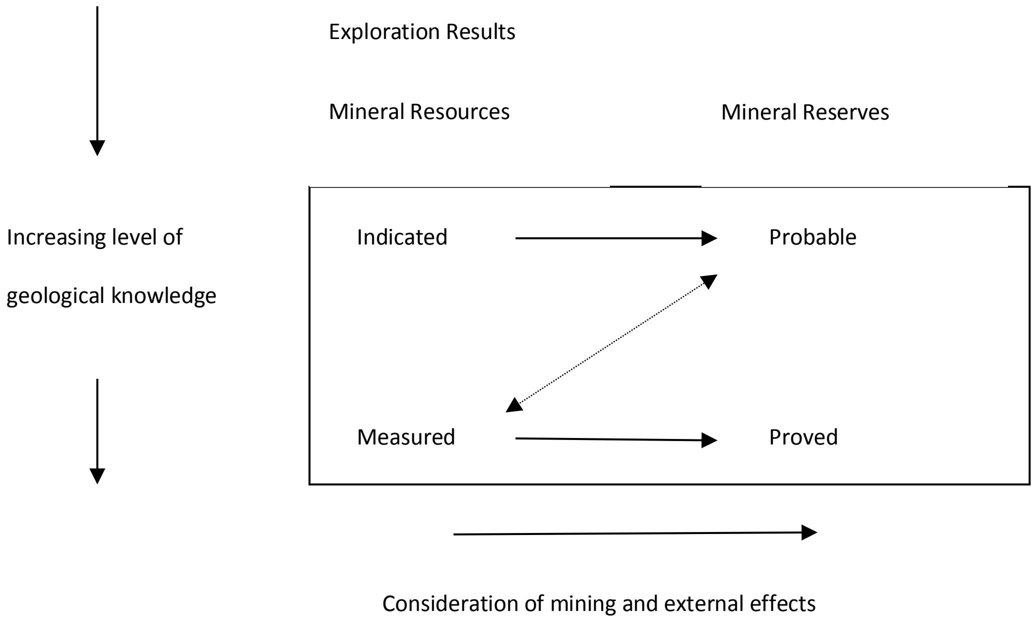


***Figure 5.2*: Mining and Metals: Refining IFRS August 2008**

Characteristics within the sector environment are independent of any singular factor and may affect all participants within the context.

This dynamics within the industry sector imply that:

Proposition1: *Contextualised sector characteristics impact the High Technology Provider and Organizational Technology Environment in either a positive or negative direction dependent upon the event.*

5.2.3.2 High Technology Provider

High Technology Provider
Support Services Communication Reputation Technology Characteristics R & D Allocation Competitive Forces

The *High Technology Provider* is a service provider of an information system/technology which is unique to the context as described by the Sector Environment. As a result of the revision of the conceptual model, Advertising as a characteristic was removed from this factor.

The remaining characteristics as shown have raised the following propositions.

Support Services is defined as the availability of assistance by a technology vendor to the adopting organization of the high technology post adoption. This may take the form of operational manuals, on-line documentation, training or vendor-support type functionality.

Proposition 2: *The provision of support services by the vendor is perceived as essential to the adopting organization and therefore contributes positively to the diffusion of the technology by an adopting organization.*

And

Proposition 3: *The provision of support services contributes positively to the rate of assimilation of high technology within the organization.*

Communication within the High Technology Provider element represents the extent of channels of communication and the proactive nature of communicating knowledge of a technology to an organization.

Proposition 4: *Communication channels which provide rich content contribute positively to the initial rate of diffusion.*

Reputation taken in a contextualized sector environment is narrowed by the specificity of the technology, and may become a more dominant characteristic. This may contribute to either the elimination of competition within the sector or resulting in diversification or further specialization dependent on the nature and scope of the environment. We may therefore conclude :

Proposition 5: *The more favourable the reputation of the vendor the more rapid the initial rate of diffusion.*

Technology Characteristics is a representation of the technology characteristics as portrayed by the high technology vendor. In a contextualized environment where high technology products are considered non-core items prior to adoption it is expected that the representation and effective communication of this representation would provide an effective signaling mechanism for innovative early adopters.

This may be expressed as:

Proposition 6: *The effective communication of technology characteristics by the technology vendor acts as a positive signalling mechanism for early adopters.*

Research & Development Allocations (R & D). The investment in R &D as situated in the High Technology vendor displaces the larger cost from the adopting organization replacing it with a smaller immediate cost in assimilating the knowledge to utilize the technology effectively in meeting the organizational specific needs. This suggests that:

Proposition 7: *R and D allocation invested in producing a technology application for a strategic sector need positively influences the rate of adoption and diffusion.*

And

Proposition 8: *An adopting organization perceives the cost of assimilating knowledge as a preferred option to in house development.*

Competitive Forces represent the competitive intensity to provide a technology type to a given context. This study firmly places Competitive forces as a supply-side characteristic that drives innovation between high technology providers to the contextualized environment. This may be expressed as:

Proposition 9*: As competitive forces increase, investment in R & D Allocation increases as a strategy to maintain or increase market penetration.*

5.2.3.3 Organizational Technology Environment

Organisational Technology
Resources Size Communication Relationships IT Champions Organizational Structure Workforce Characteristics

The Organizational Technology Environment represents the client organizations and the adoptive environment. Emerging from the recommendation of Fichman (2000) to produce theory applicable to context or technology characteristics and therefore a context relevant model. The following characteristics (which have been operationalized in previous research) are utilized within the current theoretical model: resources, communication, relationships, IT champions, technical expertise, organizational culture, size and organizational fit.

Resources as discussed in the description of the initial conceptual model will be used in this study to represent a simpler construct than defined in previous research; being the availability of the resources for technology innovation. This proposes that:

Proposition 10*: Resource availability is positively related to localised decision making.*

Size within this study follows the assertion of researchers who found a positive relationship between size and the ability to innovate (Nystrom et al, 2002;

Germain, 1996; Boecker and Huo, 1998). Connecting these ideas leads to the conclusion that:

Proposition 11*:* *Organizational size will be positively related to innovativeness and the rate of diffusion.*

And

Proposition 12*:* *Diffusion of radical innovation is negatively related to organizational size in large organizations.*

Communication and is located both in this element and within the High Technology Provider as the researcher is also seeking to determine if there is a substantive impact from a push or pull construct (Lyytinen and Damsgaard, Delhay and Lobet-Maris, 1995; Premkumar, Ramamurthy and Nilakanta, 1994). This suggests that :

Proposition 13*:* *Users ability to access rich information of an innovation increases the positive perception of a innovation and increases the likelihood of assimilation.*

And

Proposition 14*:* *Organizational employees who are actively able to seek a rich information source prior to contact with the high technology provider perceive this as empowering.*

And

Proposition 15*:* *Organizational interest in a technology is primarily instigated by contact from a high technology provider.*

Relationships represent the network of associations that individuals operate within in the contextualized environment. Katz (Deroian 2002, p 835) finds it unthinkable that diffusion studies would omit consideration of the social networks and makes an analogy to the study of circulation without an understanding of veins and arteries. As expressed in the description of the initial conceptual model, mining as a context as in this study comprises individuals whom in general possess skills and attributes that are unique to mining, additionally the work context is often located in remote locations. The added nature of contractual employment within the lifecycle of mining operations may result in weak but long term ties that are facilitated by professional organizations in an otherwise locale transient population. The effect of professional ties implies that:

Proposition 16*:* *Weak peer to peer relationships facilitate initial awareness of an innovation and positively influence the rate of diffusion.*
And

Proposition 17*:* *Peer to peer relationships facilitate the assimilation of a new innovation.*

IT Champions act as the facilitator of change within an organization, often also acting as the gatekeeper of new innovation. This research will seek to determine within the contextualized environment whether an IT Champion exists and has influenced the adoption and implementation of a product. This may be stated as:

Proposition 18*:* *The existence of an IT Champion promotes the adoption of innovative information systems/technology.*

And

Proposition 19*:* *The existence of an IT Champion promotes the assimilation of an innovative information system/technology.*

Organizational structure in this study describes the organizational hierarchy in terms of managerial approach to formalized acquisitions of innovative systems. This research will therefore seek to establish whether a centralized organizational structure inhibits the diffusion of innovations at a unit level. This may be expressed as:

Proposition 20*:* *A centralized organizational structure inhibits the unit adoption of an innovative technology at a unit level.*

Workforce Characteristics in this study describe those primary characteristics of users of a technology/system within the contextualised sector. As discussed in the initial conceptual model, previous research has considered only a permanent workforce where the organizational culture is inculcated. Within a largely contractual workforce, the importance of personal professional attributes dominate ethical behaviour and collective professional behavioural norms operate (Valente, 1996). This confluence of behaviour suggests that:

Proposition 21*:* *Contracted employees inhibit assimilation organizationally due to their employee status.*

And

Proposition 22*:* *Contracted employees exhibit personal interest in innovative technologies where they perceive personal professional benefit.*

Table 5.3 summarizes the propositions presented as an outcome of refining the initial conceptual model.

Table 5.3: Summary of Propositions

Construct	Code		Proposition
Sector Characteristics	SC	P1	Contextualised sector characteristics impact on the rate of diffusion of technological innovations.
Support Services	SS	P2 P3	The provision of support services by the vendor is perceived as essential to the adopting organization and therefore contributes positively to the diffusion of the technology. The provision of support services contributes positively to the rate of assimilation of high technology within the organization.
Communication	CHTP	P4	Communication channels which provide rich content contribute positively to the initial rate of diffusion.
Reputation	REP	P5	The more favourable the reputation of the vendor, the more rapid is the initial rate of diffusion.
Technology Characteristics	TC	P6	The effective communication of technology characteristics by the technology vendor acts as a positive signalling mechanism for early adopters.
R & D Allocation	R&D	P7 P8	R & D Allocation invested in producing a technology for a strategic sector need positively influences the rate of diffusion. An adopting organization perceives the cost of assimilating knowledge as a preferred option to in in-house development.
Competitive Forces	CF	P9	As competitive forces increase investment in R & D Allocation increases as a strategy to maintain or increase market penetration
Resources	RES	P10	Resource availability is positively related to localised decision making.

Organizational Size	OS	P11 P12	Organizational size will be positively related to the rate of diffusion. Diffusion of radical innovation is negatively related to organizational size in large organizations.
Communication Channels	CC	P13 P14 P15	Users ability to access rich information of an innovation increases the positive perception of an innovation and increases the likelihood of assimilation. Organizational employees who are actively able to seek a rich information source prior to contact with a technology vendor perceive this ability as empowering. Organizational interest in a new technology is primarily instigated by contact from a high technology provider.
Relationships	RR	P16 P17	Weak peer-to-peer relationships facilitate initial awareness of an innovation and positively influence the rate of diffusion. Peer to peer relationships facilitate the assimilation of a new innovation.
IT Champion	ITC	H18 P19	The existence of an IT champion promotes the adoption of innovative information systems/technology. The existence of an IT champion promotes the assimilation of an innovative information system/technology.
Organizational Structure	OS	P20	A centralized organizational structure inhibits the adoption/diffusion of an innovative information system/technology at a unit level.
Workforce Characteristics	WF	P21 P22	Contracted employees inhibit diffusion organizationally due to their employee status. Contracted employees exhibit interest in innovative technologies where they perceive personal professional benefit.

5.2.3.4. Phase 2 Additional Outcomes

Innovative technology diffusion studies do not exist in isolation from adoption or implementation research. In this research, we draw upon Rogers' classic Diffusion of Innovation Theory (1983, 1995) which addressed the success of an innovation amongst individual adopters and forward through information technology and systems. This encompasses generational change in diffusion research as organizations move from automation to strategic advantage. Further distinctions are drawn between technical and process definitions or the use of technology typing. The maturation of the research and evolution of technology continues to provide currency to diffusion studies and in doing so reflects also the changes exhibited by users as a generation accustomed to technology. As a result of Phase 2, the following elements of the research were clarified:

1. We can now statethat diffusion in the current timeframe refers to the spread of the technology across a network defined by a context which comprises the characteristics of both individuals and organizations which jointly contribute to the rate and extent of the diffusion process.

2. The second element, and one which distinguishes this research, is the inclusion of the supply-side variables as a critical element of the adoption and diffusion process from the organization perspective, and which, despite been acknowledged throughout marketing research as a driver of change, has been largely ignored in innovative technology diffusion studies.

3. The third element acknowledges the forces that exist within a specific context and whose control is outside the bounds of the either organization or vendor.

4. A contextualized environment bounds the factors and their interactions and provides an opportunity to discover, clarify and understand the dynamism that influences technology diffusion.

The following chapter describes and discusses the outcomes of research phase 3 – The Multiple Case Studies.

Chapter 6 Outcomes of Research Phase 3- Multiple Case Studies within the Minerals Mining Sector of Australia.

A multiple case study approach was selected as an appropriate strategy given the segmented nature of the mining industry within Australia. It allows the researcher to study information technology in a real-life business context in a natural setting (Benbasat et al., 1987). The mining industry in Australia is segmented not only by overall organizational size, but also by the functional participation in the mining value chain. Thus, the case study strategy optimizes the ability to make comparisons and test theoretical propositions while facilitating the collection of rich data across a more complex industry where the larger organizations may be part of more than one segment. Thus, the multiple case study approach was selected as it permitted the researcher to study in real time the context of the selected environment, that is, the minerals mining industry in Australia. Moreover, this approach increases the strength and therefore the validity of the revised research model.

Phase 3 utilized semi-structured interviews with representatives of both the High Technology Providers and Organizational Technology Environment of the model in order to confirm, validate and refine the revised research model which includes an examination of the propositions presented in Phase 2.

6.1 High Technology Providers

The literature review suggests that supply-side variables have a significant effect on diffusion when viewed in a contextualized environment. Porter (1985) states that technology and information systems are pervasive in the supply chain; a change in one technology therefore flows down the value chain. This flow affects technologies and industrial behaviour patterns present in the industry sector (Porter and Millar, 1985). Figure 6.1 below depicts the value chain of the mineral asset in isolation as described by HTP 1 (website, April 2012). Previously described in Chapter 1, the mineral asset is at the core of the mining chain and therefore the supply chain for business realization. As pictured in Figure 6.1, any change in information systems that describe, manipulate or report the asset may therefore impact on the larger value chain.

Thus, the choice of technology and the relationship between both the providing and adopting organization may be critical for both parties. This relationship may be more critical for high technology providers as the scope of the market may be limited by the nature of the technology market itself. High technology products provide specialized functionality to the market they serve which may not be directly transferable to other markets.

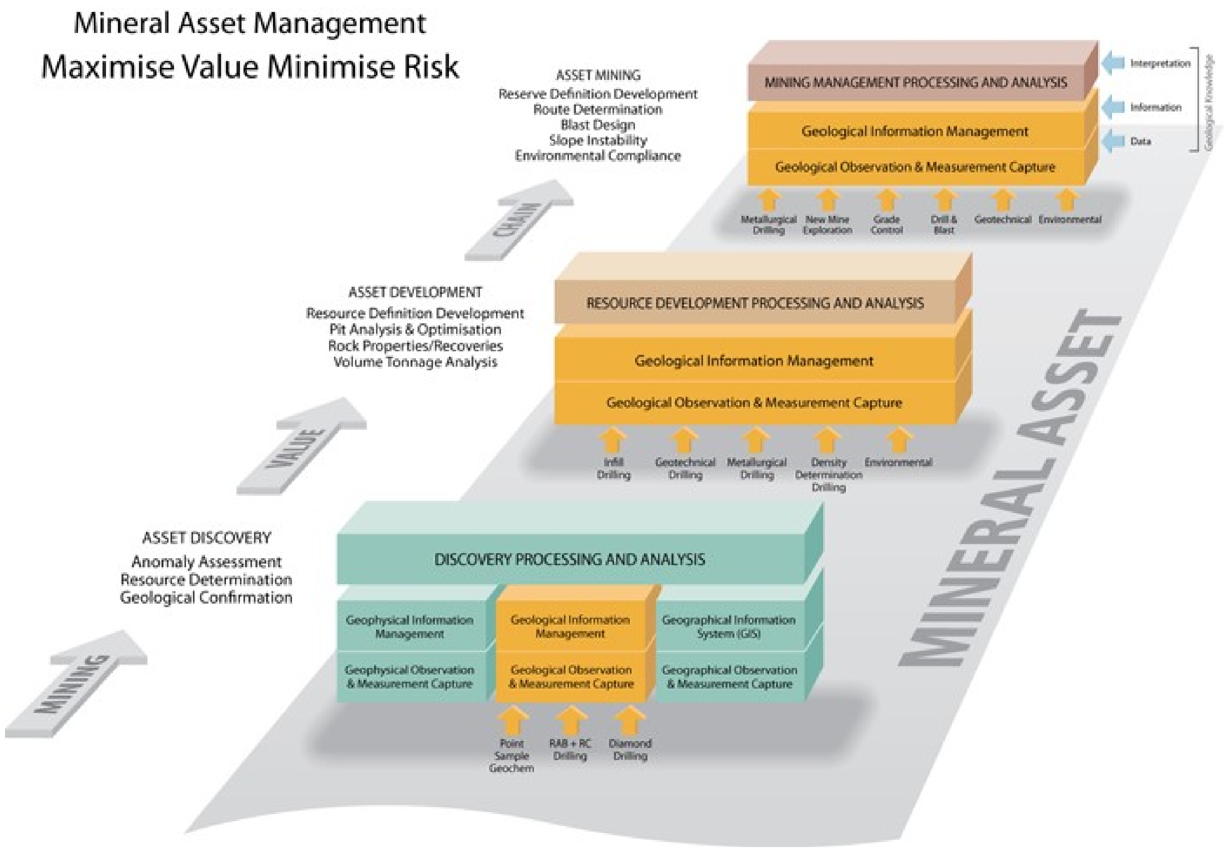


Figure 6.1: The mineral asset as a value chain (HTP 1 website).

The following presents a discussion and findings from the analysis of the interview transcripts from the High Technology Providers. This analysis focuses on the research questions and variables outlined in Phase 2. Each factor and its characteristics are reproduced below.

High Technology Provider
Support Services Communication Reputation Technology Characteristics R & D Allocation Competitive Forces

Three high technology providers participated in this study and are denoted as HTP1, HTP2 and HTP3. The sector segments (previously described in Chapters 1 and 4) pertaining to these high technology providers are shown in Table 6.1 below. Please note that junior companies are involved only in exploration and therefore no technology element is shown in the junior column outside the segment indicated. Additionally, Table 6.1 shows only where a solution is marketed by the technology provider for the express purpose of the function indicated. It should be remembered, however, that the data collected in the exploration phase is retained for the life of the mine as required by the Australian Commonwealth and must be retained in the format in which it was originally presented. However, it may be transformed for use in other formats where that interoperability is available. Where data is transformed for reporting purposes to the ASX, the transformed data must also be retained.

The nature of the segmentation of the mining sector into distinct activities suggests that a case study methodology is the most appropriate as it provides the opportunity for both literal and theoretical replication. As can be seen in Table 6.1, literal replication occurs in the provision of functionality within each of the mining activities. Theoretical replication is possible because each provider offers services across the scale of mining activities from junior to major.

The use of cross-case analysis allows the researcher to enhance generalizability and provide a more comprehensive understanding (Huberman & Miles, 1994; Herriott and Firestone (1983) see multiple case studies as being more compelling and increasing robustness.

Table 6.1 – High Technology Provider Segment Participation

	Junior	Mid -Tier	Major
Exploration	HTP 1 HTP 2	HTP 1 HTP 2	HTP 1 HTP 2
Feasibility/Analysis	X	HTP 2 HTP 3	HTP 2 HTP 3
Extraction	X	HTP 1 (limited) HTP 2 HTP 3 (limited)	HTP 1 (limited) HTP 2 HTP 3 (limited)

6.1.1 High Technology Provider Profile

Three high technology providers participated in this phase of the case study research. All providers have offices located in the City of Perth, Western Australia and provide services to the mining industry of Australia. HTP 1 and HTP 2, originating in Perth to service the Australian domestic market, also have offices elsewhere in Australia and additionally provide services globally as dedicated mining solution providers. HTP 3, as a provider, has its origins in the USA and has offices in multiple locations throughout Australia. However, this provider offers services to other industry sectors, mining representing approximately only 8% of their Australian operations.

The HTP profiles are summarized in Table 6.2 for comparison. The participants provide both depth and scope of knowledge and participation in the minerals mining sector of Australia over an extensive period of time and have remained buoyant through both boom and stagnant periods of resource activity within Australia.

Table 6.2: Organizational Profile

HTP	Point of Origin	Market Focus	Date of Commencement	R & D	Product Domain	Interoperability
HTP 1	AUS	Mining	1996 (as its current entity)	YES	Exploration Data Acquisition Data Management	By License
HTP 2	AUS	Mining	1986	YES	Total Mining Solution Visualization	By License
HTP 3	USA	Govt Commerce /Industry Agriculture Utilities Mining	1969	YES	Data Management Mapping Visualization Environmental	Accepts data from all major providers, mapping is not interoperable

HTP 2 differentiates itself by offering a 'total solution', i.e. one which is marketed to provide a solution for every aspect along the length of the mining asset value chain. However, the 'total solution' is modularized into applications and may be acquired as a distinct module application by an organization, thus enhancing their ability to participate in different solution spaces. HTP 2 is therefore across all segments of the market spaces where the other high technology operate.

The organizational structure of each of the high technology vendors also differentiates the above providers. HTP1 operates within Australia as a post-bureaucratic type of organization where the organizational structure is flatter and an organic type of management is utilized. Employees are encouraged to participate in the decision-making process and benefit from shares assigned to employees. The founder of the company has recently retired as CEO, but maintains a role in research and design.

HTP2 is a small company that has experienced significant growth in both domestic and offshore markets within the last ten years. As such, the organization has over this period developed a more traditional bureaucratic operation with reporting processes and formalized business process rules. The organization remains under the direction of the founder as CEO and current market focus is directed towards offshore operations whilst maintaining domestic markets. Its application modularity and interoperability features provide a considerable marketing impetus to the market share.

HTP3 operates as a branch of a global company with formalized business processes. Perth-based operations have had a more relaxed management approach from inception which appears to be a result of the previous director’s management approach and may not be typical of any other operation. Since late 2010, the foundation associate has retired and operations within the Perth office have been more formalized as new technology has driven a push into the existing sectors serviced by the branch. Additionally, advances in the technology represent a significant variation to previous versions of the software and the platform within which it operates. The discussions held with the then-director and manager of mining relate only to mining modules within Australia.

6.1.2. High Technology Provider Interviewee Details

Three semi-structured interviews were conducted. The participating high technology provider’s representative/s was needed to have knowledge of the technology and the management of the customer relationship. The first section of each interview began with a clarification of the role, experience and involvement of the interviewee within the provider organization and also within the mining sector. Table 5.4 summarizes the information provided.

HTP 1 and HTP2 provided additional materials that indicate that company policy is to employ staff who possess geological/geophysical or similar backgrounds. The view taken may be summed up by the following verbatim remark from HTP1 :

" it's easier to teach them the technology than teach them mining".

From HTP 2:

"most geos in the mining industry in Western Australia know each other either personally or by reputation".

HTP1 and HTP2 perceive that the importance of an appropriate background is significant in cultivating and retaining relationships within the mining community in Australia. These relationships are initiated and maintained by inclusion in professions substantiated in the market space and context. The importance of professional recognition by peers within the context appeared as a qualifier in responses given early in the interviews. Both HTP1 & HTP2 originate in Perth and attach significance to the value of professional reputation within the context and to the value that this brings to their organization. When subsequently providing feedback to these providers post- interview, the CEOs of both providers indicated that they believed their early success and continued stability is based not only on the quality of the technology, but also on the professional ethic that has been a fabric of the culture of the provider organization. An appropriate background permit levels of professional discussions regarding the ability of the technology to perform the required functionality, and enables on-going contact through professional associations in social networks. HTP1 and HTP2 interviewees indicated that mining professionals' membership of their professional associations was regarded as a professional obligation. Therefore, employment of mining professionals by high technology providers strengthens the relationship-building from within the professional associations by virtue of individual reputation and trust based on a common background. Although HTP3 did engage employees on the same basis, they rely on a global presence and reputation and invest heavily in the training of personnel.

Table 6.3: High Technology Provider Representative Details

	Position Title	Years in Company	Years in Mining Sector	Primary Roles	Background
HTP 1	Special Projects	8	15	R & D	Geophysicist
HTP 2	Sales Manager WA	5	8	Management of Sales Team, Customer Relationship Management	Geologist
HTP 3.1	Associate	7	24	R & D Executive Duties	Climatologist Management
HTP 3.2	Mining Manager - Sales	3	3	Sales CRM	Sales

It may be suggested that the requirement of background also validates the importance of an appropriate reputation within a bounded context such as mining and reflects the validity of the vendor by ethical association. This may be seen as an example of the concept of weak ties in action as was suggested by Granovetter (1973). Although Reputation is discussed as a provider characteristic later in the chapter, the early significance of the professional reputation and its inferred importance to the strength of relationships, require it be acknowledged and mark it for possible further research.

In addition, all interviewees indicated that they considered themselves to be long-term company staff. In terms of involvement in the mining industry, long-term employment is regarded as a period of 3 -5 years and is often contractual. Employment is also influenced by fluctuations in commodity prices, take-overs and policy reflecting the influence of sector characteristics. Thus, the concept of longevity within an associated context reflects strongly the strength of high technology vendors in a market which the vendors perceive has growth capability despite the effect of external influences. Also, all interviewees confirmed prior experience in sales and/or customer relations within their current organizations.

Following is a discussion of the research characteristics of the High Technology Provider factor as described in Chapter 4 derived from the analysis of the interviews.

6.1.3 High Technology Provider Factor Characteristics in detail.

Support Services

High Technology Provider
Support Services Communication Reputation Technology Characteristics R & D Allocation Competitive Forces

Proposition 2 (P2)

The provision of support services by the vendor contributes positively to the diffusion of the innovation.

Proposition 3 (P3)

The provision of support services contributes positively to the rate of assimilation of high technology within the organization.

All high technology providers provide support services in the forms of operational manuals, on-line documentation, training or vendor-support type functionality. Additional options for the adopting organizations are provided by HTP1 and HTP2 as required on a cost basis and may be accessed at any time within the contractual period as an additional service. These types of support include 24-hour help desk support regardless of location, on-going training support and software updates. HTP 3 provides support only on a contractual basis normally stipulated by the original contract.

HTP3.1 stated that

"…our contracts are detailed in the type of support and the rationale for need at the outset".

From the vendor's perspective, these services are regarded as mandatory in the provision of technology products. This concurs with Leonard-Barton (1987) who found that access to training was important from an organizational perspective. The strength of this conviction can be demonstrated by the following comments.

HTP1 : "We wouldn't even consider a product rollout that didn't include support. Increasingly support services are a matter of contractual priority especially where remote locations are involved".

HTP2: "Our clients have immediate expectations in regard to service. We have a 24hr turn around for solutions and will customize training to the request of the client. Non-subscription to support would leave the client literally out in the cold. They know it, we know it".

HTP 3.1: "Our contractual arrangements are quite specific and past version support has been maintained up until present. The new version is a big upgrade and a recent decision has been made to cease support for the very old versions. We have notified all clients and this has allowed new conversations in regard to products to be initiated. We have previously maintained support for previous versions far in excess of any competitor as an act of good faith and customer relationship".

High Technology Providers perceive that the provision of support services is essential to the diffusion of their respective technologies. Providers believe that the absence of support services would result in their respective technologies becoming non–utilized and therefore non-viable within the market space. The perceived inherent complexity of many specialized technology products create the perception that they are difficult to use. High technology providers regard the correct communication of outcomes as vital in sustaining their products and inherent in this belief is the provision of support services to overcome any negative perceptions held either by individuals or organizations. This is supported by the research of Eveland and Tornatzky (1990) and Robertson and Gatignon (1986). Fichman (2000) comments on the level of resources applied to propagate through communication can enhance the technology and increase diffusion.

HTP1: "No product could be sustained without the provision of support service".

Additionally, technological solutions in the exploration segment are utilized at remote locations where data is collected and transmitted by satellite when the hardware components are docked. HTP1 regard support as vital in these circumstances and provides market advantage in the exploration segment. HTP1 guarantees support regardless of the location of the hardware/software component. This particular component's promotional material in the market space in terms of technology products substantiates their claim to uniqueness of support in the exploration technology segment. HTP1 also provides the satellite technology required to diffuse their technology in the mining context, demonstrating agility and their preparedness to work closely with their client base to extend their services.

Examination of supporting material gives substantial space and prominence to the availability of supporting services that include the aforementioned services. All vendors currently provide subscriptions to various newsletters, company conferences and workshops. Each of these materials contains information with regard to operating tips, additional scheduled workshops and general updates. A recent inclusion in newsletters are case studies which demonstrate the possible advantages to be had with the adoption of a technology. Case study examples are utilized by all vendors and are perceived as promoting the benefits and encouraging technology diffusion by demonstrating the benefits. In addition to the newsletters, case studies feature in all of the providers' websites.

HTP1 also organise annual conferences where clients can receive updates and have access to a range of support and training workshops free to attendees. Workshops are well attended and provide substantial opportunities for vendors to liaise with existing clients informally whilst promoting their products. In providing this supporting service, potential customers are identified and the fees for attendance are often subsidized.

Support options are communicated by sales staff in contractual negotiations and promoted primarily by email in updates to clients. Support services are also visible as a link on the home page of all high technology providers. Hence, the availability of services is communicated by multiple methods or additional support is provided by login mechanisms whereby clients can access information or online tutorials.

Table 6.4 summarizes the activities of the high technology providers in respect of support services that they offer.

Table 6.4: Support Services

HTP	Email	Help Desk	Workshops	Conference	Seminar	FAQs	Secure Login	Online	Customer Training
1	√		√	√	√		√	√	
2	√	√	√			√		√	√
3	√	√	√	Offshore only	√	√		√	

High technology providers offer services related to the deployment of technologies as a matter of course, perceiving this as critical to the adoption and subsequent diffusion of the technology. The variety of support services indicates the vendors' perception that support services are a vital mechanism for the adopting organizations and is therefore a marketing mechanism for distinguishing and differentiating technologies. HTP1 and HTP2 also indicate that training is now offered to individuals as opposed to organizations only. The providers perceive this to be a change in the adopting organizations' employment policy (post-implementation) in junior and mid-tier mining segments. In meeting this need, these vendors recognize that they create a user loyalty by supporting individuals to be functionally competent for employment and, by doing so, create user networks which support their respective technology.

According to high technology providers, support services would seem to support Proposition 2. However, confirmatory evidence will be sought by cross-case analysis from the organizational technology environment.

Proposition 3 asserted that a relationship exists between support services and assimilation of the technology. However, no clear evidence of assimilation emerged from the interviews to support Proposition3. The high technology provider's assertions of the ease of assimilation of a product cannot be affirmed by the provider itself. Further evidence should be sought by analysing the organizational technology environment to establish whether the organizations in the environment acknowledge that support services facilitate assimilation.

Communication

High Technology Provider
Support Services **Communication** Reputation Technology Characteristics R & D Allocation Competitive Forces

Proposition 4 (P4)

Communication channels which provide rich content contribute to a positive perception of the high technology product.

Proposition 5 (P5)

Communication channels which provide rich content contribute to the rate of diffusion.

Communication is vital for the marketing of goods and services (Porter and Millar, 1985; Robertson and Gatignon, 1986). Communication in the High Technology Provider factor represents the extent of channels of communication and the proactive nature of communicating to an organization any information pertaining to a technology. Frambach et al. (1998) regarded communication as an important determinant for intangible products, although they incorporated communication as an awareness mechanism through the use of marketing strategies. From the perspective of the high technology provider, communication is a push mechanism which is utilized to create awareness of a product.

HTP1: When a new product/version is released we contact our existing client base via the preferred contact method. If this is email we will provide a link to a webpage which highlights the campaign for the product. Such web pages are a primary communication method which allows us to provide the most advantageous information for prospective clients.

HTP2: As sales manager we have a pre-release process which allows the appropriate salespersons to contact their clients. Prospective clients will also be contacted but a differing campaign will be used for these clients and will always be direct contact followed by appropriate materials.

HTP3: The mining space is a relatively small part of our overall business scope and so we are able to maintain our clients with a dedicated mining person in relevant states who understands the needs of the clients and will contact appropriate persons and follow through by email. Updates, new products are also communicated within the newsletter which has been well received by our existing clients. Individuals departing organizations may also receive the newsletter. We have found that our users often act as technology evangelists taking their enthusiasm with them to new locations.

Frambach et al. (1998) considered communication to be a marketing/sales device. When questioned, the participating interviewees all confirmed that communication represented the foundation of any marketing strategy and that a well-designed ongoing push campaign is essential to the establishment of a market presence. All interviewees indicated that web pages targeting both users and management are an essential means of providing information about the benefits of technologies. The advent of web pages has produced a change in marketing strategy as multiple-access means are now possible. Content that focuses on a specific topic may be constructed to target both users and management. This reduces duplication of efforts by sales personnel and provides a single point of discussion for adopting organizations to review marketing content if required. Such web content is rarely technical in nature and is usually promoting the benefits of a product. Technical information is available on request from clients. The rationale here is that, nowadays, technologists themselves rarely make acquisition decisions as these are corporate functions based upon the utility of the product. The dual push to both technology advocates and management was noted by Fichman (2000) as being a key to adoption as it operates across the two groups, although it is the management that makes the final decision regarding adoption and subsequently its diffusion across a sector.

Mining is also subject to isolation. Therefore, users and multiple stakeholders are unlikely to be in the same location as the high technology providers. To address this drawback, all technology vendors utilize multiple communication channels to make their solutions as visible as possible. All high technology providers utilize email as a primary type of contact unless otherwise specified by the organizational contact. This would seem to be an outcome of both distance and the fly-in/fly-out nature of the industry. Organizational contacts are generally direct management areas of the function that utilizes the technology, and are rarely located in corporate offices. Web pages, however, allow access at any time to clients conditional upon the availability of an appropriate service.

HTP1: We use the internet as a tool to maintain a less invasive form of contact. It allows us to notify clients of events, reminders of courses etc. without concern of where they are currently located.

HTP2: Most clients prefer email. However we use trade magazines to also showcase technologies as part of a more general marketing strategy. These marketing tools have proven valuable and include links to our web pages which allow prospective clients to gain additional insights.

HTP3: News type items are sent via email with web-links. We also have a magazine which is specific to the mining industry and as well as news items which feature uses of the technologies.

Technologies which are specific to a market space require that the high technology providers maintain an up-to-date knowledge of market movement (Moore, 2002). Such knowledge of the market space would indicate when it is appropriate to communicate with their clients both existing and potential. The interviewees made the following comments:

HTP1: We maintain interest in our clients' operations as a matter of course.

HTP2: Our staff are expected to be current in understanding their client's prospective needs.

HTP3: We constantly scan and appraise activities relevant to our suite of products and act accordingly.

Additional insight was offered by HTP1 who commented that queries from clients also arrive by text messages where a long-term relationship exists. These queries may not only be confined to sales-only issues. The use of alternative communication methods to acquire information in a timely manner raises an additional possible characteristic which might be termed 'accessibility'. The organizational framework and employee accessibility of HTP1 appear not to be characteristic of high technology providers in general, but rather are a strategic move initiated by the CEO and founder of the organization to build binding relationships between the organization and the provider.

Communication technologies have integrated electronic media and marketing and provided a convenient push mechanism for the transmission of marketing strategies which have the ability to be rich in content at minimal cost. These technologies have provided new avenues for the transmission of information and may also expand the characteristic to include marketing strategy and support services.

The high technology providers perceive communication technologies as providing a significant strategy for a push mechanism which not only is cost effective but provides rich media content to address differing organizational stratum i.e. management and users.

Therefore, Propositions 4 and 5 (P 4 and P5) appear to be supported by the actions and perceptions of the high technology vendor. Confirmation is required by the Organizational Technology Environment.

Reputation

High Technology
Support Services Communication **Reputation** Technology Characteristics R & D Allocation Competitive Forces

Proposition 6 (P6)

The more favourable the reputation of the vendor the more rapid the initial rate of diffusion.

Reputation of the vendor has been seen as a significant factor where the product is intangible (such as the case with technology products) or where complexity is perceived by the user. In these cases, reputation may have a mitigating effect (Frambach et al., 1998). Moore (2002) states that the reputation of market providers is critical to the buyer's perception of the quality of a providing organization, and consumers care about not only the cost and quality, but also the ability to provide supporting infrastructure in a reliable manner into the future. This is supported by Hewitt et al., 2002) whose research specifically examined corporate culture. When interviewees were queried in regard to the importance of their respective reputations, they expressed the following:

HTP 1: Clients perceive us as a high quality provider of services across the mining chain. Our "GIMS" is unrivalled in the market space.

HTP2: Our products speak for themselves. We are at the forefront of visualization technologies.

HTP3: Our leadership in the market space has been unchallenged due to quality and the organization that supports the quality.

The statements above might be considered typical of the expected response to such a query. However, each of the high technology providers who participated in this study maintains a high profile both within the Australian mining industry and overseas in terms of their products. Individually, they have survived the mining downturns of the past which saw some competitors cease business. Following the indications of Frambach et al. (1998) that reputation may be significant when choosing a technology provider, interviewees were asked about the primary competitor in their market space, historical dominance and how they felt their product was distinguished from this competitor. Table 6.5 displays the result summary.

When asked directly about their reputation in the market space, all claimed an outstanding reputation for quality and service. Comments from HTP 1 and HTP2 indicate that the current market space would not tolerate a sub-standard product or service within Australia.

Table 6.5: High Technology Provider Competitor Perception

	Primary Competitor	Dominance	Distinguishing Features Claims
HTP 1	HTP2	Self	Dedicated data management
HTP 2	Nil in the total solution space within Australia. In terms of packages: HTP1, Company X, Company Y	Self Was not answered	Total Mining Solution Provider Superior Visualization
HTP 3	Company X	Self	Comprehensive visualization Total Solution Capability Technical Superiority

HTP1: *Australia is an extremely competitive market place for technology providers, poor quality means you just don't survive*.

HTP2: *You'd need to be pretty damn good to compete against the current market leaders.*

HTP3: *We don't have a genuine rival for the complexity of our product. There are other providers who offer only basic services in comparison.*

All high technology providers also participate in trade fairs and are regarded as premium clients in dedicated mining events. HTP2 has a substantial profile and evidence of awards from the Australian Government in relation to their participation in offshore events aimed at raising the profile of Australian trade companies. The CEO has received personal awards in relation to his business performance. Raised profiles either of individuals or organizations within a niche market space are communicated by self-promotion, awards bodies or industry magazines and are perceived by the high technology providers to be of strategic importance for the marketing of products. The visibility of management and sales persons within their closed community means that the value of reputation also resides in the providers' representatives. All interviewees stated that the culture of the providers reinforces the awareness and the maintenance of reputation as being a vital activity for employees.

Reputation is significant to the high technology providers and appears to substantiate Proposition 6; however, confirmatory evidence for this proposition is required by the organizations in the organizational technology environment.

Technology Characteristics

High Technology Provider
Support Services Communication Reputation **Technology Characteristics** R & D Allocation Competitive Forces

Proposition 7 (P7)

The effective communication of technology characteristics by the technology vendor acts as a signalling mechanism for early adopters.

Technology characteristics were incorporated into Roger's (1983) Diffusion of Innovations Theory where it was posited that the more favourable the characteristics, the more likely it was that diffusion would occur. Fichman (1992) noted that this is an over-simplification for organizational diffusion and that favourability is a perception of users which may not be transferable to the organization. Attewell (1992) found that the better the communication of the beneficial technology characteristics, the more likely adoption and diffusion are to occur. Information Systems research has largely ignored the effective use of recent communication technologies in influencing diffusion by the availability of rich media where the media has been generated by the high technology providers. In marketing and supply-side research, the transfer of product information has long been of strategic importance in establishing the relationship between provider and client (Moore, 2002). The interviewee comments affirm the importance of communicating the technology characteristics. However, it should be noted that the written presentation of text from oral interviews may lose the importance that the interviewees give to words and phrases, given that inflection, emphasis and tone are not captured. This proved to be the case when the characteristics of technology were being discussed. All interviewees were animated when discussing the strategy that is utilized to provide information to clients and indicated that the goal is to promote the benefits of the technology in non-technical terms for the widest possible coverage to potential adopters.

HTP1: Detailed descriptions of our products and their benefits are available on the web. Sufficient information is available for clients to make an early assessment of the products. We also use case studies to demonstrate their implementation and what was achieved by their usage. These together provide impetus for prospective *clients to see the strategic benefits that may be achieved by adoption of the products .By the time we receive a cold call the adopting organizations have usually researched and require more detailed specifications or cost benefits.*

HTP 2: We provide web pages and documents that outline the technology in terms that business requires to evaluate their needs in understandable business terms (rather than IT jargon). When we follow-up with clients we only discuss technical issues at the appropriate juncture. Clients are interested in what is provided not how it's achieved.

HTP3: We like to feature case studies where we can provide insights to prospective clients or existing clients upgrading and the advantages they can achieve. We prefer to have face-to-face meetings as soon as possible to highlight what benefits can be achieved in each adopting organization. These are value-adding assets that achieve strategic benefits.

The presentation of the benefits of technology can be seen to be primarily couched in terms relevant to business needs rather than the simple technology characteristics first promulgated by Rogers (1983). Technology is no longer considered "just technology; it is appraised in terms of benefits to the organization".

All high technology providers stated that the characteristics and the benefits are the product and thus the information provided is crucial to the marketing of the products. Interviewees indicate that email alerts of changes to products, and therefore web pages, are forwarded to the organizational contacts as a means of alerting them to product updates. Emails are also forwarded to a secondary group composed of power users who may act as technology evangelists and are usually early adopters. Table 6.6 indicates the rationale in new/updated products employed by providers to contact the employee whom they perceive as being the early adopter. These persons are those most likely to initiate and maintain an early interest in product updates/new technology within an organization, thus raising the possibility of future adoption and therefore diffusion.

Table 6.6: Contacts for promotion of technology characteristics

	Primary means of contact	Role of Contact	Rationale for Contact person
HTP1	email	Senior geophysicist - management	Decision maker Expert in exploration data acquisition
HTP2	email	Dependant of application module – Many applications have premium/power users, these are always primary contacts especially in larger organizations.	Primary/Power users have insight into user requirements and also organizational strategy.
HTP3	email	Normally a power user unless otherwise specified.	Power users have a depth of understanding not found elsewhere.

Power users in this study proved to be those to whom other users turn for expert knowledge. As perceived experts, they match the definition provided by Rogers (2003, page 300) as being able to influence others. Rogers (2003, page 319) in discussing the research of Walker (1966), states that "innovations can diffuse from organization to organization through inter-organizational networks in a process parallel to an individual within a social system". He further states that "the most common way to use a network is to identify and utilize opinion leaders" (Rogers, 2003, page 321), and draws upon the research of Valente and Davis (1999, page 56) who stated that "a network can be used, rather than ignored when creating diffusion programs". Rogers (2003, Ch. 8) devotes a substantial chapter to diffusion networks and the use of opinion leaders within inter-organizational diffusion.

However, Moore (2002) states that intangible products require a deliverable that interests the client beyond the visionary first adopters. The use of web pages and newsletters provides a rich content that not only attracts the early adopters, but can be utilized in attracting a strategic benefit to the more pragmatic management contact. Proposition 7 appears to be supported by the observations made by high technology providers.

R & D Allocation and Competitive Force

High Technology Provider

Support Services
Communication
Reputation
Technology Characteristics
R & D Allocation
Competitive Forces

Proposition 8 (P8)

R and D allocation invested in producing a technology application for a strategic sector need positively influences the rate of diffusion.

Proposition 9 (P9)

As competitive forces increase, investment in R & D Allocation increases as a strategy to maintain or increase market penetration.

R & D Allocations were included by Robertson and Gatignon (1986, 1989) as a supply-side variable in which they found a positive relationship between the greater investment in R & D leading to technology enhancements and a stimulation of the marketplace. This stimulation was predicted to result in a more rapid diffusion and possibly an expansion of the market as new technologies are adopted. However, this has been largely ignored outside of marketing studies.

All interviewees indicated that their companies regarded R & D as a necessary investment in future success within the market space.

HTP1 released a new technology concept during the previous 24 months (at the time of writing) and has another delivery for a different mining segment due in the immediate future. They stated that 18 months previously they conducted a survey of the mining industry in Australia to establish opportunities for continued engagement for the next three years. The survey is a tool that has been previously employed by HTP1 and which they regard as successful on this and the past occasion. The survey is initially sent to both existing and past customers; followed by a second round to companies who are identified by the high technology provider as prospective clients.

All staff within HTP1 are able to contribute suggestions to the R & D committee whilst a steering committee directs the allocation of resources to projects. Investment is significant for this provider and an annual conference is heavily utilized to present upcoming technologies to participants. This represents a relationship building process as an action plan by the provider and a strategy for further industry presence.

HTP1*: Understanding the sector and looking for opportunities or future sustainability is vital. The close relationship we have with our clients and the professional knowledge we retain enables the company to find opportunities.*

HTP2 similarly invest in R & D. Their current focus differs from HTP1 in that their goal is to enhance their total solution option based upon their growing offshore interests. The offshore growth has displaced domestic focus as returns are greater and growth is continuing. Offshore R & D will transfer to a domestic market where appropriate. Little information was provided by the interviewee regarding the operation of the R & D function although it was indicated that feedback by clients was utilized in future development. The CEO advises the direction of the R & D function and also the investment of resources.

HTP2: *Our current focus is global opportunity and we've invested in making our technologies adaptable for differing cultural markets. This will guide future R & D investment for the immediate future.*

HTP3's organizational head office is based outside Australia. Technical requests and feedback from Australian clients are relayed to the parent organizational area on a regular basis. R & D is conducted at the parent location and feedback in the form of future directions updates senior partners in all locations worldwide for the purposes of future planning. Mining within Australia represents only approximately 8 - 16% of the Australian HTP3's operation and therefore does not feature as a priority area in itself. Rather, it would appear to benefit from advances in technology in more general terms and these are customized for the mining context post-development. The interviewee indicated that a major new revision has occurred in the prior 18 months (within Australia) that also resulted in some older versions no longer being supported. This is a significant update and was accompanied by a change in policy in regards to the cessation of support now applicable globally to older products. The new product is a significant development incorporating the latest technologies and moves their products away from previous platforms and data storage solutions.

HTP3: *We ensure that feedback from the Asia-Australia area is fed back to the parent from all our areas. Direction and investment is however directed from head office as a global vision for the organization.*

Additionally, all High Technology Providers perceive themselves as providing new direction for the maintenance of data and sustainability of junior and mid-tier mining organizations. HTP1 & HTP2 (previously) have found strategic market share by investment with a particular focus on these segments. The size of these organizations prohibits investment in technologies internally and they in particular have provided stability for the providers who have guided the segment's selection of technologies and implemented and integrated their business processes as a result.

All interviewees state that high technology providers who wish to remain viable in a technology market will invest in future market research that leads to new or product enhancements in tune with technology developments generally. The market visibility of R & D outcomes is carefully managed by providers so as to maximise their market impact and return on investment. All providers also scan their competitors regularly for advance news of releases.

Competitive Forces are driven by influences within the market place to retain or increase market share. In a contextualized market space, there is strong competition to retain the reputation and dominance historically cultivated, especially given that technologies may not adapt outside the context. High technology providers also perceive themselves as enablers of new technologies in that the junior and mid-tier partitions of the mining organizations are unable to invest in R & D internally due to the limitations of their investment capital. These partitions are therefore reliant on the high technology providers to offer solutions that reduce costs and provide efficiencies within their scale of operations.

In the preceding discussion of R & D there is a perceived recognition by the high technology provider of the need for R & D and its value as a determinant in the provider's continued viability within the contextualized environment.

The high technology provider believes that the investment in R & D secures the future viability of the organization through innovation. However, as Moore (2002) states, the marketing and diffusion of new products is not guaranteed just by investment. Not all product releases result in diffusion or long-term success. Therefore, it may be that the knowledge and relationship with the client base and wider context contribute also to the success of innovation through the R & D mechanism.

Although Proposition 8 is confirmed from the perspective of the High Technology Provider, confirmation must be confirmed in the integration of post-analysis findings pertaining to the Organizational Technology Environment.

However, Proposition 9 appears to be supported given not only the investment, but the confirmation of competitor scanning and market planning by the high technology providers.

6.1.4 Summary of the Discussion & Outcomes of the High Technology Provider Factor.

High Technology Providers are the vendors of technologies that specifically support the functions of the mining market space. They inform potential client organizations of the strategic advantages of the technologies that they provide. The adoption and desirable subsequent diffusion of the technologies are perceived by them as re-defining business processes post-adoption, thereby providing advantage in efficiencies not only organizationally but within the market space in which they operate. Equally, High Technology Providers see their role as being more integrated with their clients; they are more than mere on-sellers of products. The desirability of relationship building is recognized as a market tool and as a means of providing insight and feedback to strengthen their own futures; hence, the relationship is a symbiotic one.

The participants who are high technology providers all possess significant practical experience both as professional practitioners and in their roles within their organizations. They individually perceive their backgrounds as a significant enabler to promote their organizations within their professional bodies. In the mining community, a personal reputation reflects n on both the individual and on the associated provider organization; therefore, appropriate skill sets and professional affiliations are essential in establishing and maintaining desirable relationships.

Distinctions between nearest competitors are based on both finance and functionality. Reduced or more basic functionality is reflected in the contractual commitments and lower cost structure which may make them an option as desirable suppliers. These providers have found a niche by servicing junior companies or those companies whose assets are limited and therefore seek only to implement the necessary functionality to perform set services. Alternatively, they provide a specialized service or product which may be consumed as a service or utilized as in a limited lease arrangement. Interviewees state that provider activities are visible within Australia due to the nature of the mining community and the events in which providers participate both locally and offshore, but additionally due to the professional networks within the community which act as conduits of information for their membership. Two tables conclude this section. The first is a summary analysis table for the high technology provider followed by a summary table for the Proposition and factors.

Table 6.7: High Technology Provider Analysis

	Vendor Perception of Industry Role	Primary Market Focus	Relationship to Clients	Market Technology Innovations	Vendor Internal Focus	Marketing Communication	Company Structure	Reputation	Prof. Ass'n
HTP 1	Data Quality Quality Control in Business Processes	Primary Focus – Australian Secondary - Offshore	Long term industry ties – expanding – basis in exploration	R & D new releases in previous 18 mths.	Geophysics Geology in practice	Web page Email Conferences Help Desk Workshops Training	Owner as Director Decentralised	Owner personal recognition – Quality Australia awards Trade show recognition	Staff are encouraged to join their professional ass'ns.
HTP 2	Strategic Operational Management	Primary Offshore Expansion Secondary - Australia	Strong Market Push – Building Phase	Global Expansion – Cultural Adaptions	Prior to expansion Geology based – Expansion promotes new vision	Web page Email Training Help desk Indication of online possibilities.	Owner as Director of Company	Participation in Trade shows Industry Recognition Trade Awards	Individual professional association of choice.
HTP 3	Operation Essential	Global focus – utilities as a growth market	Long term global relationships	Driven by technology advancements – Significant product revision and cessation of some product support	Geology background – significant diversification in skill sets	Web page Email Help desk training	Hierarchical	Global recognition of technology product	By individual choice across markets

Table 6.8 Hypotheses Summary Post HTP

Proposition	High Technology Provider (HTP)	Organizational Technology Environment (OTE)	Sector Environment (SE)
1	Not tested in chapter		
2	Tested, confirmation sought in OTE √		
3	Not supported X		
4	Supported √		
5	Supported √		
6	Supported √		
7	Supported √		
8	Tested, confirmation sought in OTE √		
9	Supported √		
10	Not tested in chapter		
11	Not tested in chapter		
12	Not tested in chapter		
13	Not tested in chapter		
14	Not tested in chapter		
15	Not tested in chapter		
16	Not tested in chapter		
17	Not tested in chapter		
18	Not tested in chapter		
19	Not tested in chapter		
20	Not tested in chapter		
21	Not tested in chapter		
22	Not tested in chapter		

6.2. The Organizational Technology Environment

Organisational Technology
Resources Size Communication Relationships IT Champions Organizational Structure Workforce Characteristics

The Organizational Technology Environment represents the client organizations within the contextualized adoptive environment. In the mining space, junior organizations are exploration-only ventures. Mid-tier organizations may conduct their own exploration or purchase the exploration rights and data from a junior company. Mid-tier companies also mine and on-sell the ore, usually focusing on only one or two ore types. Major companies encompass both the junior and mid-tier operations but also have representation in a global market space in multiple ores.

The information previously shown in Table 1.2 is re-represented below.

Table 6.9: Mining Organizational Capacity (previously shown as Table 1.2)

Description of Organizational Mining Partition	Description of Participation
Junior	A company that is yet to generate revenue and is usually financing exploration projects via raised capital; the observations and measurements collected by this type of exploration company form the basis of a mineral reserve that will subsequently be sold, shelved or evaluated for mining.
Mid-tier	A company which is generating revenue and consequently has both exploration and mining operations.
Major	A company that has a significant exploration budget and also a large number of operations. They are involved in mining a range of commodities and often have projects in many countries

This section provides a discussion and analysis of the semi-structured interviews from the Organizational Technology Environment.

Organizational contacts were initially sourced from introductions provided by the high technology vendors. In order to provide representation across the mining value chain, organizations were selected that met the industry definition of junior, mid-tier and major. The organizational contacts were supplied with a copy of the protocol prior to the interviewee and were able to request additional information, select prospective interviewees or decline to participate. The participating organizations are shown in Table 6.10 below. A total of five organizations are represented, with nine interviews being conducted across the organizations.

Table 6.10: Organizational Technology Environment Representation

	Junior	**Mid -Tier**	**Major**
Exploration	OTE1 OTE2	OTE3	OTE4 OTE5
Feasibility/Analysis	X	OTE3	OTE4 OTE5
Extraction	X	OTE3	OTE4 OTE5

6.2.1 Organizational Technology Environment Profile

All interviewees represent organizations that operate within the state of Western Australia. OTE1 is in the process of moving from exploration-only to alternate activities, but has been a junior organization since 1993. OTE2 operates an office in Perth limited to exploration, although it is part of a major company whose corporate office is located in Canada and who operate mines globally. OTE2 was established in Canada in 1909 and owns significant diversified assets in North America. OTE3 conducts exploration and mining activities across Australia and exploration activities globally. It commenced mining operations in 1954 and continues to demonstrate growth. It also participates in a venture arrangement with OTE4. OTE4 is a large, diversified organization with a history of over a century of activities from the merger of two organizations. Its global operation employs in excess of forty thousand staff in over 100 operational areas. OTE5 is a diversified organization that has operated in Australia for over forty years as an Australian registered company, the parent organization having operated for over a century. Their asset investment for this period is in excess of $40 billion and all the Australian operations continue to grow.

6.2.1.2 Interviewee Profiles

All interviewees have individually been employed in the mining industry in their professional roles in excess of 10 years.

Table 6.11: Interviewee Profiles

	Employee Position	Sector duration	Employment Type
OTE1	General Manager	35 yrs.	Permanent - Retiring
OTE2	Geologist Geophysicist Exploration Manager	15 yrs. 15 yrs. 20 yrs.	Contract – staff Contract – staff Permanent
OTE3	Technology Manager - Geophysics	20 yrs.	Permanent
OTE4	Cross Technology Operations Manager	13 yrs.	Permanent
OTE5	GIS Manager Operation Technology Manager Mine site Manager	25 yrs. 15 yrs. 25 yrs.	Permanent Permanent Permanent

Where employees are long-term contracted, they are considered to be in staff positions and have responsibilities more typically assigned to a permanent staff employee.

OTE2 has professional earth scientists employed in this manner. The parent operation is located outside of Australia and the Australian function is limited to exploration. The exploration manager commented that when additional employees are required, they are employed on a short-term contractual basis but are not considered as staff. All other interviewees are permanent staff members in their respective organizations.

Following is a discussion of the research characteristics pertaining to the Organizational Technology Environment factor as described in Chapter 4 and derived from the analysis conducted in Phase 3.

6.2.2 Analysis of Interview of Characteristics for the Organizational Technology Environment

Resources

Organisational Technology Environment

Resources
Size
Communication
Relationships
IT Champions
Organizational Structure
Workforce Characteristics

Proposition 10 (P10)

Resource availability enabled at a localised decision making level increases the rate of diffusion.

Proposition 11 (P11)

An adopting organization perceives the cost of assimilating knowledge as a preferred option to the process of resource allocation within the organization in replicating technology available through a vendor.

Resources refer to the availability of resources for high technology products. Formally, these were operationalized as 'Slack Resources'- a term that implies idle or unallocated assets. In this study, the term is reduced to 'resources' which considers that the resources may be allocated on the presentation of an appropriate business case. This definition also better encompasses the structure of the sector, the organisational types, and whether funds can be allocated locally.

Junior companies are those participating in exploration-only activities and profit from the on-selling of valued-added mining rights post exploration. These companies account for approximately 80% of all resource companies listed on the Australian Stock Exchange and are responsible for most new discoveries (GrantThornton, 2009). The structures of these companies differ depending on the available investment; they are characterized by minimal staff and have no significant hierarchical structure; rather, it is a flatter adhocracy of partners. This structure implements a local decision-making policy and technology acquisition is on a strategic necessity basis.

OTE1: Technology acquisition is a significant issue for juniors. The outlay for technology can represent a major cost for new juniors or keeping abreast of technology changes. It is normally the recommendation of the senior geologist or exploration manager that will generate interest or awareness in the need for this kind of investment. It is usual for the choice of technology to be a well-known product that meets minimum requirements. In recent times one provider has offered lease arrangements which are being well received within juniors. For the first time we can have the technology for a period stipulated by us and with all the bells and whistles.

OTE2: We make recommendations to our corporate office with the business case and we rarely have a problem. This being said as an exploration venture our needs are pretty specific functionally and we have little interest in the capability of the any technology outside these functions. Our technology is industry standard and our information handling outside of acquisition is managed by an outsourcing company. We minimize costs in terms of technology.

The cash limitations of the venture structure of juniors, appears to limit the interest of these organizations, deterring them from either creating or acquiring technology other than through a vendor. Therefore, the concept of assimilation does not appear to be relevant to junior companies.

Whilst junior companies undertake local decision-making processes, they have little interest in technology outside of their immediate need; rather, cost minimization appears to be the major driver. This correlates with the findings of GrantThorton's (2009) survey where 70.2% juniors highlighted the need to make reductions in the future financial year. However, the view of the junior vendors in selecting a high technology product regarded as a standard suggests that some technologies/ or classes of technologies diffuse and are in fact assimilated into the sector environment. Such diffusion and assimilation suggests to the researcher that the context holistically is a driver and that the participants within the minerals mining sector are influenced by networks of associations rather than by the traditional organizational adoption and diffusion characteristics described in previous research (Zmud, 1982; Nilakanta & Scamell, 1990; Damanpour, 1991; Fichman & Kemerer, 1997).

Mid-tier companies have some production capability and usually operate a set of specific mineral operations which enables them to develop expertise in the relevant mineral exploration and extraction processes. Price Waterhouse Cooper's Aussie Mine, Rise & Shine report (June, 2010) sees a 32% growth in revenue in the preceding 12-month period. Furthermore, from July to September 2010 the same level of growth occurred as market commodity prices increased. The increase in investment has provided expansion opportunities resulting in a review of assets including a technology review.

OTE3: We were in the position of reviewing our technology suite and the management of those operations. Although corporate technology suites are managed centrally, the provision of mine related services are provided at the minesite. These are separated into GIS and other technologies, each having their own budget. Two years ago GIS was cut back to the bone but we have now revised this operation and have re-negotiated and updated the technology and contract. The drive for the contract revision and update was led by the GIS staff. Prior to the cutback the GIS manager could have authorised the acquisition, however since this time a business case must be forwarded to a management acquisition panel. This is also true for other technologies. The initiative is expected to generate from the users or technologists.

OTE3 indicated that technology is not developed within the organization with the exception of GIS where a user interface was developed for a front end to the then previous version. This was the outcome of various add-ons that complicated the operation of the product. The interface was an easier option for the general user population and was distributed to all operational mine sites. Technology providers are perceived as the given mechanism for technology acquisition; in-house services are limited to user interface, training and similar services. Budget is not allocated for technology resources and development.

Mining Operations in the mid-tier partition exhibit specific needs which address the mineral asset. For example, mineral sands are located near the surface, whilst quality iron ore is located at substantial depths. The class of technology and capacity is, therefore, driven by the market for this product. Additionally, OTE3 run a number of operations and, as stated above, technology assets are managed at each mine site rather than as an organizational acquisition across all operations.

The exception, as indicated, is the GIS technologies which were adopted by OTE3 upon acquisition of another mining operation which employed the technology to produce significant benefits. OTE3 management then diffused this technology across their other operations but centralized the control as they wished to replicate the benefits already identified. The rationale lay in the customization and significant level of expertise already achieved by the acquired operation. Mining operations within the mid-tier partition have historically managed the acquisition and management of IT products locally due to factors pertaining to the lifetime of the particular mining operation. These include the estimated lifetime of the mine, the value of the mineral resource, difficulty of extraction and market price. A mining operation may be suspended virtually overnight should the market return plummet. The provision of IT contracts to a specific venture/mine mitigates losses to a particular operation rather than being carried across the organization in the event of a downturn.

The Aussie Mine, Rise and Shine Review (2014) still sees mid-tiers as profitable to a lesser degree than in preceding years. However, it notes the loss of some companies as a result of the mining downturn and as a result the remaining companies look toward consolidation and a conservative approach.

Major organizations operate in all functional areas of the mining value chain both domestically and in the larger global market. Majors have traditionally undertaken R & D operations and have reported technology advancements although primarily in the mining excavation and extraction domain.

OTE4 operates an R & D operation and develops specialist technologies which are used internally to meet the goals of the operation. Technologies developed internally have not been marketed outside the organization to date. Limited specialist developments are partnered with external experts and are subject to non-disclosure arrangements. Traditional technologies marketed in the wider mining space are not reproduced by the organization and acquired in the normal contractual manner. Mining operations conducted by this organization are siloed (run independently of any other mining operation) and economies of scale in terms of technology acquisition are not sought. Products acquired from providers represent best practice, although there is no norm regarding silos since individual investment partnerships may influence any acquisitions.

Assimilation, a traditional barrier to adoption, is no longer an issue as responsibility for knowledge of industry standard technologies is pushed back to the employees whether contract or permanent staff. Contract employees are expected to be 'work ready' (www.edumine.com), which includes being conversant with technologies which are used within the profession. Therefore, by purchasing and maintaining technology through interaction with the high technology providers, assimilation barriers and costs are reduced, especially as the costs cannot be spread across an organization where the main form is based on venture capital structures.

OTE5 also conducts an R & D operation the focus of which is extraction technologies. Once again the technologies are for internal use only and are rarely discussed outside a small team of persons. The organization has undergone a holistic review of mining technologies (outside of extraction and processing), initiated by technologies no longer supported and non-performing, and is undertaking a strategy of replacement/update to match future organizational needs. Whilst management has endorsed this major undertaking, users remain unconvinced of the outcome. Previous acquisition was performed without consulting users about their needs.

OTE5.1: In 25 years I was not consulted at any time regarding the introduction of a technology. They've been selected by accountants or engineers and we've been told to make it work.

OTE5.2: I had to fight tooth and nail for 5 years to implement 'product x' despite the obvious need and the advantages it would accrue. Now that this product has a high profile and its use is standard in mining we still face battle with the accountants at every corner. No training is provided and it's up to the users to seek assistance via blogs, user groups etc. when we need assistance.

OTE5.3: (Please note English is not the first language of this interviewee) The technology people have had training for deployment but we have no idea how the whole plan will ultimately unroll. From the perspective of deployment and testing *initial installations have been good but they are not in use. I'm not sure from the user perspective what evolves, but I am optimistic despite the problems highlighted by mine people.*

The major organizations structurally are hierarchical and practise a bureaucratic style of administration; however, they have little in common in their approach to technology acquisition although both organizations use a centralized management authority in determination of acquisition of technologies. OTE4 users appear to have some input into the choice of product and provider, whereas OTE5's product acquisition is determined outside of the mining functional area where it will be utilized. OTE5 interviewees all strongly saw a history of a technology being imposed without consultation with users or regard for their needs. Interviewees 1 & 2 from OTE5 are both 25+ year veteran employees with strong opinions about the management approach and see assimilation as a non-issue for management. Instead, anecdotally staff members rely on each other for transmission of skills in an ad hoc manner based on the relationships that exist in the organization. The strength of network ties appears to be a prominent feature in the transfer of information within this organization, resulting in fragmented knowledge and an organizational divide between users of the technologies and the management whom are seen as remote decision makers.

The segmentation of mining companies into junior, mid-tier and majors exposes significant differences in approaches to technology and the input/consultation of users. From the interviewees' statements it appears that the juniors have the most consultative approach and are influenced by usage patterns across the mining sector which they perceive as a norm or standard, thus making the data more readily transferable and able to be sampled for evaluation purposes. This, however, must be offset by the financial constraints experienced by juniors and the limited requirements of the segment. Mid-tier companies are experiencing a growth period but technologies are acquired once again from the perception of standards in terms of functional usage. Resource control in terms of budget allocation was surrendered in the recent past, although users feel that their input remains a driver for change. Once again, majors appear to be the most constrained by the centralised structure and change is slow and without user consultation.

Proposition 10 sought to substantiate an increased rate of diffusion through a more dynamic local decision-making process. This appears true in the case of junior companies where there is a limited technology requirement and changes within the sector will propagate quickly through the juniors as a necessity for continuity although borne against cost drivers. However, this proposition cannot be substantiated by the current interviews outside of the junior sector. Interviewees indicated that a preference for particular technologies appears to exist based on a subjective understanding of a 'standard'. However, the use of a standard is particular to the context and should not be considered as a model or best practice or indeed to a particular product or provider. It refers to the most common format utilized in Australia for the capture of exploration data in its original form and its subsequent maintenance or utility. Indeed, there is no pre-defined legislated format. Therefore, a number of high technology providers offer products which meet this requirement. However, the market has evolved to allow a number of dominant providers within each mining sector whose products meet the capabilities to either capture or transform such data. Further constraint is evident in the interviewees' statements that the centralization of technology acquisition and the removal of localised budgets maintain the technology status quo resulting in less innovation in functional areas.

Proposition 11 looked for confirmation that assimilation of technologies is a preferred option to investment in R & D for in-house replication of technologies available from providers. All junior and mid-tier companies have a practice of technology acquisition rather than an internal research and development strategy. This is based purely on the cost of research and development and the availability of suitable technologies for the environmental context within which they operate. Majors possess the necessary resources and have developed technologies that are unavailable outside their organizations. However, all interviewees also indicate that management has little regard for the internal cost of assimilation of technologies. Whilst it appears that sourcing technologies from providers is the preferred approach for non-extraction technologies, in the mining domain there seems to be an expectation that employees should have the skills to use the technology that is required by their professional role. This expectation relieves organizations of the cost of assimilation, leaving them to bear only the acquisition costs. Therefore, Proposition 11 cannot be substantiated as management perceives no preference based on the need for organizational assimilation. However, as stated earlier in this chapter, the context itself may contribute to a form of assimilation borne through professional networks and the perceptions of the earth scientists' recognition of industry requirements that are de-facto standards.

Size

Organisational Technology Environment
Resources **Size** Communication Relationships IT Champions Organizational Structure Workforce Characteristics

Proposition 12 (P12)

Organizational size will be positively related to the rate of diffusion.

Proposition 13 (P13)

Diffusion of radical innovation is negatively related to organizational size in large organizations.

Organizational size has been the subject of opposing views ranging from an assertion by Nystrom et al. (2002) that there is a positive relationship between size and the ability to innovate to that of Wilson et al. (1999) who see it as being problematic as a single-dimension characteristic. The segmentation of mining organizations into junior, mid-tier and major reflects the organizations' ability to participate in the mining value chain. These segments also reflect organizational size. If organizational size is positively related to diffusion within the mining context, the expectation will be that diffusion would be more evident within the major organizations. Radical innovation would be indicated by diffusion within juniors or mid-tiers where a flatter hierarchical structure theoretically leads to a greater capacity to innovate and absorb radical innovations.

Juniors, although involved only in exploration activities, will adopt technologies quickly where visible benefits are evident primarily from improved process or the prospect of financial benefits.

OTE1: The availability of technology by lease arrangement, by one provider, for acquisition of exploration data proved an immediate success. This is the first innovation that has been specifically aimed at juniors. It was introduced just at a time when the juniors were feeling the pinch and we required no expertise, HTP1 managed everything. There was even a further option for data cleansing.

When querying OTE1 as to whether they would adopt a radical innovation, the following response was obtained.

OTE1: If the sector required a different technology we would meet the need but radical and exploration aren't terms usually found together.

OTE2 acts as a junior within Australia but is part of a major mining organization based in Canada and conducting mining operations globally. Three interviewees represented this organization and operate as staff, but are long term contract employees. They indicated they had little interest in technology apart from its immediate use to record data or had indeed little interest in the quality of the data.

OTE2: As our parent company is based in Canada and our operations are limited we stick with tried and true. We are aware of other options but we just don't require anything.

These interviewees differ from the other participants in that they appear almost uninterested in the technology or the other benefits that the technology might provide. This organization also stands apart in that it outsources the management of its data. When asked whether this was normal practice, based on the parent company policy, they responded in the negative. OTE2 adopted this approach because of the terms of the contract (in mining terms) which limited its life expectancy in Perth. The interviewees, when asked about the attitude of the parent company, expressed the belief that the parent company would be innovative in terms of technology in their global operations where their contract period would be substantially long term.

OTE1's remarks indicate that juniors will innovate but only when there is a specific rationale for doing so, such as a financial benefit either from reduction in the ownership of technology and/or an associated process improvement as the technology is managed by the vendor. OTE1 also commented that the diffusion of technology in exploration was historically slow. The initial introduction of technology was expensive, cumbersome, and required technology expertise. These factors limited the initial interest from juniors. Additionally, there was resistance from geologists who were skilled in exploration techniques and had no incentive to adopt new technologies. The 1990's mining boom stimulated the sector and organizations began looking at technology afresh to maximize profits. The reluctance of individuals to adopt technologies was overcome by the push of organizations to acquire quality data quickly to produce profits and maximize opportunity. In terms of employment, preference was given to those individuals who were already technologically competent.

OTE3 is a mid-tier organization and had long been interested in technologies that were designed to maximize extraction processes. This outlook had pre-disposed the organization (in the opinion of the interviewee) to consider the potential for technologies outside of the extraction process. As in the case of the junior organizations, the mining boom stimulated interest and technologies were adopted across the mining value chain.

OTE3: Each technology group originally had its own budget and was able to purchase/upgrade appropriate technologies on the development of a business case. Some technologies were managed at a corporate level others were managed at a mine site location. In recent years the technology groups have all become corporate entities as financial constraints have been imposed across the organization. Most upgrades have now been postponed.

When asked the reason for constraints, the interviewee indicated that declining commodity prices over a number of years (in their particular commodities) caused by the introduction of new operations from South America and Africa, had seen cutbacks throughout the organization. Although technology was not an isolated instance or a cutback target, it was considered less important than operational activity. Corporate management of all assets and sites was seen as extending the viability of the organization until prices steadied.

OTE3 saw that as an entity, this organization was innovative when budgets were operated locally but as a centralized body it had become rigid.

A major organization, because of its size and resources, has the capacity to adopt new technologies. OTE4 is the outcome of a merger between a major and mid-tier organization over the previous six years. In this instance, the mid-tier organization possessed superior technology in terms of exploration management and GIS. The major organization reviewed the technologies and incorporated these into the existing organization and modified their organization to acquire the same benefits. Despite redundancies across the mid-tier company, the ICT areas were left untouched as the major organization recognized the need to retain the organizational knowledge that was required to produce the technology benefits. Contracts were also re-negotiated with those high technology providers responsible for the technology products. The technologies are managed as siloed operations. Each mine site is responsible for day-to-day management with specialty corporate overseeing of contract negotiations and a coordinated support function. OTE4 demonstrates a willingness to adopt those technologies whose benefits are obvious. The siloed operations require that technology contracts be managed individually, rather than deriving financial benefits that might be achieved by a corporate level arrangement.

As a major, OTE5 has historically lagged behind in the introduction of technologies which have been selected and implemented without input from the users. This remains true of the current overhaul and major update of all technologies related to their operations within the mining value chain in Australia. This update was initiated by aging hardware, data quality issues and inability to access information in a timely manner. This posed a significant problem to the daily operation of mining activities and the associated corporate functions. External consultants were utilized to assess options and implementation plans. Operational staff members were subsequently informed of the choices and timelines and were expected to incorporate changes while maintaining current mining schedules.

The segmentation of the mining value chain and the respective characteristics of each segment introduce a level of individuality to each organization which reduces commonality across the mining value chain segment when viewed by partition. This is summarized in the table below.

Table 6.12: Organizational Size Summary

	Mining Segment	**Level of corporate hierarchy**	**Localised Decision-making**	**Willingness to adopt by users**	**Barriers**
OTE1	Junior	flattened	yes	yes	Financial
OTE2	Junior	flat locally	No (global offshore parent)	Display no interest	Nil
OTE3	Mid-tier	corporate	Now corporate: Prior to 2009 local	yes	Declining commodity prices
OTE4	Major	corporate	No	Yes	Corporate business case
OTE5	Major	corporate	No	Yes	Corporate control

Proposition 12 postulated that organizational size would be positively associated with the rate of diffusion. Whilst there can be no doubt that resources exist for the acquisition of technologies, current market restraints have tightened corporate spending with localized decision-making having been replaced by corporate control of acquisitions. Despite the move to centralization, OTE3 and OTE4 have both demonstrated the ability to adopt technologies where there is evidence of organizational benefit. Additionally, OTE5 has undertaken a major replacement of all technologies despite a period of limited growth and the Australian government’s threat of imposing taxes on mining resources. It appears that the acceptance of a technology by a major organization also permits the technology to diffuse since interoperability between joint venture partners acts as a driver. Therefore, in this research it appears that support exists for the proposition that organizational size is positively related to diffusion in a complex, multi-layered environment.

OTE1 has indicated that financial limitations constrain juniors and that the scope for radical innovation is unlikely. However, they demonstrated rapid adoption of a technology when an innovation presented itself that provided an alternative means of gathering exploration data and the technology represented a significant advance. The benefits associated with the particular technology (which was targeted at juniors) demonstrated the ability of juniors to be agile in adoption, and the rapid diffusion of the technology when the benefits were found to be reproducible. The rapidity of the decision and adoption process is unlikely to be replicated within the majors where the centralized bureaucracy of acquisition limits innovation. This may lead to an argument that juniors are capable of rapid innovation when required and supports Proposition 13. The larger segments with a centralized bureaucratic procurement processes are capable of transformation but lack the agility to be innovators or early adopters. Therefore, Proposition 13 is supported across the context.

Communication

Organisational Technology Environment
Resources Size **Communication** Relationships IT Champions Organizational Structure Workforce Characteristics

Proposition 14 (P14)

The ability of users to access rich information of an innovation increases the positive perception by users of the technology.

Proposition15 (P15)

Users who possess a positive perception of a technology are more likely to assimilate change.

Proposition 16 (P16)

Organizational interest in a technology is primarily instigated by contact from a high technology provider utilizing existing communication channels.

Rogers' (1983) Diffusion of Innovation model found that communication channels were a major factor in understanding the transmission of information in regard to an innovation. Communication technologies continue to be pervasive in the day to day working lives of western nations and organizations where ability to access information is an expected norm. High Technology Providers have recognized the value of modern communication channels, especially the internet and email. Both provide a mechanism for contact that may be rich, yet non-invasive from the client's perspective. The push mechanism employed by the high technology providers may now be reciprocated by a pull mechanism from adopting organizations. The pull mechanism may be independent of contact from the high technology provider's contact as organizational users seek information on new technologies or updates to existing acquisitions. The rich web pages of the high technology providers allow users to become informed without the necessity or desire to communicate with providers.

All OTEs indicated that when researching a technology of interest they will access information via the internet. The expectation from OTEs is that high technology providers will impart product information using sufficient rich media content to indicate whether the product may be of further interest. A lack of appropriate information would signal a lack of commitment from the high technology provider and a decrease in interest for any follow-up with the provider.

This may be summarized by OTE3 who perceives himself as a technology advocate in his current role.

OTE3: I'm interested in the benefits of technology both personally and at work. Not surprisingly I keep in contact with others who are like-minded and if I hear something favourable then going to a web site is an easy option. If there's nothing there to hold my interest I won't go back, I'm too busy to waste my time. First impressions are important and as a norm I'd suggest that the webpage for any company in mining/mining related activities is the first stop for gathering information.

OTE1 scans the relevant technologies more frequently since HTP1 introduced an improvement that produced dramatic savings for juniors. Prior to this event, the technology providers' web pages were not significant priorities as juniors require less in terms of new technologies and emphasis was placed on data quality.

OTE1: The introduction of technology X by HTP1 caught us by surprise. It has produced some significant savings both from a cost perspective and a process view. Whilst exploration has limited technology requirements the savings were significant *enough to ensure organizationally we pay more attention to this area and will be checking in future for news of updates and the like.*

When asked about the means by which OTE1 was made aware of technology X, the organizational representative indicated a colleague was informed via their professional network. This concurs with previous discussions of the importance of ties and demonstrates the strength of a professional network within this context. Organizationally, it may suggest that in particular contexts there exists a dual network: an intra-organizational one and an external professional network that bypasses the concept of a gatekeeper (for the organization) and exerts an influence that previous studies have not considered significant.

OTE1 indicated that the one of the main benefits of the latest technology solution that was adopted was that the high technology provider managed the software/hardware combination; moreover, learning the technology was simple. It varied little from the current technology used and required no additional knowledge. In fact, it freed up resources that were previously required for data management.

When asked about the quantity and quality of providers' web pages OTE1 stated the following.

OTE1: I'm an old guy, but do expect to find sufficient information on the web pages to make a formative judgment as whether to proceed with contacting the provider. This is what happened with the latest technology. However the recommendation of an associate carried great weight. I followed up firstly with the web site and then made contact. I've known the MD casually over a number of years and his word is to be trusted.

When asked if the perception of a provider would affect users' expectations, OTE1 indicated that as a junior their needs were limited, but HTP1 was known to staff and the general feeling was that it was a good move as the products were generally considered to be high quality and therefore not problematic. The personal reputation of the managing director also appeared to carry significant weight. Once again, within this sector, the ties and personal reputations carry significant weight through professional contacts and associations. When asked if it would be normal practice for juniors to contact the high technology providers, the interviewee indicated that whilst they had contact from providers, at times their segment's (junior) needs were limited and they would be followed up when needed. It appears that the opinions of professional network members carried equal, if not greater weight, when creating an initial interest.

OTE2 showed little interest in the use of updated technologies and, as previously indicated, this appears to be an outcome of a short-term contract employment basis. Staff have no expectation of continuance and whilst are professionally aware of advances have no interest in pursuing these within their current employment. Their professional knowledge is derived from professional associations and personal development within their profession rather than from electronic communication channels. These professional ties and the transfer of knowledge via this channel is a significant factor for all interviewees and emerged as a recurring theme throughout the interview process.

OTE3's interviewee regularly reviews web pages and acts as a technology advocate within this organization. This person indicated that he may be considered as an early adopter in personal technologies and is therefore disposed to 'keep in touch' with technologies utilized within the workplace. OTE3 indicates that 'keeping in touch' with technologies is limited and influenced by existing relationships that have endured over a number of years in the workplace. Selection of high technology products within this organization has rarely seen a change of vendor, and the existing relationships are strong and highly valued. The push from the existing vendors appears to strengthen the relationship, reducing the effect of competitor marketing. OTE3 also indicates that because of this regular contact, there is little need for a push attitude from providers to this organization.

OTE3: We have investigated alternate providers but have not pursued these avenues.

When asked if financial commitments were a factor, OTE3 responded:.

OTE3: In fact the existing vendors are the most expensive however we value the relationship and understand how that relationship functions. Additionally we are comfortable with the technology and our processes are geared over a considerable period of time to that technology.

OTE 4 and OTE5 are major organizations but operate in different ways in terms of technology acquisition. OTE4 operates its mining ventures as silos. Each technology is licensed for that operation in isolation from other operations regardless of size. OTE5 has centrally administered its technology and looks for financial savings in acquisitions.

In the past, OTE4 has acquired technologies where benefits have been evident. The technology manager states that, in his role, he scans web pages as a matter of course. Vendors also communicate with his office regularly given the siloed operations and therefore the possibility of sales. OTE4 states that the needs of each operation are evaluated in terms of mineral type, green or brownfields operation, infrastructure over the life of the mine and the controlling venture partner. The awareness for this major is matched by a pull mechanism whereby information is expected to influence the decision-making process.

OTE4: The expectation of relevance needs to be met otherwise I won't be enquiring further.

When undertaking a major review and replacement of technologies, OTE5 relied on consultants to make recommendations. Three consultants were asked to submit recommendations. Users were consulted on their functional requirements and limited interviews were undertaken with selected managers by all three consultants. Feedback from the three interviewees indicated that none perceived that their requests were considered to maximize their needs. At the time of writing, selected small projects have commenced. However, given the size of the undertaking, no feedback has been provided regarding any outcomes of the overhaul process. Initial reports from the interviewees indicate a level of pessimism born of a history of past technologies foisted on users without any consultation.

OTE5.1 : I've seen it before, someone has decided that a product looks good and we are told to make it work. This is what happens when accountants are allowed to run the business. Mining isn't like other industries, you can't make something fit for purpose when it was never designed for it in the first place. In one of the last times (interviewee referring to the introduction of a technology) we ended up having to re-test 30,000 samples to get the correct data.

This level of pessimism impacts on the assimilation of a product and indicates the importance of involving the users early in the project. Repeated instances of this approach, in this organization, have inured staff to the introduction of new technologies which is intended to benefit the users but in fact increases their workload without any additional support being provided.

OTE5.2 : It is my opinion that a good perception of a technology is always a bonus. Unfortunately as indicated by OTE5.1 there has been a history of technology choices that weren't always perhaps appropriate. This has led to some degree of mistrust amongst some staff.

When asked if they visited web pages of technologies they were interested in obtaining, all replied they had done so in the recent past. Only one of the interviewees made regular visits due to personal interest and the fact that he belonged to a user group where information was regularly posted. All interviewees from OTE5 are long-term employees; two are approaching retirement and possess detailed knowledge of past implementations and the outcomes both at an organizational level and from the perspective of a user. . Both also indicated that no succession planning was in place to retain the implicit knowledge of employees.

A summary of findings for hypotheses associated with the communication characteristics are shown in Table 6.13.

Proposition 14 saw the user's ability to access rich information of an innovation as increasing the positive perception of the technology. The summary table indicates that organizations have an expectation of rich media whose absence creates a negative perception of the high technology provider. Rich media for the interviewees is primarily not a technical description, but rather a comprehensive description which includes both utility and fit-for-purpose information. This type of information appears to be best conveyed through case studies that have an outcomes-based focus. An additional aspect is the influence of third party professional recommendation as a catalyst for seeking information. Overall, Proposition 14 appears to be supported by the comments of the Organizational Technology Environment interviewees.

Table 6.13: Communication Summary

	Utilization of the web for product information	**Expectation of rich media**	**Lack of information affects perception**	**Perception affects assimilation**	**Direction of initial communication**	**Existing communication channels**
OTE1	Yes Based on recent experience	Yes	Yes	Yes– limited requirements but comments indicate the value of reputation carrying positive perception	Pull – from organization to provider	Web followed by call to MD (based on relationship)
OTE2	Marginal interest	Yes	Marginal interest	No	nil	nil
OTE3	Yes	Yes	Yes	Yes – super users pass down information and accepted as a cultural expectation.	Pull from technical advocate based on personal interest	Web followed by email
OTE4	Yes	Yes	Yes	Yes – super users direct and control	Push from providers	Email contact from existing providers
OTE5	Yes where there is motivation to access. Strong centralized culture acts as a disincentive.	Yes	Limited yes based on removal of input from users as a centralized hierarchy	No – centralized control reduces user control.	Pull by organization	Consultant acts as third party

Proposition 15 suggested that users with a positive perception of a technology are more likely to assimilate change. This appears to be borne out in general, although the interviewees temper their responses with comments that indicate a technology which provides value and creates employment possibilities will also engender interest and a need for a specific skill set, thereby increasing the likelihood of assimilation. The summary table above, whilst indicating that a positive perception will increase the assimilation, suggests that further research focusing on specific scenarios may be required to establish whether alternate or concurrent rationales for assimilation exist.

Proposition 16 queried whether organizational interest in a technology is primarily instigated by contact from a high technology provider utilizing existing communication channels. The summary table suggests that in this study organizations are aware of the high technology providers and are prepared to initiate contact at a time that suits the organization or the technology advocate when required. The availability of rich media via the internet appears to have displaced the older traditional concept of communication as a push-only mechanism for the high technology providers. According to the interviewees, it appears that there exist bi-directional relationships between some high technology providers and their client organizations which also moderate traditional communication mechanisms. Thus, this proposition is not supported by this study.

This study's findings regarding this characteristic suggest that the availability of rich media modifies adoption behaviour, and that communication from high technology providers need no longer be directed towards a single organization. Instead, it may be construed that well-constructed rich media available continuously to informed users acts as a significant marketing approach for high technology providers.

An additional outcome from this characteristic is the importance that interviewees attach to professional associations and ties within their community. The recommendations for high technology products which stem from the professional network are increased by the weight of personal reputation and knowledge from within the network of association. This recommendation may act as an initiator of interest and information sources for other members, also supplementing the activities of the high technology providers.

Relationships

Organisational Technology Environment
Resources Size Communication **Relationships** IT Champions Organizational Structure Workforce Characteristics

Proposition 17 (P17)

Weak peer to peer relationships contribute positively to diffusion of an innovation.

Proposition 18(P18)

Weak peer to peer relationships contribute positively to the assimilation of an innovation.

Relationships represent the network of associations within which individuals operate in the contextualized environment. A key element of Rogers' (1962, 1985) Diffusion of Innovation Theory was the social system that propagated the diffusion. The social network (peer-to-peer) in organizational diffusion studies appears to have been largely disregarded in favour of more formal organizational relationships where hierarchical structures remove the individual's ability to directly acquire goods and services. However, the mining context is characterized by employment on a contract basis (both short and long term) where professional competence and recommendation are highly valued. The contractual basis for employment does not readily establish organizational loyalty; rather, it appears to reinforce the value of alternate social networks. In the mining context, this is present within the professional associations to which earth scientists and mining professionals belong. Professional associations are in evidence and are strongly supported both in Australia and globally. These associations commence in university where student chapters exist and are continued throughout the professional lifetime and into the retirement of the individual (http://www.ausimm.com.au) .

All interviewees indicated that they belong to their respective professional associations. The technology managers all possess undergraduate degrees in earth sciences and moved into technology management later in their careers as information systems became increasingly integrated with mining exploration and production. The interviewees were asked to comment on the strengths and value associated with their membership. Table 6.14 provides a summary of responses.

Mining engineers, geophysicists, geologists and other earth scientists are often employed on a contractual basis and therefore may move between mining locations within Australia. When asked about the composition of the professional associations, remarks from OTE1 are representative of interviewee's responses.

OTE1: Our associations tend to be a mix of older permanently situated members. Many move to consultancy as experts and travel in their roles from a permanent base. Younger mobile graduates making their reputations and moving on as contracts come and go. A middle group especially in Western Australia where there has been sustained mining activity who are to all purposes permanent staff members of a particular company. There are also persons who maintain membership who have moved into other areas of occupation whether in mining or other activity and retain their membership for either social or business contacts.

Table 6.14: Professional Membership Profile

	Membership	**Active Participation**	**Perceived benefits**
OTE1	Yes	Yes	Knowledge of mining activity
OTE2 (panel of 3)	Yes Yes Yes	Yes Yes Yes	Potential contracts News of Colleagues Incident reports
OTE3	Yes	Yes	Certainly technology updates
OTE4	Yes	Yes	Changes in products, contacts Gossip of on the quiet happenings
OTE5 (panel of 3)	Yes Yes Yes	Yes Yes Yes	Updates of mining activity not normally reported in the public arena Contract Information

Interviewees were also asked whether contact is maintained outside the professional association.

OTE5 -1: If you're active you will see people regularly enough not to require additional external contact unless there are friendships formed. It's quite easy to locate persons through the associations if you wish track down an individual.

Finally, when asked if the recommendation of associates would influence the choice of a technology, all interviewees agreed that this would be the case. Professionals in the mining context value their reputations highly as it is a primary means of evaluation in contract employment in a closed context. Equally, professional associations to which mining professionals belong require its members to conduct themselves in a professional and ethical manner as stipulated in the associations Code of Conduct.

Proposition 17 (P17) suggested that weak peer-to-peer relationships contribute positively to the diffusion of an innovation. This proposition is supported by the statements of the interviewees, as well as their comments on other characteristics regarding the utilization of professional bodies as a primary network.

Proposition 18 (P18) posited that weak peer-to-peer relationships contribute positively to the assimilation of an innovation. There is no evidence to concretely confirm that weak peer-to-peer relationships contribute to the assimilation of the innovation. Traditional post-diffusion assimilation falls within the domain of the organization and the change management processes engaged as an innovation is normalized within the environment. However, it has been previously based on the premise of a permanent workforce which, in this context, is displaced by contracted employees. There remains the previously ignored (in existing research on diffusion) notion that contract staff are required to maintain the appropriate skills necessary to remain competitive within their contractual context and that these are not the financial responsibility of the organization to whom they are contracted. Given the time constraints limiting the scope of this study, future research may seek to investigate the effect of the change in employment practices to casual and contract employees across a range of diffusion characteristics.

IT Champions

Organisational Technology Environment
Resources Size Communication Relationships **IT Champions** Organizational Structure Workforce Characteristics

Proposition 19 (P19)

The existence of an IT Champion contributes positively to the diffusion of innovative information systems/technology.

Proposition 20 (P20)

The existence of an IT Champion contributes positively to the assimilation of an innovative information system/technology.

This research defines the IT champion using the definition provided by Prescott and Conger (1995, page 25), "Champion support for an innovation means that someone within the organization becomes a special advocate for the innovation, taking actions to increase the probability of successful adoption and implementation".

The presence of an IT champion that meets the definition above is limited to two organizations only within the study, OTE4 and OTE5. These interviewees are employed by organizations that are majors in the sector and context.

The OTE4 organization adopted the information system/technology on acquisition of another company. The benefits of the particular technology were not already in existence in OTE4 and were not only retained in the existing operations, but were subsequently acquired and distributed throughout existing operations.

OTE4: OTE4 as an organization perceived the technology as beneficial and meeting a gap in their current operations.

OTE4 indicated that in his position as both the manager and advocate of the technology, he was retained to maintain and introduce the technology across OTE4 and their operations. OTE4 maintains a continued interest in the technology and promotes the technology by producing a newsletter for all mining silos who now utilize the technology as a corporate mandate. Additionally, OTE4 also uses a blog which deals with problems and solutions for the overall user group. Even though the organization values the technology, OTE4 feels that his extended activities (blogs and newsletters) promote an unseen capability that would otherwise be overlooked. OTE4 also has seen the use of technology expand within the organization and perceives this to be partly due to his actions which demonstrate the potential of a technology beyond its original acquisition rationale.

OTE4*: I have people come to me know to ask if 'the technology' could do a particular task. I don't think this would have happened without pushing the newsletters and blog.*

There is no doubt that in this case OTE4 acts as an IT champion, although this is a self-imposed role. His actions are not promoted by the organization or recognized officially.

When asked if these activities were required as part of his position description OTE4 replied:

OTE4: *When I came over to this organization I needed to reach out to various sections and chose to maintain the activities. The answer is no, it's not part of the job, but it helps me manage the technology and educate the users. I feel it is recognised by management as a valuable contribution.*

OTE5 introduced an information system/technology after the continued promotion of OTE5 -1. This occurred more than 20 years ago. In addition to the business case, OTE5-1 delivered numerous presentations which were recorded and distributed across the operations within Australia. After receiving funding for initial development, OTE5-1 continued to deliver presentations throughout the organization. During the intervening time, OTE5-1 has continued to promote the technology and its benefits as the technology has evolved since its original deployment and use. OTE5-1 stated that the relationship with the high technology provider has ebbed and flowed over the twenty year period, but the technology is superior and, reportedly, provides advantages to the organization in a number of areas.

OTE5-1 continues to promote the technology by providing periodic updates to users; moreover, he acts as an intermediary between users and the high technology provider. He maintains a database of calls and solutions which can be accessed by other users of the technology. OTE5-1 has personally invested time and effort in the long-term promotion of the technology and has acted as a visionary in its initial acquisition when little corporate interest was demonstrated. His actions have incorporated the product far beyond its specific use and he maintains an active interest despite his approaching retirement.

As a junior, OTE1 uses specific technology which has explicit functionality and therefore does not require an IT champion in the defined role. OTE2 has indicated little interest in technology and operates in the same manner as OTE1.

OTE3 operates at a personal level when promoting the use of technology; however, he feels that he does not operate within the terms of the provided definition. Over the past five-year period, corporate restrictions in respect of technology products (outside of production) have been gradually increased. OTE3 continues to promote the use of technologies but feels that centralized corporate strategy reduces the effectiveness to nil outside that of interested user groups.

OTE3: *I was effectively notified that corporate strategy was not interested in technology updates/new technology unless it was production oriented.*

Table 6.15: IT Champions

	IT Champion	**Diffusion**	**Assimilation**
OTE1	No	No	No
OTE2	No	No	No
OTE3	Yes	No Recent	No Recent
OTE4	Yes	Yes	Yes
OTE5	Yes	Yes	Yes

Proposition 19 (P19) promulgated that the existence of an IT Champion contributes positively to the diffusion of innovative information systems/technology. Within the mining context, IT Champions appear to exist only within the mid-tier and major organizations. These two segments on the mining value chain require a wider spectrum of technologies within a larger context of activity. The width and depth of these organizations may contribute to the development of IT Champions. Despite the assertion by OTE3 of not meeting the given definition, his actions continue to promote the use of technologies and assist in the assimilation within the organization. Proposition 19 is therefore considered to be supported in mid-tier and major sectors of the Organization Technology Environment.

Proposition 20 (P20) suggested that the existence of an IT Champion contributes positively to the assimilation of an innovative information system/technology. IT champions exist within the major organizations where more diverse technologies are being utilized. The activities of the IT Champions appear to have contributed to the assimilation of technologies. This can be demonstrated by the access of blogs and databases and also the querying of OTE4 by other areas to assist in localized problem-solving, and by the actions of OTE5.3 who is an ongoing advocate within his organization. Thus, Proposition 20 appears to be supported in the major sector.

Organizational Structure

Organisational Technology Environment
Resources Size Communication Relationships IT Champions **Organizational Structure** Workforce Characteristics

Proposition 21 (P21)

A centralized organizational structure negatively impacts the unit adoption of an innovative technology.

In this study, Organizational Structure refers to the organizational hierarchy in terms of the managerial approach to formalized acquisitions of innovative systems. Previous studies have operationalized factors in terms of centralization, formalization and vertical differentiation (Damanpour, 1991; Fichman, 1995).

Previous research indicates that the more structured and layered the organization, the less flexibility exists to rapidly adopt an innovation. Within the mining sector, this implication should demonstrate that juniors or mid-tier organizations, which are less bureaucratic, are more likely to adopt an innovation in a timely manner.

OTE1 is a junior and adopted a new technology expeditiously when it became apparent that the technology could produce significant savings for the organization. The lack of hierarchical layers meant that decision-making could be expeditious.

OTE1: Although we investigated the product and had a presentation by the vendor, we had already decided that if everything checked out we would run with the product. The advantages were so obvious that it wasn't something we needed to discuss at length.

OTE2, because its current activities in Western Australia are short-term, does not require any additional technology. However, OTE-2 indicated that the parent company had adopted technologies in an expeditious manner when required in locations outside of Australia. (The company acts as a junior within Australia only within the timeframe of this research).

OTE3 as a mid-tier currently has a centralised corporate structure where business cases are submitted to a purchasing area for approval (or not) by a management board. OTE3 has stated that since the change to the centralised acquisition strategy, no technology business cases have been approved that are not directly linked to production. In the period (4 years ago) pre-dating the re-structuring of the organization, purchasing and acquisition was available within the budget of the respective departments. This allowed the technology manager to choose appropriate technologies and develop relationships with high technology providers. The centralized organizational structure was a result of declining commodity prices due to the entry of inferior mineral from new African mines. In the elapsed time from the entry of these mines, the commodity prices have begun to re-stabilize as the quality of the ore remains inferior to West Australian commodities. OTE3 has indicated, however, that in the current climate the organization is likely to retain the centralised acquisition structure.

OTE3: The re-structure caused some pain within the organization as managers felt a loss of direct control within their own departments. Even though the situation has improved it is unlikely that we will return to the previous structure. The corporate types have made savings at what some believe is at the expense of better practice.

The majors operate as traditional hierarchical organizational structures where authority to acquire is based on business case and strategic goals.

OTE 4's acquisition of a technology was based on a merger and the recognition of best practice. This has demonstrated agility when there is perceived advantages. However, within OTE4, this was not normal practice and the acquisition of technology was managed by the silo management for the particular venture.

OTE4: Although some technologies are corporate, most are licensed to the silo venture and are handled within the operational management. Corporate acquisitions are considered through the relevant purchasing area and require a business case, costing and management support before even being tabled.

OTE5 has a traditional hierarchical organizational structure where technology acquisition is managed outside of the functional area which uses it. This centralised structure has been in place for the last twenty years and OTE5 has recently undertaken a major review of technology across its operations with a view to integrating and maximising the technological benefits for the first time within that time period as a concerted holistic exercise. The periodic, piecemeal introduction/update of technologies without consultation during the previous twenty year period has caused workplace resentment as the implementation has never met needs and required work-a-rounds to be functional.

Proposition 21 (P21) supports the view that a centralized organizational structure negatively influences the unit adoption of an innovative technology. The responses from the interviewees, representing organizations across the mining value chain, support the proposition that organizations where a less centralized organizational structure exists, such as in OTE1 and OTE3, a greater agility for diffusion has existed.

This indicates that increasing structure appears to negatively influence unit adoption.

Workforce Characteristics

Organisational Technology Environment
Resources Size Communication Relationships IT Champions Organizational Structure **Workforce Characteristics**

Proposition 22 (P22)

Contracted employees negatively impact assimilation organizationally.

As previously elucidated in Chapter 3, a dearth of previous research assumes that the workforce is permanent and not skilled in the use of information technology. However, those who interact with information systems/technologies within the mining context have post-secondary education or specialized training and at a management level would be considered professionals (tertiary educated). The mining context is also populated by a large number of contracted employees ranging from exploration, management and production personnel across the mining value chain. These may be divided into two further categories: long-term contracts (2-5 years) and short term contracts (2 years or less). Long-term contracts mean that employees are treated as staff, whereas short-term employees are treated as contracted individuals who have no input into the organization.

OTE1, as a junior, operates with a minimum number of permanent staff. Exploration is often conducted by a professional staff member, although when required, juniors utilize contracted (short-term) professionals. Contracted employees are expected to be skilled in the use of appropriate technologies and therefore do not require training within the organization. Nor are they expected to provide feedback to the organization or make an impact outside of their contractual obligations.

OTE1: If we use an external geo, we expect them to be ready to go. Whilst we tend to re-contract the same staff, we will utilize someone else on the recommendation of known geo.

OTE1: Given we (the organization) have the expectation of competence and relatively narrow technology usage I have to say that I don't feel that contracted staff have any impact within the organization beyond utility or professional service.

Throughout the interview process, OTE2 interviewees displayed an indifferent attitude to the technologies or the acquisition of additional knowledge about existing technology or alternatives. The three interviewees are considered staff but are all long-term contract employees. They appeared (to the interviewer) to be aware of the limits of their contract duration and offered little extended commitment to the organization beyond the duties expected of them. Not evident in written transcriptions is the lack of engagement which was conveyed by body language and tone. When asked about the long-term existence of the organization within Australia, the response was summarized by OTE2 -1.

OTE2-1: We don't have any long-term plans at this point and as we are exploration only so we could be gone tomorrow.

OTE3 is a mid-tier organization which employs predominantly permanent staff. Those staff members who are contracted for short-term employment are required to be skilled in their particular technologies. The requirement for pre-employment technological competence resulted from the costs incurred by the organization for the training of non-permanent staff that departed upon contract completion, providing no long-term return to the organization. Employees currently contracted meet the fit-for-duty expectation required by the company, but are not considered as staff and have minimal influence beyond their job description duties.

OTE3: We advise contracted staff of the technological requirements needed by the date of commencement. If for some reason they are unable to fulfil duties they are contractually terminated immediately.

Organizationally, OTE4 utilize long-term senior contract staff who are integrated into the organization in accordance with their role (e.g. mine manager). Many are rolled over into new positions when their contracts expire. Whilst their activities have the capacity to impact on assimilation, OTE4 indicated that their seniority also carries an expectation of commitment, and that indifference is not tolerated by this organization. The long-term contract is suited to mine ventures where the venture partners are the employer as opposed to any one major partner (although a major partner may control the human resource activities). Short-term contracts (which are largely limited to production) are handled by human resource agencies, and other exploration activities are outsourced to junior companies or mining service companies as required.

OTE5 appears not to employ short-term staff outside of production areas. The organization states that it is committed to providing a stable workforce. However, this statement may be tempered by comments from OTE5 as follows.

OTE5-3: Once upon a time the company provided training, now it's up to the individual to keep up to date. With the upcoming planned changes, some training will be provided to selected individuals who are expected to distribute the knowledge to others within their areas.

OTE5-2: We are all veterans so to speak within the organization, seen lots of changes but you learn how the place works and either stay or go, depending if it suits. Attitudes are different within younger staff members who are more committed to themselves than the company.

Table 6.16: Workforce Characteristics Summary Table

	Contract Staff Utilized	Evidence of Impact	Comments
OTE1	Yes	Nil	Junior- short-term contract: must demonstrate competence
OTE2	Yes	Yes	Junior – long-term contract: obvious lack of commitment beyond duties
OTE3	Past	Yes	Mid-tier – short-term: financial cost as motivation
OTE4	Generalized as long term contract or Production only	Nil	Major: expectation of competence
OTE5	Generalised as long term contract or Production only	Nil	Major: expectation of competence

The responses from interviewees indicate that short-term contract employees are predominantly engaged in production whilst long-term contract employees tend to fill professional or management roles. The statements from interviewees imply that the behaviour of long-term contract employees should be professional, and their skills should be current and maintained as a professional requirement. Short-term employees are also expected to have competent skill sets. With the exception of OTE2, the required professional behaviour and mandatory specialized skill set appear to preclude non-commitment or possible negative impact of a contract status. OTE2, as the exception, indicates that a lack of continuity of employment (i.e. expiry of contract) combined with individual attitude may produce a sub-optimal environment. Proposition 22 (P22) postulated that contracted employees would negatively impact on assimilation organizationally; however, from the preceding discussion the proposition appears unsupported within the mining context.

6.2.3 Summary of the Discussion & Outcomes of the Organizational Technology Environment.

Organizations which operate within an Organizational Technology Environment possess and utilize systems and technologies that are customized for the industry context. The preceding discussion of the propositions suggests that across the mining context, the responses of the interviewees indicate the individual functional and financial capacities of the junior, mid-tier and major organizations to which the participants belong.

The various responses to characteristics demonstrate the impact of context and industry segmentation which cannot be generalised with any accuracy beyond the specific context sector. The complexity of a multi-layered segmented sector provides the insight that diffusion and/or assimilation cannot be categorised or generalized across a sector based only on a specific profile. As indicated by Fichman (2000), new knowledge must be driven by research which is contextualized and qualified by the data to provide insights that would otherwise not emerge. Only within the boundaries of a context can a dynamic environment be comprehended to provide a useful model which also incorporates the relationships within the modern business environment which is strategically enabled by information technology and systems.

The table below summarises the findings based upon the multi-layered context of minerals mining within Australia segmented by junior, mid-tier and major organizations.

Table 6.17: Multi-layered Organizational Technology Environment Outcomes

	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22
Junior	√	-	√	√	√	√	x	√	x	-	-	√	x
Mid – Tier	√	-	√	√	√	√	x	√	x	√	-	√	x
Major	x	-	√	√	√	√	x	√	x	√	√	x	x

Table 6.18: Hypothesis Summary Post-Analysis HTP & OTE

Proposition	High Technology Provider (HTP)	Organizational Technology Environment (OTE)	Sector Environment (SE)
1	Not tested in chapter		
2	Tested, confirmation sought in OTE √		
3	Nil Evidence X		
4	Supported √		
5	Supported √		
6	Supported √		
7	Supported √		
8	Tested, confirmation sought in OTE √		
9	Supported √		
10	Not tested in chapter	Nil Evidence X	
11	Not tested in chapter	Nil Evidence X	
12	Not tested in chapter	Supported √	
13	Not tested in chapter	Supported √	
14	Not tested in chapter	Supported √	
15	Not tested in chapter	Nil Evidence X	
16	Not tested in chapter	Nil Evidence X	
17	Not tested in chapter	Supported √	
18	Not tested in chapter	Nil Evidence X	
19	Not tested in chapter	Supported √	
20	Not tested in chapter	Supported √	
21	Not tested in chapter	Supported √	
22	Not tested in chapter	Nil Evidence X	

Chapter 7 Outcomes of Research Phase 4 - The Sector Environment

7.1 Introduction

This chapter examines the effect of the “Sector Environment” factor and its associated characteristics on the diffusion and assimilation of IS/IT systems within the case study. The characteristics for the Sector Environment in this case study (the minerals mining industry of Australia) were established by the focus group in Phase 2. These characteristics met the criteria in that they affect the sector as an entity and are seen to be beyond the control/perspective of any single adopting organization or interest group.

Sector Environment
Sector Characteristics - Political Policy Global Commodity Price

The Sector Environment completes the circle of interaction between the other factors of High Technology Provider and the Organizational Technology Environment. Changes to the state of the characteristics within the Sector Environment may elicit a response from both or either of the other factors within the context. The response to changes from a factor will be the sum effect of its characteristics. The response will also be characterized by the segment in which each organization or provider participates within the sector. It should therefore become possible to contextualize the external effects which influence the industry/sector and develop a richer picture of the dynamic interactions related to diffusion of systems/technologies. It should be clearly expressed that the term “sector characteristics” in the model is deliberately deployed as a placeholder for context-specific characteristics, thus enabling the model to be generalizable to other industry contexts where high technology products are utilized.

The context-specific characteristics relevant to this research were established by the focus group. Members of the group agreed that the characteristics that impact on all sectors of the minerals mining industry in Australia are ‘Political Policy’ and ‘Commodity Prices’. Both of these characteristics are seen as external influences beyond the control of any single organization within the industry sector/context either within the high technology providers or organizational technology environment singular or combined.

Political Policy reflects decisions made by governments located at the point of the resource that directly affect the viability of a mineral resource and that are not a characteristic of the resource itself.

Global Commodity Price represents the return on investment based upon the resource and is subject to market forces. The higher the commodity prices, the higher the potential investment and likelihood of new or extended projects. Commodity prices fluctuate and are affected by supply and demand globally, forward selling and macro-economic forces.

Confirmation and information in respect of the characteristics was sought from principal mining consultants who may be contractually employed by an organization but remain philosophically independent of the culture and commitments of that organization.

The industry-accepted definition of these members is shown in Table 7.1 below.

Table 7.1: Description of Principal Mining Consultant (Mining Plus, 2011)

Role	Description
Principal Mining Consultant	Is a qualified Mining Engineer with over 15 years' experience in mining across a range of different commodities and mining operations. Throughout the career, he has developed skills and expertise in the areas of scoping through to feasibility studies, Resource/Reserve evaluations, mine design and scheduling, due diligence reviews, operational improvement / optimization projects as well as providing external training and mentoring. He is competent in various software packages including Datamine and Surpac.

In addition to the tabled definition is the expectation in Australia that the principal mining consultant be a competent person under the 2004 Edition of the Australian Code for Exploration Results, Mineral Resources and Ore Reserves. Without this competency, the resources cannot be reported to the Australian Securities

Exchange (ASX) and therefore the organization would be unable to participate in the market.

Responses from seven principal mining consultants (hereafter referred to as consultants) were obtained, three by interview, the remainder by completion of a questionnaire, which was forwarded and received by email at the request of the consultants (as a result of their contract or time commitments). Both groups of consultants were asked the same questions to maintain consistency. All were provided with an interview protocol. All consultants have offices in Perth, Australia, although they consult throughout Australia.

Whilst all consultants indicated they had been employed abroad, they were asked to limit their responses to their Australian experience. Consultants were asked to comment not only on the impact of contextualised sector characteristics but also on the technology diffusion as reflected in hypotheses submitted to the High Technology Vendors and the Organizational Technology Environment participants. Consultants 1 – 3 inclusive reflect the interviewees, 4 -7 those who completed the questionnaire. Sector Characteristics are discussed below. .

7.2 Discussion of Sector Characteristics

Following is a discussion in response to the relevant Proposition by characteristic:

Proposition 1 (P1):
Contextualised sector characteristics impact on the factors of the contextualized environment.

7.2.1 Political Policy

As previously stated, Political Policy reflects government-directed policy at the point of the resource. In Australia, this may be established as either state or federal law. All consultants agreed that until May in 2010, the Australian government and the mining sector had enjoyed a relatively harmonious relationship. The congenial relationship benefited the Australian economy, and Australia's political stability attracted overseas investment which sustained the Australian mining boom and prevented Australia from feeling the more dramatic downturns of the global financial crisis seen in other western countries (Healey, 2012).

The Australian Government also promotes Australian technology and investment opportunities through Austrade and has sought liaisons with high technology providers and mining organizations to showcase Australian capabilities and export opportunities. As a consequence, Australian high technology providers regularly participate in offshore trade shows organized by Austrade (http://www.austrade.gov.au/Export-Events) to promote Australian exports as an incentive for investment in Australian technologies. Mining organizations reporting end-of-year profits demonstrate a favourable climate for investment in Australian resources. However, the announcement of a mining super tax by the federal treasurer on 2 May 2010 caused an immediate reaction in the stock market as share prices dropped dramatically in the major mining organizations (http://www.abc.net.au/news/2010-05-03/market-spooked-by-mining-super-tax/419462) .

Evidence of the concern about investment opportunities was reflected in the editorial from The Global Speculator (http://www.globalspeculator.com.au/documents/SuperProfitsTax.pdf) and was followed by threats from major organizations to reduce operations within Australia, dramatically affecting the export credibility of Australia (http://www.theaustralian.com.au/business/mining-energy/rudds-mining-super-tax-has-damaged-australias-image-says-albanese/story-e6frg9df-1225870461337). The following comments reflect the general sense of mistrust generated by the announcement and the subsequent follow-up talks.

Consultant 2: "the effect is not localised to one market, but impacts employees, housing, providers of many services and would be a disaster for the individual as well as organizations. This country has become increasingly reliant on the resource sector for stability".

Consultant 4: "Many employees in the mining sector now have a general mistrust of the government. The perception is that it will result in job losses. Companies will move to protect profits and it will result in some job losses undoubtedly as less profitable operations are mothballed".

Consultant 6: "One of the reasons Australia has profited from investment is the favourable government policy, a back-flip will result in investment going offshore to Africa and South America and a resultant decline for the immediate future".

However, *Consultant 7* saw the introduction of a higher tax as a well-overdue event which companies will inevitably fight in order to protect their profits. The fight will not be directed specifically at company profits, but on the effect it would have on the employee and therefore the resultant political backlash from voters.

Indeed, Alan Kohler, Editor-in-Chief of Business Spectator and Eureka Report stated that the rationale for the mining tax was linked to the second characteristic of commodity prices (such is their importance). The original proposal was to replace mineral royalties that were based on mine production values with a rent tax on profits (because the Australian government was able to share in the high commodity prices per dollar increase).

The flow-on effect from changes to political policy inevitably affects not just the mining company or venture partners in terms of profit margins. The cessation or reduction of mining operations impacts on the suppliers of goods and services in the supply chain including mining technology providers (by reduction of licences and/or adoption and renewal of services). Equally, as previously indicated, employment is also threatened by reduced job opportunities thereby continuing the impact on the consumer markets. The back-down by the Gillard government and watering down of the economic plan was achieved only by the immediate combined backlash by mining organizations and the threat to economic stability that resources had provided as a buffer.

All consultants saw that the concept of stability of political policy was important to investors. Historically, Australia has been a desirable location for investment due to its political stability and therefore presents a low risk compared to other countries such as Africa. A threat of change and the subsequent backlash by organizations was reported globally and posed a significant threat to Australian export dollars. The rapidity of the reaction demonstrates the significance of context characteristics to an industry sector.

7.2.2 Global Commodity Prices

High global commodity prices equate to profit, while low prices generate losses for the particular commodity. In the previous five-year period, several mining companies experienced a downturn as commodity prices declined. This was mainly a consequence of China's investment in mining in Africa which reduced the overall investment in Australian commodities, and the effect of the Global Financial Crisis. This is clearly evident in Figure 7.2 below from the World Bank key indices prices published in June 2011.

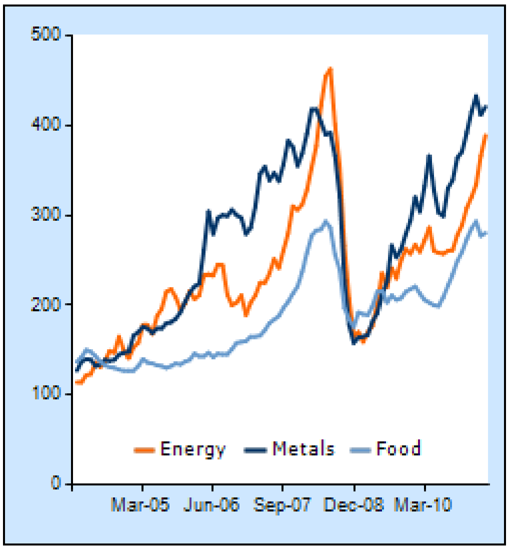


Figure 7.1: World Bank Key Indices (http://go.worldbank.org/ES1DGJ57Y0, 2012)

The World Bank's (http://go.worldbank.org/ES1DGJ57Y0) commentary on global commodity prices specifically highlights China's impact on the resurgence in prices to March 2010. However, the World Bank warns of the effect of China's policy of warehousing and stockpiling resources which leads to artificial prices in the market.

A further fall in the market could lead to the slow development of future mines, an issue already attracting attention in the prospects commentary of the World Bank.

The World Bank states that "The causes of the supply shortfall are numerous. Inadequate investment early-on has played a role, especially given the long lead times required for new mines. Because of years of low prices and limited expansion, the industry also suffered shortages of skilled labor, equipment and materials during the upturn—which have pushed up costs. In addition, technical problems, strikes, and geopolitical risk prevented new projects form moving ahead quickly".

All consultants considered the effect of the global commodity prices to be beyond the direct control of any investor or company. Moreover, they indicated that large organizations relied on the skill of their relevant employees to track, monitor and predict trends to cushion organizations against losses.

Consultant 1: *Commodity prices fluctuate not only from availability and futures trading but also from internal politics in some countries to exchange rates and unforseen events. Australia is internally relatively stable but futures trading remains unpredictable therefore organizations must respond according to their strategies as events occur. There are future traders who seem to have made fortune but they are few.*

Consultant 3: *We all follow trends in the commodity prices, over supply of any particular ore means lower prices and investment in mining for that commodity drops. The longevity and value of the mine is going to be evaluated against the returns it will make and therefore the commodity prices. The effect is obvious. Global commodity prices affect us end of story.*

BIS Shrapnel (September, 2011) state that the high commodity prices against a free floating Australian dollar would make the economy vulnerable once the boom winds down and investment in mineral resources declines. The Australian Government and Reserve Bank of Australia will have little to offer in this situation due to under-investment during the previous decade in other industries such as manufacturing and agriculture.

Commodity Prices, as in the case of Political Policy, demonstrate the possible impact on external factors which in turn will influence the industry sector and therefore the context. The sector's response to the characteristics has demonstrated that both organizations and providers will respond to the characteristics and that the subsequent organizational responses may flow through the context, resulting in favourable or unfavourable change to those operating within the contextualized environment.

7.3 Summary of Impact of Sector Characteristics on Diffusion of High Technology Products

The negative impact of political policy and/or global commodity prices results in a destabilizing effect in the industry sector. This hiatus in continuity, if sufficiently protracted or threatening, results in a response from organizations participating in the 'organizational technology environment '. The organizational response has been to re-prioritize or suspend further investment in what would be regarded as non-essential investment. This was noted previously in Chapter 5 in the Organizational Technology Environment section, where OTE3 commented on the suspension of all IS/IT investments as the ore price for their particular mineral had slumped over a sustained period of time. The organizational response was not only to suspend investment, but also to re-define the acquisition process as a corporate responsibility. All consultants saw this as a normal response to IS/IT adoption and diffusion from 2009 to the present present. All consultants stated that information systems were little understood other than by their immediate users in the mining sector. Four of the seven consultants referred to an 'oft quoted remark', 'that a tyre is far more valuable than some invisible system' (Consultants 1,3,4 & 7). The flow-on effect is on the high technology providers whose investment in their technologies define their longevity and on-going commercial value. Organizational reduction in expenditure and cost-cutting of technologies has an obvious implication for the viability of vendors.

Geoffrey Moore, in his book *Crossing the Chasm* (pages 156-7), states that the goal of high technology vendors is to create and maintain strategic partnerships with their clients, thus minimizing the impact of both uncertainty and competitors. He further states that clients/potential clients will “look to the quality and number of partners and allies you have assembled in your camp”. Thus, the vendors are directly tied to their clients for viability where a high technology or context-specific technology is the marketable product.

7.4 The Relationships within the Context

Within the bounded context of an industry sector, relationships exist between factors. No organization, whether it be a high technology provider or commercial venture, operates within a vacuum. The current globalization of industries suggests that partnerships play an ever-increasing role in determining commercial viability. Management research has referred to these as value-adding relationships or strategic networks (Carlos Curillo, 1988). Ackerman and Bodegraven (2007), in discussing supply chains, describe how there may be a combination of strategic, operational or tactical relationships at an inter-organizational level, yet these appear to warrant little if any mention when determining the probability of information systems diffusion. There exists a strong relationship between the minerals mining industry of Australia and the high technology providers and mining organizations who recognize that they can reduce risk to their sector by jointly lobbying against both federal and state policy when required. Such unified action empowers the sector and in doing so consolidates the relationships within the industry sector already in existence through contractual and professional arrangements. The NOIE and ABARE reports (discussed in detail in Chapter 8) strongly emphasize the fact that the technology providers perceive themselves as miners, not technologists, and that the mining organizations share the same perception. This synergy in itself may provide a conduit for information exchange which enhances the likelihood of increasing diffusion.

7.5 Summary

The Sector Environment demonstrates the ability of sector-specific characteristics to influence the industry sector both positively and negatively. Whilst positive effects produce opportunities for both stability and growth, the opposite is true of the negative effects. The result of a sustained negative effect can be seen within the minerals mining sector as it produces a marked downturn in production and the abandonment of new mining ventures. Such outcomes then flow down the mining value supply chain, also compounding the effect on the greater community within the industry sector. The long term mining boom experienced within Australia has produced stability and growth perhaps not seen in other industry sectors. Despite this stability the response to changes in global commodity prices was felt relatively quickly within the mining value supply change itself. This demonstrated surprisingly the lack of cushioning to economic change that may have been presumed by having such a long period of stability. Such quick response further demonstrates the importance of context, which has not been previously demonstrated in earlier research when the perspective has been intra-organizational. The internal focus constrains and masks the effect of the context and limits true comprehension of factors. It may be assumed that in the context of any industry sector a change in some factors should demonstrate an affect amongst the participating organizations. However, the response to change are rarely documented outside of global economic change or major events. The integration of the supply chain infer that a context events will influence the factors of diffusion and assimilation and that Proposition 1 must be supported. The demonstration of relationship and actions between factors provide further evidence that the impact of both professional networks and relationships is important for an understanding of the context and its operation.

Chapter 8 which follows presents Phase 5 of the research which includes industry-wide surveys of the context.

Chapter 8 Outcomes of Research Phase 5 – Survey

8.1 Introduction

The original intent of Phase 5 was for the author to conduct a sector-wide survey based upon the outcomes of the preceding chapters of this thesis. The survey was intended to provide objective verification of the interpretive findings of the case studies and was to follow the approach suggested by Attewell and Rule (1991) and Gable (1994) whereby surveys are recommended as a means of following the development of the conceptual model and case studies. This complementary approach supports both the interpretive analysis and internal validity of the research outcomes.

In the intervening time from Phase 4 to Phase 5 and the construction of the proposed survey, it was found that two surveys had been commissioned and conducted by Australian government departments that addressed (although not singularly specific) the concerns of the research being undertaken. The author believed that the conducted surveys taken together provided sufficient content (given their high response rate) to render an additional survey redundant. Although regarded as secondary data, independent surveys provide a focus that is external to the researcher, thereby reducing the risk of bias and providing an independent reference point.

Additionally, a subsequent analysis report produced by The Minerals Council of Australia (an industry representative organization) in 2013 and the ICT Roadmap for Minerals and Energy Resources 2013 by Deloitte is included in this phase as further secondary data in order to provide further convergent validation.

The research included covers a ten year period from 2003 to 2013, a decade of continued prosperity in the minerals mining sector within Australia. Both the mining organizations and the high technology providers within the sector were maximizing the opportunities to increase both production and economic profit. The gap between each of the survey's and the subsequent economic report confirms the stability of the decade. This therefore represents an ideal environment to research diffusion of innovations as the duration provides confirmation to the research findings over an extended period of time. It has provided an optimal time frame where only the industry context has a demonstrable influence and has reduced possibility of external variables. Subsequent to the original material further validation is found in more recent publications from Austrade, Austmine and a pilot study undertaken by the United States Studies Centre in 2011.

8.2 Survey Background

Two surveys were incorporated into the research. The first survey which resulted in a publicly published and available report was conducted in 2003 for the National Office for the Information Economy (NOIE) and the Department of Communications, Information Technology and the Arts (DCITA)(hereafter referred to as the NOIEReport). The research was undertaken in order to acquire an understanding of the relationship between technologies and the Australian mining industry. It also specifically examined the contribution of High Technology Providers to the mining market and the relationships that exist between the High Technology Providers and their Australian mining clients (the Organizational Technology Environment).

The second survey which was conducted by the Australian Bureau of Agriculture and Resource Economics (ABARE) in 2010 and reported in 2011, covered the specific periods of 2006 – 07 and 2008 – 09. The two periods yielded comparable source data sets which provided quantifiable data on the contribution of High Technology Providers to innovation, the economy and performance and information on the "supplier/customer relationship" in the given time frames (ABARE-BRS Research Report, page 4) over a period of economic fluctuation. This research report will hereafter be referred to as the ABAREReport.

Both surveys were initiated by Australian government departments and are particularly valuable as a source of external and secondary data to the researcher as they were able to obtain greater industry participation, thereby eliciting information reflective of the wider industry sector.

8.3 Survey Details

This section provides a detail of each survey and its relevance to the research outcomes.

8.3.1 The Australian Mining and ICT Industries – A report to NOIE and DCITA (2003)

The NOIEreport was commissioned by NOIE and DCITA to "examine the way in which the Australian mining industry has used and fostered the development of ICT" (page 8) and the way in which the providers have responded and developed their businesses both domestically and internationally. The survey instrument and survey report may be found in Appendix II. The survey was conducted by an independent international organization, Ovum (www.ovum.com), which specializes in providing technology-related research to business and government. Their initial list of mining organizations was obtained from Dun & Bradstreet with a subsequent list of mining ICT providers obtained from ABARE. The breakdown of respondents is shown in Table 8.1, taken from Appendix C of the report.

Table 8.1: A report to NOIE and DCITA (2003)

FIGURE C.1: COMPOSITION OF SURVEY RESPONDENT GROUPS

COMPLETED SURVEYS	Employee Size			Total
Miners	**1-19**	**20-99**	**100+**	
Coal Mining			2	2
Oil and Gas Extraction			3	3
Metal Ore Mining		3	4	7
Other Mining (incl. Construction Materials)	1	1		2
Services to Mining (including exploration)	5	1	1	7
Several sub-sectors	2	5	2	9
TOTAL	8	10	12	**30**
ICT Providers	**1-19**	**20-99**	**100+**	**Total**
Mining Technology Providers	7	12	2	21
Generic Providers				0
TOTAL	7	12	2	**21**

The surveys, one for the mining organizations (OTE) and the other for the technology providers (HTP), were forwarded by email and followed up by telephone calls which in some cases enabled an Ovum employee to complete the survey whilst speaking with the survey respondents. As in the case study protocol described in Chapter 4, the surveys for both the mining organizations and technology providers mirrored each other although they were adapted to suit each perspective. The four parts of the survey were structured as shown in Table 8.2.

Table 8.2: NOIE Report Survey Structure

Part 1 – Your Business	Establishes identity and contact points within the business together with business background
Part 2 - Technology	Providers – Competitive Advantage, challenges & lessons learned Organizations – Factors regarding technology , view of strength & weakness of providers, ICT contribution to productivity
Part 3 - Outlook	Providers – Future threats and Opportunities and general observations in regard to the industry sector. Organizations – Any changes that influence their future investment
Part 4 – Enterprise Classification	Providers – Linking providers to mining sector classification Organizations – Linking Organizations to mining sector classification

In terms of respondent location, there was representation from every state in Australia; the majority (37%) were located in Western Australia followed by 24 % in

Queensland. These states accounted for the largest revenue derived from exploration, feasibility, resource extraction and production. Technology Providers range in size from small to large firms (as shown by employee numbers in Table 8.1) with revenues shown in Figure 8.1.

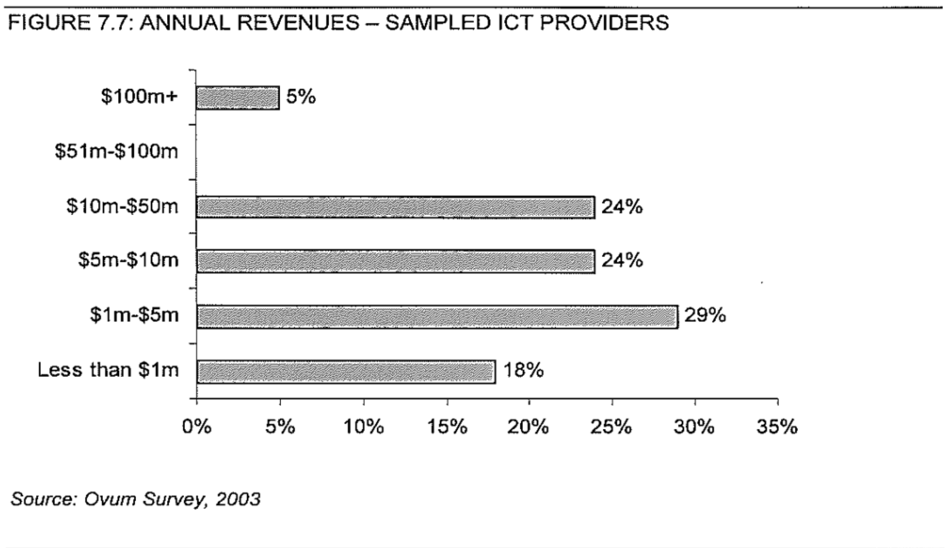


Figure 8.1: Technology Providers Survey Revenues

8.3.1.2 A report to NOIE and DCITA (2003) Outcomes

As the surveys covered both domestic and export potential, only the domestic findings are reported as specified in the scope of this research. The reported outcomes are linked to the research propositions and the discussion of the findings presented in previous chapters.

The Mining Technology Providers (High Technology Providers)

The NOIEReport, describing the commercial behaviour of providers, details the behaviours of firms when protecting their clients, and their perceived commercial behaviour. According to the NOIEReport, these behaviours include the development and maintenance of personal contacts through internet (email) communication and industry associations. This concurs with the findings in respect of Proposition 4 and the significance of communication channels, but additionally adds weight to the additional finding of the study regarding the importance of relationships between personnel in the mining sector, and its critical importance to the high technology providers. The emergence of industry associations as a network of importance for individuals, providers and mining organizations, has been an increasingly evident theme within the mining context of Australia. The significance of personal relationships maintained through industry associations was also seen to be a reflection of the reputation of the technology provider (Proposition 5) and was confirmed by Proposition 16 and Proposition 17 from the perspective of the mining organizations.

Tied to reputation is the concept of the providers' perception of their competitive advantage. According to the NOIEReport, the following were cited by more than 80% of respondents as factors that gave a competitive advantage: superior products and services, reliability and management, intellectual capital and familiarity with the Australian market. These are aligned with those in the research study. Superior products and service (P2, P3, P5 and P6), Reliability and management (P5), intellectual capital (P7) and familiarity with the Australian market (P5). The perspective of the technology providers evidenced within the report confirms the outcomes of the case studies with respect to Support services (P2, P3)Reputation (P5), Technology Characteristics(P6) and R & D Allocation (P7) as affirming the propositions.

The NOIEReport also specifically states that "74% of respondents developed 90% or more of their products and services within Australia" (page 35) and that their clients' requirements have led to the development and the meeting of needs, indicating that the strength of the relationship also stimulates investment in R & D in order to meet market needs (P7 and P8) and the need to address the competitive forces which stimulate and compete in this market (P9). This is affirmed by the technology provider who stated "It is now necessary to partner with miners and be focused on their financial goals" (page 42).

It is clear from the aforementioned findings that the relationship between the high technology providers and the mining organizations is a significant factor. Additionally, the survey findings based on responses from technology providers across Australia and representative of all partitions confirm the outcomes from the case studies, thereby demonstrating and enhancing the validity and strength of the research.

Mining Organizations (Organizational Technology Environment)

The mining organization participants are representative of the various mining partitions and the resources types defined by organizational size and, therefore, functional breadth and depth. The NOIEReport confirms that the mining organizations possess a good understanding of the strengths and abilities of the technology providers as depicted in Figure 8.2 (and thus confirms the propositions concerning the high technology providers' perspective). However, the report also suggests that the mining industry has little regard for the benefits of information systems, focusing instead on operational issues and maximising extraction. This supports the viewpoints of mining consultants in this research study who stated that organizations were more focused on extraction technologies as opposed to information systems. The NOIEReport also indicates that organizations have no understanding of how to measure the effectiveness of systems or even an inclination to do so as the operational focus is based on production output or down times.

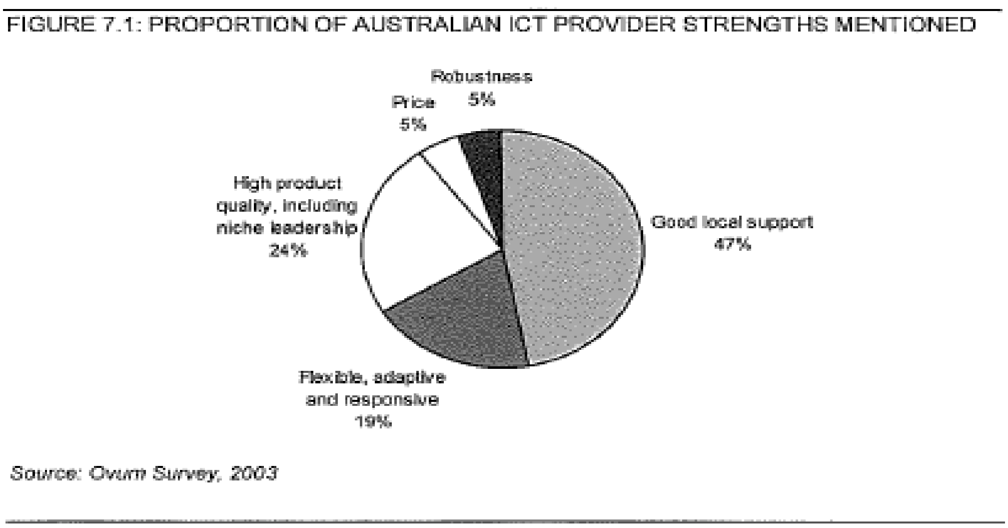


***Figure 8.2*: Extract from the Report**

In selecting information regarding investment, the mining organizations were able to confirm the desirability of case studies and web sites as means of evaluating the type and extent of returns based on a technology investment. The focus is on economic rationalistic choices and suggests a centralised acquisition authority as decision makers remote from the direct users of the technology/system being implemented. The desirability of rich media choices which exclude a technical focus confirms and supports the findings for propositions P13 and P14 regarding communication channels and rich data sources. There also exists a bias for existing technology partners based on the understanding of the technology and standardization across mining sites. This was mentioned in the case study interview conducted with OTE3 and OTE4 where the duration of the relationship between the organization and technology provider created a barrier to competitors even when there would be cost savings. This once again confirms the existence of strong relationships within the context; these are bi-directional between the high technology providers and the organizational technology environment and furthermore may have sufficient strength to alter the behaviours of adoption and diffusion as a consequence.

The NOIEReport includes a description of employment practice that supports the discussion of Workforce Characteristics and the continuing emergent theme of contract professionals being employed in place of full-time staff. Table 8.3 extracted from the NOIEReport shows for the report period the breakdown figures of full-time employment and the percentage of contract staff. Anecdotally, consultants report (at the time of the research study) that this figure continues to rise as mining organizations seek means to lessen costs associated with human resources and employment.

Table 8.3: Employment in the Mining Context

FIGURE 3.3: NUMBER OF FULL TIME EQUIVALENT PEOPLE EMPLOYED IN THE MINING INDUSTRY

	1999-2000	2000-01	2001-02	% change 2001-02 Year on Year
Direct employment				
Exploration	2,214	1,447	1,011	-30.1
Mining Operations	35,336	35,362	32,106	-9.2
Smelting & Refining	14,503	14,135	14,886	5.3
Total Direct Employment	**52,053**	**50,944**	**48,004**	**-5.8**
Contractor Personnel				
Contract Mining	11,894	11,595	12,022	3.7
Other Contracting	5,739	4,474	3,929	-12.2
Total Contract Employment	**17,633**	**16,069**	**15,951**	**-0.7**
Total Employment	69,686	67,013	63,955	-4.6
% Contract employees	25.3	24.0	24.9 [2]	

Source: Minerals Council of Australia [2]

Note. The table above only includes those considered to work full time in the mining industry. It excludes part time contractors, who are included in total number of people employed statistics.

Sector /Context Influence

The research study suggested that the context bounds the environment and the sector including the sector characteristics its inherent factors. Between the factors were relationships which have been shown to have a dynamic influence on the behaviours and interrelationships of the factors. The NOIEReport (page 34) states that “the providers considered their businesses to be highly subject to the fortunes of the mining industry”. This statement from the technology providers confirms the existence of relationship ties which directly contribute to their financial wellbeing, particularly given that the majority of providers do not have a diversified product but, rather, are industry-specific. What the report addresses is product-specific orientation. Additionally, on page 35 it is stated that constraints are “declining commodity prices” and “access to ore titles”, the latter a result of political policy. These constraints are those described in Proposition 1, thus confirming the case study findings that relate to this proposition. The NOIEReport report also mentions the inter-related nature of the factors, further confirming the necessity of taking context into account in this type of research.

8.3.1.3 An economic survey of companies in the Australian mining technology services - ABAREReport (2011)

ABARE's survey completed in July 2010 was voluntary and relied on the willingness of companies to provide confidential information. This ABAREReport defines the contributing organizations as those which have developed alongside the mining organizations and that "provide goods and services that embody specialist technology, innovation, intellectual property or knowledge specific to the minerals industry" (page 9). The survey consists of six sections and includes both quantitative and qualitative questions. Directed at the technology providers only, the survey sections cover the Australian industry, international experience, labour, innovation, business operations and other issues. Only those results relevant to the Australian experience are included here as they are relevant to the research scope of this study.

A response rate of 15% was achieved from a total of 1022 surveys. Although distributed to technology providers throughout Australia, the summary profile of participating technology providers finds them predominantly located in Western Australia and Queensland where mining operations and the resource sector are the major sources of revenue and employment. Of those respondents, for the period 2008-9, 99% of companies had a head office in Australia.

An economic survey of companies in the Australian mining technology services - Outcomes

Between 2004 and mid-2008 until the impact of the global financial crisis, technology providers experienced sustained periods of growth and managed to survive the economic downturn despite fluctuations in the Australian dollar and relied in part on the continuing strength of commodity prices of ore to offshore markets. Growth has continued to occur despite continued fluctuations in economic markets and a second global financial crisis. Figure 1 taken from the survey displays the key features of a successful technology provider (as determined by the respondents); the annotation shown in brackets represents the propositions which these statements support from the research case study analysis and additional key findings outlined in the previous chapter as an outcome of the case studies.

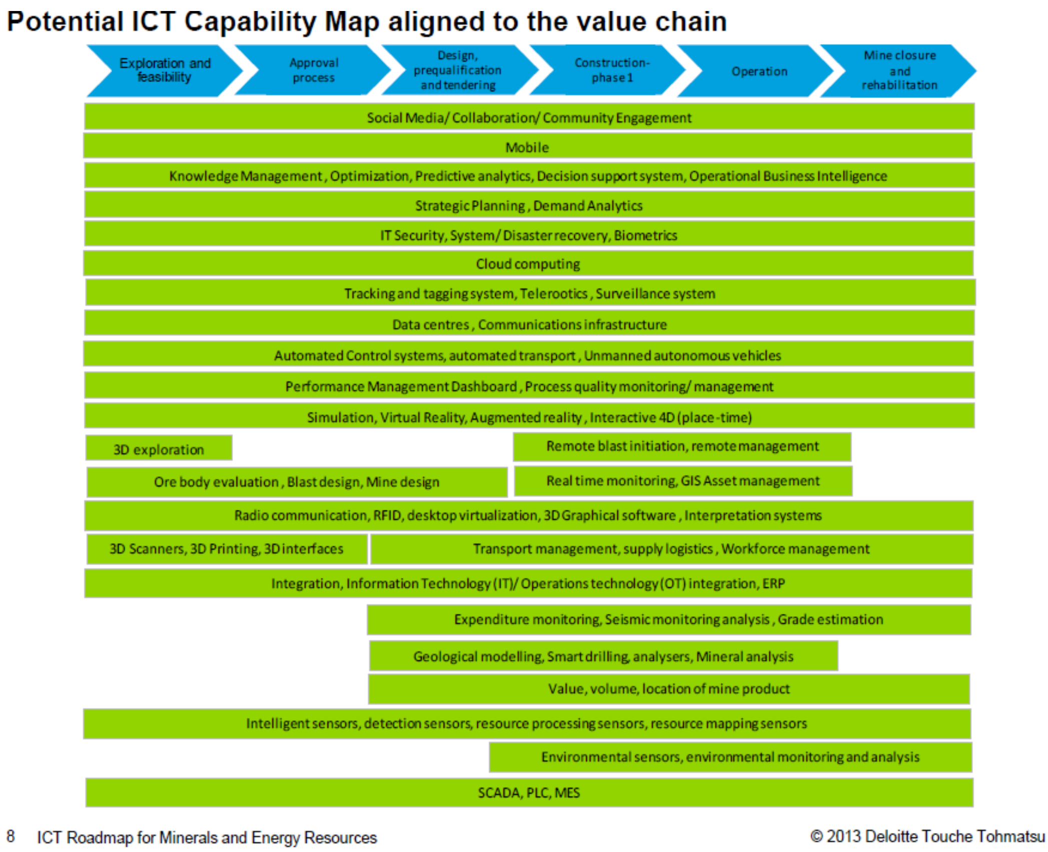
box 2 key features of a successful Australian MTSE company

A MTSE company needs to:

1. have a technology solution that solves a minerals industry problem (P5)(P6)
2. understand the mining business and language (profile)(networks)
3. maintain good working relationships with clients at all levels of the mining business, ranging from the corporate head office to the mine site (P4) (P16) (networks)
4. be customer focused (P2)(P3)
5. be recognised by its customers as supplier of first choice (P5)
6. employ skilled and experienced people (profile)
7. collaborate and network with others linked to the sector to progress innovation (networks)
8. have a dynamic web presence that includes a good informative website outlining company capabilities and product lines, which potential Australian and overseas customers can use to identify companies. (P4)(P13)(P14)(P15)

Figure 8.3: Features of a successful Technology Provider (annotated with Propositions)

The first feature would perhaps seem a statement of the obvious. However, the multi-layered sector and mining chain is specific in its requirements throughout its stages from exploration, feasibility and production to eventual mine closure. The following slides shown in Figure .4) are taken from an ICT Roadmap constructed by Deloitte (2013), and envisage what is possible in terms of technology-based solutions across the mining value chain, followed by what is currently available and being used. The customizing of general applications is perceived as being unsuitable for the mining organizations that occupy the organizational technology environment due to the complexity of the data, its usage, and layering across a segmented sector. This feature supports Propositions 5 & 6 from the research study in finding that a high technology provider in the mining space is seen as a provider of a dedicated quality mining-specific solution and the technology characteristics are perceived as being advantageous as part of the solution. This also links to feature 5 in that, being recognised as a supplier of first choice, presupposes that the provider has a high quality reputation.



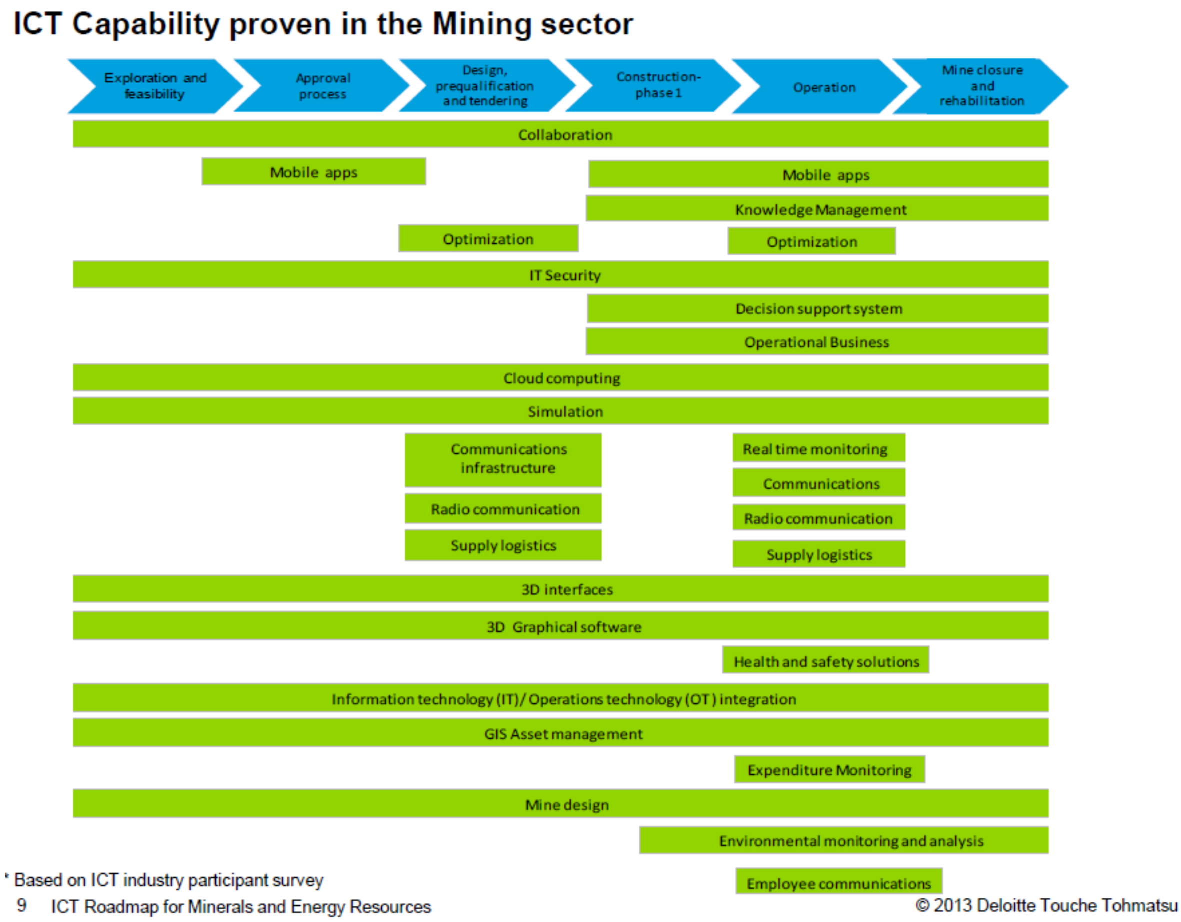


Figure 8.4: Deloitte's ICT Roadmap (2013)

Features 2 & 6 describe the need for acumen in the mining business and the language and terminology and the need to employ skilled and experienced people. As stated in the case study research, the technology providers have a stated preference to engage earth scientists as employees and train them in technology solutions. They perceive that the weight of knowledge required for the required business dialogue has both significant breadth and depth and is not easily acquired outside of the discipline areas. In employing skilled persons, the ABAREReport finds that close to 50% of employees have tertiary qualifications with a further 33% reporting technical training qualifications. The practices for employee engagement form part of the profile of the industry interaction undertaken by high technology representatives across the mining value chain. The further case study outcome of importance of the professional networks is also indicated by these features. These are often established in university based on the professional accreditations and also are the basis of peer-based social networks used throughout the professional lifetime. The case study analysis highlighted the strong regard in which affiliations are held in respect of professional standing. The increasing use of contract employees and the value attached to personal reputation increases the strength of professional associations and networks within the sector. The ABAREReport confirms the importance of the unanticipated outcomes of profile and networks in the mining environment.

The third and fourth feature demonstrates the importance placed on relationships across the mining supply chain and the value placed on the need to establish and maintain these relationships as a source of value adding for the business. As demonstrated in the case study analysis, the use of professional networks as a business tool also personalizes the interactions between the high technology providers and the organizations' technology environment, creating relationships between both individuals and organizations. Although the need to be customer-focused is not confined to the mining industry, the case study analysis has shown that the high technology providers within the mining sector actively seek to personalize the relationships through the use of professional and personal networks. This is made possible by the bounded sector environment and the widespread knowledge within that environment of reputations and relationships. In addition, the level of support services is broad and provides for a customer base that is often remotely located. Given the increase in contract employment, many providers also offer training and services to individuals, thereby increasing their market presence though individual customers. The ABAREReport also confirms propositions 2 and 3 and the additional characteristic of networks.

Feature 5 is stated as being the supplier of choice and is therefore a reflection of the reputation of the technology provider. All respondents cited in the report considered this as a high value statement for the provider organization. Furthermore, it was confirmed as a finding of the case study analysis where all high technology providers considered themselves to be leaders in their particular technology and work at maintaining this position. This supports Proposition 5 from the research study and may also be linked to the technology characteristics (P6) and investment in R & D by the high technology provider (P7 and P8) as underpinning characteristics that contribute to reputation.

Feature 7 raises issue of the development of relationships that allow both high technology providers and organizations within the organizational technology environment to collaborate within the mining sector. This suggests the propensity to develop and extend products within partnerships. The case study analysis has indicated that high technology providers respond to feedback from their clients and are prepared to invest in research and development to meet the needs of the mining sector. The ABAREReport states that the high technology providers have reported spending A$2.2 billion dollars in research and development. This represents the highest investment by any industry sector reported by the Australian Bureau of Statistics in its 2009b report. As an outcome of research and development, technology provider respondents report patents both registrable and non-registrable. The ABAREReport states that approximately 30% of respondents report registrable patents and a further 40% report non-registrable patents such as trade secrets and confidentiality agreements, the latter category most commonly occurring between the technology providers and individual mining companies. This demonstrates the strong bi-directional relationships that exist between high technology providers and mining organizations within the context which tends to go unreported or be ignored in quantitative-only studies.

The last feature is that of a dynamic web presence that provides to a potential and existing client base sufficient information about the capabilities and features of a technology. The case study analysis reported that this was required by both the high technology provider and the organizations within the organizational technology environment. Both factors reported the need for information that was usage and benefit-based as opposed to the provision of technical specifications. The websites of high technology providers in the case studies offered technical information on request. However, the content was biased towards case studies and business benefits, possibly reflecting the tendency towards the centralized purchasing strategies away from the direct users of the technology and the service technology areas of the mining organizations. In reflecting this requirement, the ABAREReport supports propositions P4, P13, P14 an P15.

Additional information from ABAREReport

In ranking the priorities of issues affecting possible integration into mining supply chains, technology providers saw the development of long-term relationships as the number one issue, followed by recognition of supplier of choice and building and developing new customer relationships. This once again affirms the importance not only of a client, but the distinction that is based on the relationship and therefore the effect on the rate of diffusion. They also saw this as being essential in gaining a competitive advantage and therefore smaller organizations (compared to the mining organization) value the ability to access and build personal points of contact. They also recognised that they were required to maintain technical competency, a skilled workforce and provide services related to their products in order to maintain the quality of their products and relationships.

8.4 The Minerals Council of Australia Report 2013

The Minerals Council of Australia is an industry association that represents the interests of the minerals mining industry especially regarding policy making which has the capacity to impact on their members. The council lobbies and prepares reports presented to the Australian government and other peak international bodies to promote their industry in general in order to ensure future growth in terms of both economic and social development.

The report referenced in this study is titled "How about those METS? Leveraging Australia's mining equipment, technology and services sector". The report published in 2013 provides further confirmation to support the two surveys and outcomes of this research.

Key points from the report are shown below.

1. Supporting the premise of the importance to contextualize the understanding of specific classes of technology as proposed within this research, Page 7 of the report states that

> "Mining is becoming increasingly knowledge intensive with rising rates of R & D and innovation. The key trajectory is based on information technology.."

Page 8 continues with

> "IT forms the basis for innovation in data acquisition, modelling, mine sites and operations".

> "The greater use of IT also changes the relationships ……. between mining companies and their suppliers."

2. The need for a model or roadmap is stated on Page 8 to provide direction as mining innovation continues to develop.

3. Page 24 notes the importance of the fastest growing segments which are those firms providing highly specialized technology that in 2012 had a total of related IT sales in excess of 1 billion AUS dollars.

4. With reference to R & D expenditure, page 27 reports technology application as accounting for greater than 50% of the total R & D expenditure, a figure in excess of $530 million over the 2 year period 2008-9.

5. In respect of the relationship between the high technology providers and mining companies (OTE), page 29 reports that collaboration between the two parties plays a major role in innovation and that it is "not surprising given the importance of the close links with customers and service development." Also stated is that successive ABARE-BRS surveys all found that the collaboration between the high technology provider and mining companies is consistently considered to be significant.

6. Lastly, the conclusion notes the need to understand the importance of the knowledge supply chain where innovation is a key factor affecting future capability.

This report, whilst not comprehensive, provides confirmation of aspects already discussed as it is authored by the industry sector and therefore gives weight to other sources.

8.5 Austrade and Austmine

In addition to the previous surveys and economic reports two additional sources arise which also provide further confirmation to the existing research. Austrade (2013) represents the Australian Trade Commission which promotes not only trade but also investment and education of Australian companies for offshore markets. In 2013 they provided a specialised report on exploration mining software and specialised technologies citing direct revenue of A$600 million and more than A$240 million of exports. They confirm prior findings of a rich research and development culture (A$40 million) underpinned by the high technology providers and an increase of technologies outside the extraction segment which is providing greater networks and focuses on integration of management systems. Austrade (2013) lists their participants as contributing to the globalization of the mining industry and the increased focus on the business of mining as a specific context transformed by technology but still dependant on global demands. The participants to this research may be all be found within Austrade (2013) as global contributors to the long term viability of the mining industry.

Austmine is the leading association of the Australian Mining Equipment , Technology and Services Sector. Austmine conducted the survey in the period December 2012 – February 2013 and was aided by the Australian Department of of Industry, Innovation, Climate Change, Science, Research and Tertiary Education who expertise in the development and analysis of the findings. The response rate was 860 companies from an estimated 1200 members. The impact of the outcomes is important as the timing of the survey encompasses a time period when the mining boom within Australia is in decline. Many projects were already deferred and global prices for minerals were falling with mining companies already looking at risk mitigation strategies. All firms who had attributed drop in revenue citing external market forces as the reason. This rationale alone indicates the importance of contextualization in understanding the factors that contribute to the dynamics of the end-to-end mining value chain. High technology providers are looking to global markets to offset the decline in the Australian market space with 55% already exporting offshore. The survey indicates key findings which support earlier studies which found that the technology providers consider themselves as part of the mining industry, are innovative, customer-focused and spend on research and development in collaboration with their client needs and future markets. As part of the technology profile the high technology providers see competitive advantage as being maintained by investment back into the business, relationship with clients and maintenance of the relationship directly to the individuals. Although the greatest challenge was considered the cost of operating in Australia followed by the mining downturn generally, the 3rd challenge related to Australian policy and regulation. This also confirms that the context is significant in determining an understanding of the factor impact across the research undertaken.

Both Austrade (2013) and Austmine (2013) provide further consolidation and validation of the earlier surveys and economic reports. More so because they occur in a period where commodity prices are falling and mining projects are shelved to mitigate risk. Yet high technology providers continue to invest in research and development as a strategy for business continuity. Understanding the context of high technology providers and the relationships between themselves and the adopting client demonstrates a richer picture of the factors that influence diffusion and assimilation than the traditional intra-organizational perspective.

8.6 Summary

The two surveys proved to be complementary in their findings over the survey period of 2003 – 2009. Both survey reports included the high technology providers, the first report (NOIEReport) also including the perspective of the mining organizations.

The report findings for the high technology providers emphasised the importance of their place firmly within the mining sector and their alignment with a client market in providing products that were mining-specific. This specificity also translates to their employment practices in requiring staff who have a background in mining-related disciplines (earth scientists) and are members of the associated discipline networks as a validation both personal and organizational. Additionally, the sophistication of the communication media and its ability to provide rich and meaningful content from a business perspective focuses market contact on those responsible for acquisition in addition to the established network of operational mining staff. All providers cited vested interest in being responsive to the needs of the mining organizations and invested substantially in ensuring both the products and the mutuality of the relationships by such investment.

The mining organizations (organizational technology environment), although demonstrating little interest overall in evaluating systems, once implemented have cited the need for support and communication when required as requirements of their partnership with the high technology providers. They perceive the providers as being part of the mining sector and value the reputation of the provider as being influential as a partner.

The minerals mining report, whilst by no means as specific as the aforementioned surveys, affirms the importance of understanding the dynamics of innovation within the context. The importance of the relationships between high technology providers and the mining companies (OTE organizations) is clearly significant to both factors in providing future solutions through collaboration and the development and diffusion of technologies to support the industry sector for sustainable growth.

Table 8.4 below shows the propositions and outcomes associated with this research. An additional column indicates where propositions were supported by the independent surveys demonstrating validation for many of the findings presented.

Table 8.4: Summary of Propositions against Survey findings

Proposition	High Technology Provider (HTP)	Organizational Technology Environment (OTE)	Sector Environment (SE)	Report: NOIEReport (NR) ABAREReport (AR)
1			Supported √	NR
2	Tested, confirmation sought in OTE √			NR AR
3	Nil Evidence X			NR AR
4	Supported √			AR
5	Supported √			NR AR
6	Supported √			NR AR
7	Supported √			NR
8	Tested, confirmation sought in OTE √			NR
9	Supported √			NR
10		Nil Evidence X		
11		Nil Evidence X		
12		Supported √		
13		Supported √		NR AR
14		Supported √		NR AR
15		Nil Evidence X		AR
16		Nil Evidence X		
17		Supported √		
18		Nil Evidence X		
19		Supported √		
20		Supported √		
21		Supported √		
22		Nil Evidence X		
Additional	NETWORKS			NR AR
Additional	PROFILE			NR AR

Chapter 9 – Contextualization in Practice

This chapter integrates the findings discussed in previous chapters and views them from the context perspective. A context-relevant model of diffusion for the Minerals Mining Sector of Australia is presented and discussed which includes additional outcomes and relationships not discussed or evident in previous research. The model presented demonstrates the value of context when evaluating the factors influencing diffusion of high technology products within a contextualized environment. Having presented the model, the applicability of a generalized context model of diffusion is discussed, including the constraints associated with this research. Lastly, recommendations for further research opportunities are presented for consideration.

9.1 Integration of Findings – a Context View

The choice of the Minerals Mining Industry of Australia, whilst providing a specific exemplar of a contextualized industry sector and user of specific classes of technology, posed some difficulty in the presentation of data and its subsequent analysis. The sector demonstrates a layering and an associated functional stratification based on the segment of mining capacity within which the OTE organizations operate. This capacity is directly related to the size of the organization (as described in Chapter 1: minors, mid-tier and majors) and their ability to resource activities within the mining value chain. This is reflected in their functional requirements and also in the type and scale of information system/technology utilized.

The researcher therefore chose to present the study by research phase; for Phase 3, a chapter is dedicated to each of the factors (i.e. Sector Environment, Organizational Technology Environment & High Technology Provider) present within the conceptual model. The presentation and analysis of each factor individually in the preceding chapters enabled the researcher to demonstrate a factor perspective (i.e. akin to earlier research where, for example, the intra-organizational view is the unit of study). However, it became evident to the researcher during the course of the research, that in isolating each factor, much of the information that builds a body of knowledge remains unaccounted for in the current dynamic and global business environment.

The subsequent sections, whilst seeking to integrate the data and information into a logical research model, must also construct and represent a much greater picture of synergies than has been previously modelled or understood. The impact of the synergies in this study has been significant and the context-significant model developed (for the Minerals Mining Industry of Australia) rests on an understanding of the interplay between factors and characteristics within this context. The researcher has therefore chosen to present the contextualized model at the culmination of the following unifying discussion to hopefully enable the reader to develop an understanding of the qualifying aspects to this specific context and the rationale for the contextualized model.

9.1.1 The Sector Environment

The Sector Environment is representative of the influence of the context. A placeholder characteristic was utilized within the factor as a generic representative of characteristics that would be specific to each industry sector. These possible characteristics are beyond the influence of any single organization in the sector and each organization will respond to the specific characteristic event according to the organizational level of impact to the event. The specific characteristics were selected by the industry representatives in Phase 2 of this study and are "Political Policy" and "Global Commodity Prices".

A single key proposition was articulated as:

Contextualised sector characteristics impact the High Technology Provider and Organizational Technology Environment in either a positive or negative direction dependent upon the event.

Data was captured in this research utilizing the knowledge of the principal mining consultants. They confirm that the selected sector characteristics are independent of both the high technology providers and organizational technology environment and yet have appreciable impact on both the high technology providers and the organizations that are in the organizational technology environment. Sector characteristics were corroborated by the independent government sponsored surveys covering an eight-year period which specifically confirmed political policy and global commodity prices as primary sector dictates. The Minerals Council report further corroborated the proposition. However, the relationships that were supposed to be bi-directional between the sector environment and the high technology provider could not be supported. The sector characteristics dictate market buoyancy and consequently the opportunities that exist for high technology providers through growth in the resource sector. The providers, however, are unable to moderate these influences directly. Instead, high technology providers offer support to the OTE organizations whose greater long-term economic influence carries more significant possibility for moderating the sector characteristics. The relationship between the sector environment and the organizational technology environment remains bi-directional and was evidenced by the swift industry reaction to the attempted introduction of a mining tax.

The strong response from the mining organizations (OTE) resulted in amendments to the proposed tax and demonstrated the bi-directional nature and strength of the resources sector within Australia. The possible economic backlash threatened by the minerals mining sector was sufficient to modify political policy with respect to the sector. The continued warning about the end of the mining boom in Australia as a result of a depressed global economy also markedly demonstrates the depressed value of mining investment and an associated reduction of commodity prices. This reduction has impacted on and resulted in the cancellation of significant resource projects across Australia. This result is not confined to the mining organizations per se, but also translates to loss of income for those organizations which support the OTEs and operate within the mining sector, including the high technology providers. The flow-on effect from OTE organizations' decision-making affects the overall Australian economy as minerals mining and the greater resource sector act as the primary stimulant to Australian export growth. The Bureau of Resource & Energy Economics in their September Quarterly 2014 report cite declining commodity prices over the 2013-2014 period as being directly responsible for a 32% drop in mineral mining exploration translating to a decline in excess of 1 $billion dollars in the specified period.

This strength of confirmation of the sector environment's ability to impact the other two factors within this research would confirm that the inclusion of sector environment specific characteristics is a valid determinant within a contextualized model of diffusion. The minerals mining sector has a demonstrated response to the sector environment characteristics. Although most evident over declining commodity prices in recent years and attempted change to political policy, the preceding boom period also demonstrated an expansion of mining during the relevant period. During periods of growth more resource projects are commenced and as a result, the products of high technology providers diffuse through the sector more rapidly to meet the OTEs' requirements. All HTPs reported increased sales and expansion in the decade 2000 – 2010.

The sector environment fluctuations experienced by the OTE organizations are also reflected in the mining value chain both positive and negative. This can be supported by the Bureau of Resource and Energy Economics 2013-2014 Quarterly Report stating a decline in employment in both the mining companies and service industries as a cost cutting measure in the current period.

In a generalized model of diffusion, the strength and breadth of impact must depend on the participating sector and the factors reliance on a singular source of revenue within the context. Changes to the behaviour of a sector's operation in response to high technology's ability to modify patterns of business operation should not be under-estimated in a digitally supportive and globally connected environment.

The following section presents the core internal features of the context that have evolved over time and shape the behaviour of the remaining factors. It additionally demonstrates the significance of relationships and professional networks in determining the acquisition and diffusion of systems /technologies within the context especially those that part of the supply chain.

9.1.2 The High Tech Technology Providers and the Organizational Technology Environment.

The discussion of the integration of the remaining two factors of high technology providers and the organizational technology environment is presented as a meshing of characteristics and propositions where synergies and relationships must be included. The following will present the rich picture that has emerged from the research that is not evident through a single-perspective analysis of characteristics alone. Strikingly, two considerations rapidly emerged during the course of Phase 3 that influence the interpretation of the data.

The first consideration which was also expressed in the NOIE report, was that high technology providers consider themselves part of the mining industry, unlike technologists. This is fundamental to understanding the sector and highlights the professional community culture present within the sector and therefore within the context presented in this research. The high technology organizations chosen for this research are international leaders in their respective types of information systems and technologies and were established and still managed by persons with a mining background. They perceive their success as a result of their being earth scientists and part of this professional community which enables them to understand the complex needs of the sector. This was articulated simply by HTP1 who expressed the following:

> *"you can teach the geo's (geologists) technology, you can't teach the tech's geology".*

Earth scientists are therefore not only the providers of the technologies but are also the users, managers and decision makers in respect of mine management and economic viability. Their professional backgrounds and affiliations provide them with a common knowledge base and belief systems which override organizational culture or organizational loyalty. This consideration also disclosed a further associated emergent characteristic in the impact of professional networks on the adoption and subsequent diffusion of information systems. The effect of the network appeared across the characteristics of the study and is further elaborated throughout the following discussion within this chapter. This professional network strength is, however, re-enforced and sustained in part by the second consideration below.

The second consideration is the workforce profile of the OTE organizations. Previous diffusion research appears to have been based on the assumption that an employee population appears relatively stable and that employees are permanent members of staff. No prior research on diffusion explicitly discusses the permanence or transient nature of the employee population. Rather, studies infer permanency in that organizational learning and assimilation occur over time

(Gallivan, 2000; Leviit & March, 1988; Orlikowski, 1992) and that employees participate in a level of knowledge transfer which results in the eventual assimilation of new technologies throughout an unspecified period. However, the minerals mining sector in the current timeframe within Australia, is profiled by a large contracted workforce where contracts are between employer-employees or between the employer-contracting companies. The effect of this type of employment alters the basis for understanding the transfer of knowledge and the assimilation mechanism reported in prior diffusion studies. OTE organizations that employ contract employees now require and assume a level of "work readiness". That is, prospective employees are required to be competent in certain areas of the sector including information systems/technologies appropriate to the position. The OTE organizations no longer offer training to employees in these contracted positions or in a committed manner to those staff who are indeed permanent. Instead, they have placed the responsibility for knowledge acquisition on the employee. OTE3 in Phase 3 commented:

> "*we no longer provide training to staff they are expected to be able to walk in and commence work".*

The displacement of training costs benefits the OTE organizations in the short term, but there appears to be little consideration of any long-term effect on the organization of the loss of knowledge retention or assimilation of knowledge across a workforce which does not have a unified organizational culture. The contract characterization of the workforce has also increased the importance of professional associations as a source of information for their members. Members of professional associations now rely on the professional networks for information about the industry sector. These associations are regarded by the members as a consolidated body of information which they can access.

With the articulation of these two considerations, the original HTP and OTE factors are re-represented below as an interpretation by the author and as an aid to the reader for the subsequent discussion. (Please note the complete contextualized model is presented later in the chapter).

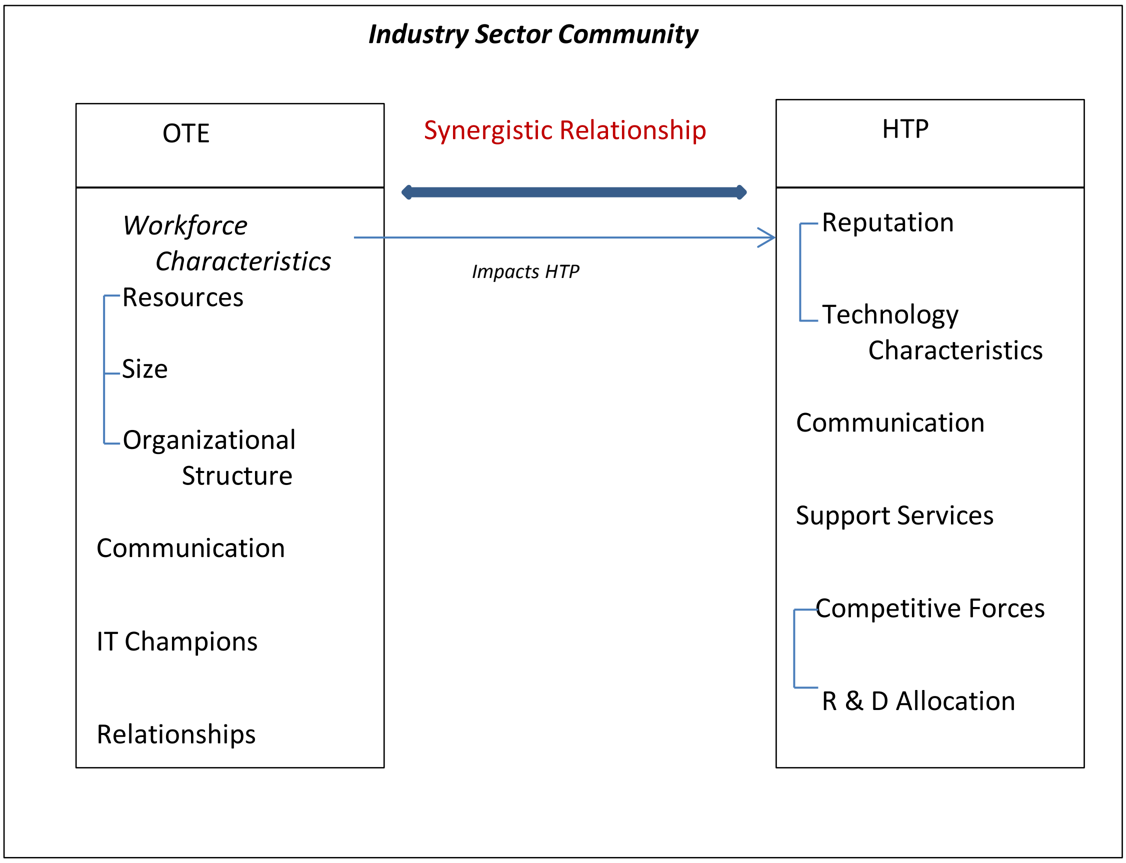


Figure 9.1: Characteristics Interpreted for discussion

An outcome of the research is the revelation of the strength and nature of the relationship between high technology providers and OTE organizations. The relationship remains as originally anticipated within the revised conceptual model as bi-directional; however, it not only includes contractual obligations, but establishes a synergy between the factors which is much greater than expected. It was assumed by the researcher that a relationship would exist between the factors simply based on a contractual business arrangement. The business objective of the high technology providers is to market products to the OTEs that represent a specialized market segment.

Not previously explicitly included in prior research as either a factor or characteristic, the relationship itself may have been considered of little significance outside of its contractual existence. However, the strength and role of the relationship appears within this research to indicate dynamism between the two factors and to contribute to the evolution and subsequent diffusion of technology. This dynamism is overtly evident in the support of the HTPs for the OTEs against Australian government policy, and is evident in the barrier to entry that some HTPs enjoy as a result of the longevity of contracts, the displacement of R & D to the HTPs and the roles that the HTPs undertake in creating de facto standards to which the industry sector responds. Figure 9.2 shows the strength of this relationship as labelled to indicate that this particular context feature is influential to an understanding of the discussion as an emergent theme.

The Effect of the Workforce Characterization

In Figure 9.1 "Workforce Characteristics" is italicized and a directed and labelled arrow points to the HTP factor. Although it is a characteristic of the OTE factor and has been discussed in assimilation literature as important to the long-term assimilation of knowledge, within this research it has demonstrated a notable influence on both the OTE organizations and also modified the market space of the high technology providers. As stated previously, prior research appears to have assumed that this is a stable workforce where individual employees are influenced by the culture of the organization and are able to acquire knowledge over time through their various roles. Organizational knowledge was perceived as having value to both the individual and the organization. However, this current context is characterized by a contract workforce that displaces the concepts of organizational loyalty, longevity of the workforce and assimilation of knowledge within the organization to individual knowledge, work readiness, contract wages and short term viability. Two factors historically contribute to this characterization: the fluctuations of the industry sector and human resource legislation within Australia. This has meant that the onus is now on the individual to be work ready and professionally competent. The OTE organizations perceive a benefit in having a flexible workforce with reduced human resource commitment. Contract employees perceive that they are not required to operate with the need for any organizational loyalty outside of professional ethics and contract discretion. Longevity is not an expectation of this workforce. Therefore, knowledge empowers the individual not the organization, and provides no incentive for knowledge transfer organizationally and therefore organizational assimilation is inevitably reduced.

Although no definitive statements can be made in respect of the long-term effect on knowledge transfer within OTE organizations as a result of this research, interviewees from both the HTPs and OTEs perceive that contracted employees no longer feel any obligation to the OTE organization to impart knowledge or act in any capacity as an IT champion. Instead, the professional network acts as a conduit of knowledge between the professional members to provide information regarding information systems/technologies their benefits, deficiencies or product comparisons amongst other industry sector information. HTPs' rationale in employing earth scientists also has additional advantages in that their employees understand the industry sector and they remain members of their professional networks, thus providing an additional outreach mechanism for the high technology provider.

In response to the work readiness requirement, some high technology providers have amended their market offerings. Previously, HTP1 and HTP3 only offered training/support to adopting OTE organizations under the contractual arrangements of acquisition. In response to individual requests for training, both providers now offer training to prepare prospective employees for their technology tasks. A scan of the websites of other high profile HTP organizations indicates that many also now offer individual training in specific systems. This provides additional revenue streams for HTP organizations and increases the reliance of the mining OTE organizations on the providers for skilled and knowledgeable staff. This embeds further the relationship between OTE and HTP organizations as a strategic dynamic.

The face of the workplace has also changed in that organizations no longer provide training for the contracted workforce; instead, it is expected that contract personnel are knowledge-ready and have a competent skills set that is readily transferable between organizations. Again this research can make no long-term assessment of the effects of such changes on an organization; however, currently this employment practice is seen in both OTE organizations and the HTPs, and influences the perspectives and actions of industry participants in their approach to the diffusion and assimilation of systems and technologies.

HTP & OTE Organizational Identity and Relationship

Figure 9.1 depicts the relationship between the HTPs and OTE organizations, and seeks to show the importance of the dynamic relationship between the factors and the influence of the characterization of the workforce. In addition to these over-arching effects are the links between the characteristics of the factors.

HTP Reputation

As identified in the considerations, high technology providers perceive themselves as part of the mineral mining industry as opposed to technologists. This belief is also held by the OTE organizations with respect to the high technology providers. The dialogue between the two factors is in terms of mining and not technology per se. The OTE organizations identify with the providers as mining specialists and they assume a sector community of use and practice that includes a common language for discourse. This community does not distinguish by organizational employment as much as by professional background. Membership of professional associations is considered mandatory within the community and acts as a validation of identity and background. The strength and extent of influence of the professional network within this context is a dynamic source of information and knowledge for its members within Australia.

As stated above, High Technology Providers (HTPs) within Australia perceive themselves as members of a mining community and have a de facto policy of employing earth scientists in outreach roles when possible. The historical background of the development of the HTPs participating in this research indicates that all founders of the organizations are earth scientists and maintain their professional associations. All HTPs are leaders within their technology areas and value and actively maintain their reputations both within Australia and overseas. They perceive that the HTPs' reputation is based not only on the capabilities of the technology, but also on the personal standing of the members of their organizations and professional affiliations. They encourage internal feedback about product development and in two of the HTP organizations, employees are also shareholders to ensure stability, loyalty and longevity. All organizations have survived sector downturns which they perceive is as a result of quality and commitment to the sector. All directors are available to their senior clients and maintain personal relationships through the professional networks for both personal and organizational outcomes. In promoting their organizations, all participants provide annual trade events at which all senior organization members attend and actively participate by providing education and information seminars. The dual initiative through business goals and professional networking has provided a successful platform for the growth and establishment of these HTPs.

The principal mining consultants o participated in this research confirm the association between organizational reputation, personal reputation and technology as being intertwined. Each of the HTP consultants consider that each of the technologies represented in the research to be accepted as a de facto industry standard and therefore a more likely first choice in their respective categories for acquisition by OTE organizations. OTE organizations state that they value reputation and confirm that reputation will displace a price differential between competing technologies based on the business needs. Proposition 5 proposed

> "*The more favourable the reputation of the vendor the more rapid the initial rate of diffusion*".

This is supported by the research findings, although a number of additional themes have emerged from this study:

1. The role which professional associations play within both respect to HTP

reputation.

> The professional networks are a community of users, decision makers, managers and consultants each bound together by professional background and industry sector. The possible moderation effect on diffusion expressed by a strong community of users is directly akin to traditional research on Diffusion of Innovations in a social network. Both negative and positive opinions are transmitted through the community becoming a perspective norm within the community and possibly influencing the perception of the

individual and their response to the system/technology. Such perceptions although held individually may influence organizational acquisition through the breadth of the belief and the weight of the professional community to moderate and influence organizational behaviour.

2. The contribution of a contextualized, layered high environment to the diffusion mechanism. The industry sector is, as previously described, layered into junior, mid-tier and majors. Each layer makes increasing use of technologies as their participation in the sector increases. HTPs have modularized their products as a result to give themselves access to each layer and not be excluded by only offering a total solution. The result of modularization was the need for different providers to make available interoperability between proprietary modules to other providers so as not to be excluded from a market. This is a response by HTPs to the Australian mineral mining organizations that appear not to choose a total solution but prefer to acquire modules with specific features appropriate for their needs.

3. Reputation in a contextualized sector may act as a barrier to entry for competitors based on a perception that a technology acts as a de facto standard. The minerals mining industry has no defined legislated standards in regard to the use of systems and technologies. Mining data is presented in a specific format derived historically from mining practices. However, some providers have developed what appears to be regarded as a standard for data representation based upon their longevity in the Australian industry mining market space. This perception is utilized by high technology providers to maintain their market position and does act as a barrier to entry, particularly for overseas entrants that may not be suitable for the Australian context.

The reputation of the high technology providers is an asset that is carefully managed by the HTPs. It has a dual identity in that the reputation has a historical cultural context which currently takes precedence over the technology characteristics themselves. The users of the systems and technologies have little interest in the technologies themselves and maintain an outcomes-only view that focuses on the reliability and accuracy of the products.

Reputation and Technology Characteristics

The apparent perception of an association between the HTP characteristics of reputation and the technology characteristics themselves resulted in linking these characteristics as shown in Figure 9.1 as

Reputation

Technology Characteristics.

Technology Characteristics in Rogers' Diffusion of Innovation Theory supported concepts comprising relative advantage, compatibility, complexity, trialability and observability. However, there is a value proposition with the adoption of a technology where a perceived benefit is gained from the technology. The proposition raised in the research and developed from the literature review was focused on the positive communication of the technology characteristics by the HTP. This proposition was supported within the framework of the proposition. However, in the contextualized environment of this research, a number of other elements evolve.

These elements rest on the understanding of the following:

1. As stated above, a perception appears to exist within the industry sector that the technologies represent a de facto best practice founded on the basis of meeting the needs of the mining sector. This appears to have evolved over time and has been driven by earth scientists into organizational processes. Such was the proprietary nature of these standards that interoperability and data conversion have been available over the previous decade.

2. No standards or regulatory requirements for output exist with the exception of reporting to the Australian Government. These, however, do not relate to technological systems or their management.

3. These technologies are inherently complex, although they are utilized by professional mining persons who are output-focused and they are used as a black

box where input receives the correct output. The earth scientists' interpretation is within their skillset and utilization of the output.

Given an understanding of the preceding, the following may be stated:

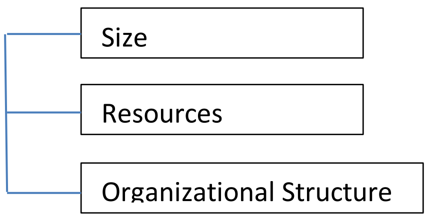
1. From the technology user's perspective the technology is considered a black box, in that it is operated in a prescribed standard, installed and supported by HTP representatives.
2. Earth scientists evaluate the potential of a technology based on the output which is in the form of common mining sector usage.
3. Earth scientists show little interest in how the technologies work or how they might provide additional features outside of any regulatory requirements such as environmental standards or regulatory reporting.
4. The HTPs acknowledge the differentiation in the OTE organization representation of requirements, and marketing is focused on two parallel streams. The first addresses the business benefits and are addressed by HTP's to a centralized procurement area. The second stream focuses on the actual demonstrable output required by mining professionals and is customized for that segment.
5. The mechanisms of technological delivery of the products are not marketed and are normally discussed only in terms of the impact of remote locations, connectivity and support.
6. All HTPs acknowledge the need to address the requirements of the earth scientists and believe that the stipulation of these requirements in a business case will create a driver for the diffusion of the technologies that the business areas will be unable to refute. HTPs primarily use example case studies in their media to build and enhance the business basis for a product.
7. The importance of the professional network becomes a mechanism for HTPs to utilize to further their technologies within the context.
8. Although no technology standards exist, the common preference from the community for specific products produces a resistance to alternatives which acts as driver for diffusion for specific technologies and a barrier to entry for others.

These points are indeed specific to the case studies of this research and their demonstrable effect strongly supports the research question, i.e. that in order to understand the diffusion of high technology the context and relationships within the context itself must be understood.

OTE Size, Organizational Structure and Resources

As previously stated, organizations within the *Organizational Technology Environment* are layered by their ability to participate in the mining value chain into juniors, mid-tier and major organizations. This layering correlates directly to the organizational size in the context of mining within Australia. Originally, three characteristics were shown within the OTE factor individually that now appear to be related.

Shown originally as “Size”, “Organizational Structure” and “Resources”, these are now represented in the Figure 9.1 as shown below.



The size of the OTE organizations not only defines the participating layer, but also is an indicator of available resources to the organization. Thus, major organizations have much greater resources available to them than mid-tier or juniors. In addition, the the case studies indicate that organizational structure appears over to be consistent across the three layers of the mining sector. Major organizations are divisional (or siloed in a venture capital investment) and increasingly bureaucratic, with a centralized procurement areas being a feature of the organizations since the downturn in the industry sector. Mid-tier organizations are structured functionally, are bureaucratic and have, since the mining downturn, implemented a centralized procurement process aimed at cost reductions. Previously, mid-tiers appeared to have had flexibility when acquiring technologies and maintaining contact with HTPs at a local level where decision-making was enabled. Staff in mid-tier organizations feel that the centralization process inhibits their ability to participate in the development of their work activities and resent the decision-making process being subject to the scrutiny of non-mining personnel. Juniors are flatter organizational structures, closer to team-based where the activities are limited to exploration and employees work across the organization to achieve goals.

The availability of resources through a centralized procurement process has reduced the likelihood of localized decision-making, which instead is now replaced with the business case as a trigger for the procurement process. In this industry sector and context, the availability of resources is undeniably tied to the size of the OTE organization, major organizations possessing global diversified interests capable of generating investment more readily than mid-tier or juniors.

The following propositions were postulated in respect of size, resources and organizational structure.

In regard to size, Proposition 11 proposed that

" Organizational size will be positively related to the rate of diffusion".

Based on the perspective of the OTE organizations, it appears that this is substantiated. However, by understanding the dynamic of the relationship between HTP and OTEs, there appears to be an unstated mechanism outside of the contractual arrangement that benefits both factors. OTE organizations viewed as entities do not promote technologies however earth scientists will recommend and build processes based upon specific output. The output will eventually influence the acquisition of technologies based upon historical development and earth scientists' preference. In the case of both one major and one mid-tier OTE organization, this was clearly acknowledged. The opposition was cheaper in both cases but the longevity of the existing contracts, the interface customizations and process tie-in made consideration of change a non-issue.

Proposition 12 in respect of size was

"Diffusion of radical innovation is negatively related to organizational size in large organizations".

This was substantiated in the research and was accounted for by reference to the scale and dispersion of technologies over multiple operations. The overhead for change in an operating mine was seen to be too large to be beneficial in the current mining environment with the exception of extraction techniques. However, it was also substantiated by the innovation evidently occurring in junior OTEs. Their investment is smaller in scale and the types of technologies utilized are limited; however, when an innovation became available and was demonstrated to be of immediate benefit, it diffused quickly throughout the juniors and was seen by the high technology providers as a possible new type of market for further development.

With respect to resources Proposition 10 stated

" Resource availability enabled at a localised decision making level increases the rate of diffusion."

Currently, it appears that local decision-making is no longer a feature of the OTE business environment. Resources are made available by a process that is marked by the provision of a business case and prioritized over other business cases and needs. However, as discussed previously, this proposition would have been supported prior to the industry sector downturn. The centralization process is a response to the change in the context characteristics marked by the global market reduction in commodity prices which has been sustained over a number of years. This has generated an organizational response and subsequent process change to reduce budgetary waste by the centralization of resource expenditure.

Proposition 8 was related to the characteristic of Resources and stated

"*An adopting organization perceives the cost of assimilating knowledge as a preferred option to the process of resource allocation within the organization in replicating technology available through a vendor*".

Already alluded to in condition 2 (which prefaced this discussion of the analysis), OTE organizations within the minerals mining sector of Australia utilize a large contract workforce which is expected to be "work ready". The provision of resources to provide training in this context has also been displaced by the change in the workforce profile. OTE organizations will acquire technologies which provide necessary functional requirements and in doing so conform to the sector expectations. However, organizations do not appear to consider the assimilation of knowledge, or indeed to the benefit of internal knowledge retention. The researcher found that few interviewees attached much value to the concept of assimilation. Participants implied that organizations would acquire such knowledge if and when required. This change in organizational culture within this context impacts not only on the OTE organizations currently but will permeate into the future organizational dynamic as the sector continues to respond to context changes. The long-term result of loss of knowledge is beyond the scope of the research but emerged as an unexpected outcome of the research which may have future organizational impact.

Communication: A Two way flow of Information

Communication is found to be a characteristic of both the HTPs and OTE organizations. From the HTP viewpoint, communication is an outreach mechanism which enables the HTPs to provide rich content to the OTE organizations in respect of their technologies. The internet has provided the HTPs with a tool to convey content through web pages and email. Whilst the former allows the availability of a rich source of information and marketing mechanisms such as case studies to be available any time, the latter also provides a less invasive or interruptive push of communication to the client that is regular and cost effective. The client can choose to ignore or read the emails and in their time. OTE interviewees expressed a preference for this means of communication from providers. The availability of web pages has equally allowed OTE mining representatives the ability to browse information at their own discretion as a pull mechanism. This is perceived by OTE interviewees as a desirable communication scenario given their locations and time availability. HTPs also provide seminars, trade events, newsletters amongst other communication tools to provide knowledge of the advantages in utilizing their technologies. Noted however, is the lack of detail about the technical requirements of the technologies. The HTPs have very much adopted technology as an enabler of outcomes, and communication of information is marketed to specifically be of a business benefit focus. Other avenues of communication include professional networks in a professional/social environment where information may be conveyed informally at networking events which are seen as organizationally neutral.

Communication is a reciprocal process. Feedback is provided to HTPs through the use of participatory outreach mechanisms which enable the HTPs to review their technologies according to the market demands. Multimedia is no doubt used by many industry sectors but personnel in the mining industry have utilized modern technology to provide a new dynamic where the direct users who may be remotely located are still able to be reached and supported by the HTPs.

High Technology Providers use of Support Services and the IT Champion.

The literature review found that IT champions were seen in roles of sponsors, initiators of changes and sources of knowledge. Although individuals appear to still perform these roles, currently they do so by choice and continue to act as unofficial custodians of knowledge in a changing context. The changing profile to a non-permanent workforce appears to have resulted in an organization where knowledge retention and assimilation of patterns of organizational culture and technologies have lesser focus. In this research, some individuals acted as sources of non-official information about technologies being used in the OTE organizations. In each case, they have been permanent long-term employees who once acted as decision-makers in respect of technologies or occupied a role associated with a technology. Because of personal interest in this area, they have kept up to date with technology and are prepared to share their knowledge. Although they no longer fulfil their previous official role in respect of technology, they are regarded by colleagues as a source of information when required. They maintain their interest through the need for self- development in a changing environment. As a result of the displacement of internal repositories of technology information the role of support services provided by the HTPs becomes more critical to systems maintenance and help desk type functions for the OTE organizations.

HTPs offer a number of Support Services to the OTE organizations under a contractual basis including those previously discussed in Chapter 6. The levels of support services range from a quite minimal support for long-standing technologies to a level of support that is quite extensive for newer technologies including complete management for remote services. The reduction in internal knowledge of OTE organizations has therefore strengthened the ability of the HTPs to further develop the relationship through technological necessity and technology direction as products/technologies further evolve.

The internal development of technologies is no longer needed when OTE organizations use high technology providers to meet their needs for technologies and services. Major OTE organizations do retain research and development to improve extraction techniques and will partner with outside providers under confidentiality arrangements. The provision of technology services to OTE organizations including the management and manipulation of data is seen to be largely the responsibility of the high technology providers.

HTP Research & Development and the OTE Resource Relationship

The specificity and sophistication of technologies appears to have led OTE organizations to displace the cost of research and development (R & D) to the providers of the technology. This has not only led to a source of saving for the OTE organizations as the cost associated with R & D is displaced, but has increased the strength of the synergistic relationship. The earth scientists in the OTE organizations provide feedback to the high technology providers in terms of their needs which become input to the research process of the high technology providers and will eventually ensure a market for new versions and products with their clients. Products are trialled and modified to ensure the OTEs' support. This synergy produces a barrier to entry for new competitors and a lock-in mechanism between high technology providers and OTE organizations. It also promotes HTP technologies and aids in their establishment and subsequent diffusion across the sector.

Information flows between the factors in a cycle of need, solution and feedback. This cycle contributes to both sector knowledge, trends and eventually the diffusion mechanism across the sector with high technology providers sustaining contact with their clients. The drive for the synergistic relationship in terms of R &D is definitively a mechanism of the HTP's. The R & D both creates product markets and ensures a market leader position for the HTP. The drive is intended to include both OTE organizations and earth scientists through the mechanism of client and professional network respectively. This synergistic relationship is once again evidence of the high technology provider perception of themselves as part of the mining industry (as opposed technology provider) as they sustain and drive technology change in both business and professional networks.

Technology changes and the displacement of R & D are most evident within the OTE organizations that are classified as majors or participate in mining ventures as primary investors. Although many majors possess R & D departments, the information made available to the researcher indicates that these areas focus primarily on extraction techniques which remain proprietary to the organization or are selective development relationships with a partner that provides exclusivity to the major. The growth in R & D within the HTPs is also enabled by overseas markets which also feed back to the Australian minerals mining sector. The R & D conducted by the HTPs is also driven by the competitive forces within the industry sector and context. Although this research focuses on the Australian minerals mining sector, all the participating HTPs are global providers of technologies. Thus, research products that are developed for external markets can also be applied to the Australian context and, predictably, this is promoted by the providers. Although all HTPs perceive themselves as market leaders, none is complacent in terms of offshore competitors or possible technological advancement, particularly in respect of remote technologies, transport and logistics, and the re-working of existing mine sites as extraction techniques improve.

Relationships and the IT Champion

In this research, the characteristic of relationships was suggested by the review panel in Phase 2. It was incorporated into the research based upon the concept of peer-to-peer networking to promote technologies and the process of assimilation from an intra-organizational perspective that have been the foci of prior research.

Closely related to this characteristic is that of an IT Champion who promotes and assists with the acquisition and assimilation of new technologies. The results from Phase 3 produced varied results, with only the majors demonstrating any intentional intra-organizational aspect to these characteristics. However, although organizations originally had promoted the individual employee activities and roles, this had subsequently ceased and the on-going actions were no longer recognized by the organizations as a requirement or necessity within the organizations' current structure. The continued activity relevant to these characteristics is as by-product of the employee's personal motivation and interest as previously mentioned. In both of these cases, the personnel have been permanent long-term employees, who admit that the organization has little interest in engaging actively in encouraging the assimilation of technologies or acknowledging the activities that the individual chooses to perform.

Organizational studies of diffusion replaced Roger's social system with the organizational context and evaluated various units of study within the organizational context in order to understand diffusion. In this research, the contract element of the workplace has altered the organizational dynamic and appears to reduce the need for or applicability of an IT Champion and to once again assert the influence of a social network (i.e. professional associations) where that influence on the organization is based upon professional expert advice. This new dynamic appears to be a combination of an altered organizational structure which requires professional consultancy due to lack of internal knowledge and where that consultancy may be influenced by a community network of professionals. Although further definitive assertions are beyond the scope of this study, the participants in this research implied that the professional networks are able to influence acquisition of technologies in a manner not visible when only an intra-organizational documented approach is taken.

The Industry Sector Community

The Minerals Mining industry of Australia has provided a unique study of diffusion of a contextualized industry sector combined with specific classes of technologies. The prior discussion has shown that various aspects or themes have emerged as a result of taking a holistic approach when examining the context of the industry sector as opposed to the singular intra-organizational perspective that considers only the adopting organization or unit of adoption. An unexpected finding was the role of professional associations in engendering both a professional and social network that encompasses both the OTE and HTP factors. The prior discussion has demonstrated the strength and breadth of this network (which is itself strengthened by the workforce contract characteristic) and the researcher has attempted to reflect its importance by including the HTP and OTE and labelling it “Industry Sector Community” as shown in Figure 9.2. The role of this network is pervasive throughout this industry and provides a conduit of information between its members that is regarded as accessible and incontrovertible by its membership. In doing so, it also supplants organizational loyalty as a cultural obligation, and membership provides a professional validation that is required by this sector.

The complexity associated with the research study has made the researcher aware of the dynamism present in undertaking a contextualized study of diffusion. Furthermore, the choice of research method has provided a much richer and more comprehensive understanding than would otherwise be revealed by an intra-organizational viewpoint alone. The following section applies the findings from the research study to the development of a model specific to the Minerals Mining Industry of Australia.

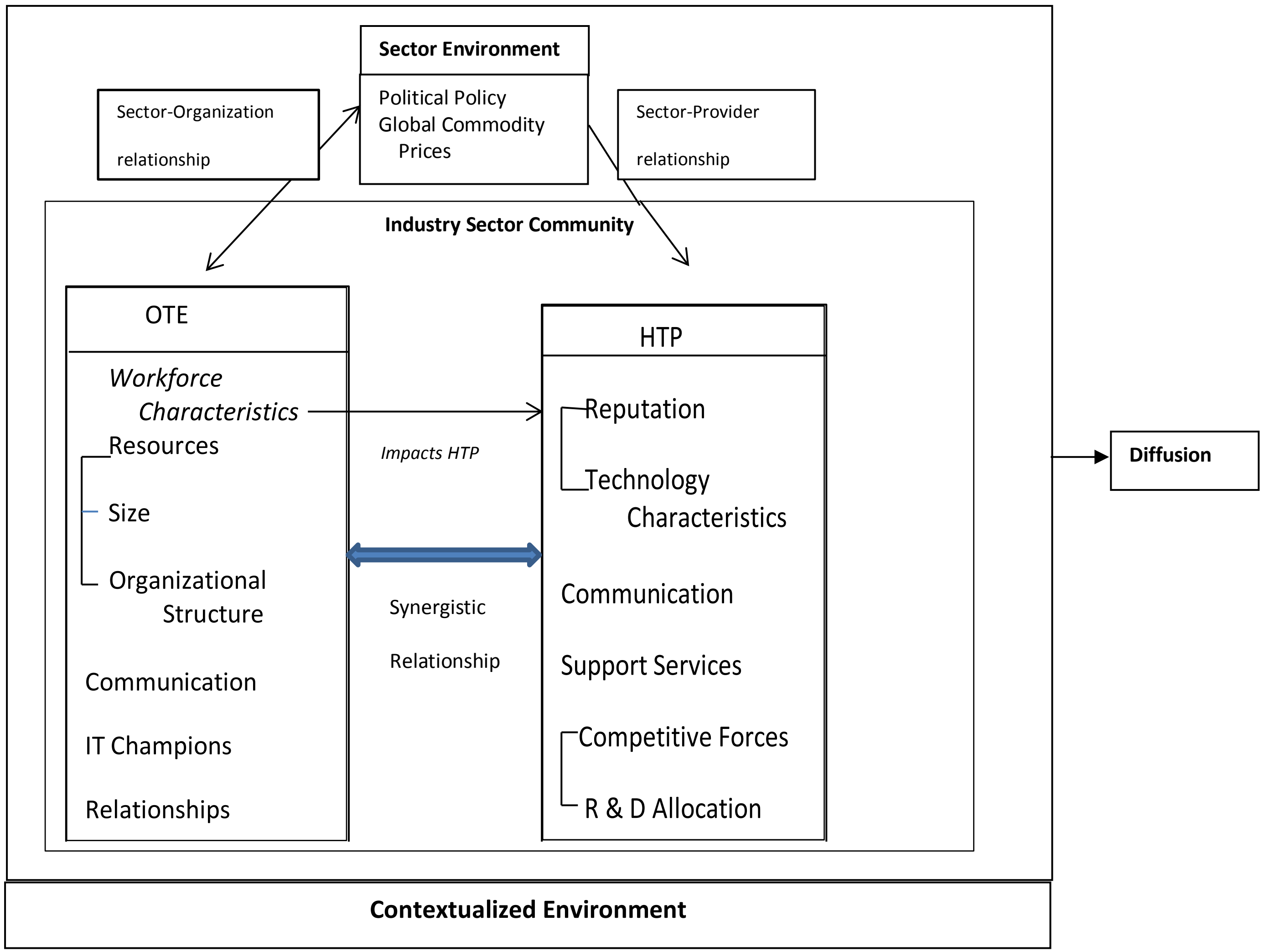
9.2 A Revised Diffusion Model for the Minerals Mining Context

The findings that emerged from this research study indicate a much more complex view of diffusion and assimilation when the context and relationships are also incorporated into a model. In this research, two significant outcomes moderate the model shown in Figure 9.2 below. The first outcome is found in the OTE factor, i.e. Workforce Characteristics (shown in italics below). As previously discussed, this characteristic has transformed the industry sector by the widespread use of a contracted workforce, changing the concept of a permanent workforce profile and, in doing so, ameliorating the need for knowledge retention and assimilation of technologies. In response to this change, assimilation has been removed from the model. In addition to not only changing the dynamic within the OTE factor, it has also altered the market space for HTPs, thereby providing more opportunity for individual training. The second outcome following on from and strengthened by the profile of workforce characteristics is the emergent outcome of the culture of the minerals mining sector. This is not simply the network strength associated with the characteristic of "relationship", but supersedes the characteristic as a pervasive force within the industry sector and therefore the context. This is represented in Figure 9.3 as the "Industry Sector Community" within which both OTEs and HTPs organizationally engage as do the individuals within the industry sector. The "Industry Sector Community" represents not only a professional and social network which provides services to its members through professional associations, but also the culture of the minerals mining industry of Australia and the inherent behaviours and beliefs which have shaped the industry throughout its history.

In addition, the "Synergistic Relationship" between the OTEs and HTPs is shown to more accurately reflect the dynamism found between these parties. The relationship goes beyond a contractual relationship and each factor benefits from the synergy within the context.

Within each factor, a number of characteristics are linked (represented by lines joining the characteristics). These links indicate that there is an affiliation between linked characteristics and that they should be understood in tandem to determine their effect on diffusion.

Figure 9.2: Revised Mining Minerals Model of Australia post study



The changes to the model are significant and reflect a context and industry sector which, arguably, may be unique. This context pertains to a specific culture which includes the organizations and technology providers that define the industry sector and its components. Organizationally, this industry sector is layered, resulting in links between characteristics not previously included in research with an intra-organizational perspective as the unit of study. Moreover, the synergistic relationship between the HTP and OTE factors was unexpected at the commencement of the research and demonstrates that HTPs may act as important drivers in respect of diffusion and that, together, the OTE and HTP factors tend to obviate the effect of the sector characteristics.

The next section evaluates the viability of a generalizable model of diffusion.

9.3 The relevance of a Contextualized Generalizable Model of Diffusion

This research study has demonstrated that context can impact on a model of diffusion, either promoting or constraining the diffusion depending on the sector characteristic event. Context, as demonstrated by this research study, incorporates both the participating factors and the relationships between factors as well as specific sector characteristics that may impact on the industry sector. In developing a model for this research study, on analysis it became evident that a context view was likely to produce unexpected relationships and new characteristic profiles. These may be influential in interpreting a model but are not visible prior to analysis without the holistic view obtained by considering the context as a whole. It is therefore unlikely that, without modification, a single generalizable model can be applied to different contexts with any validity sufficient for it to be viable.

The approach suggested by this researcher is for future researchers to consider the model that was developed from the literature review as a general, incorporated model from which a model for a specific context may be developed. The initial conceptual model previously presented in Figure 3.1 is shown below.

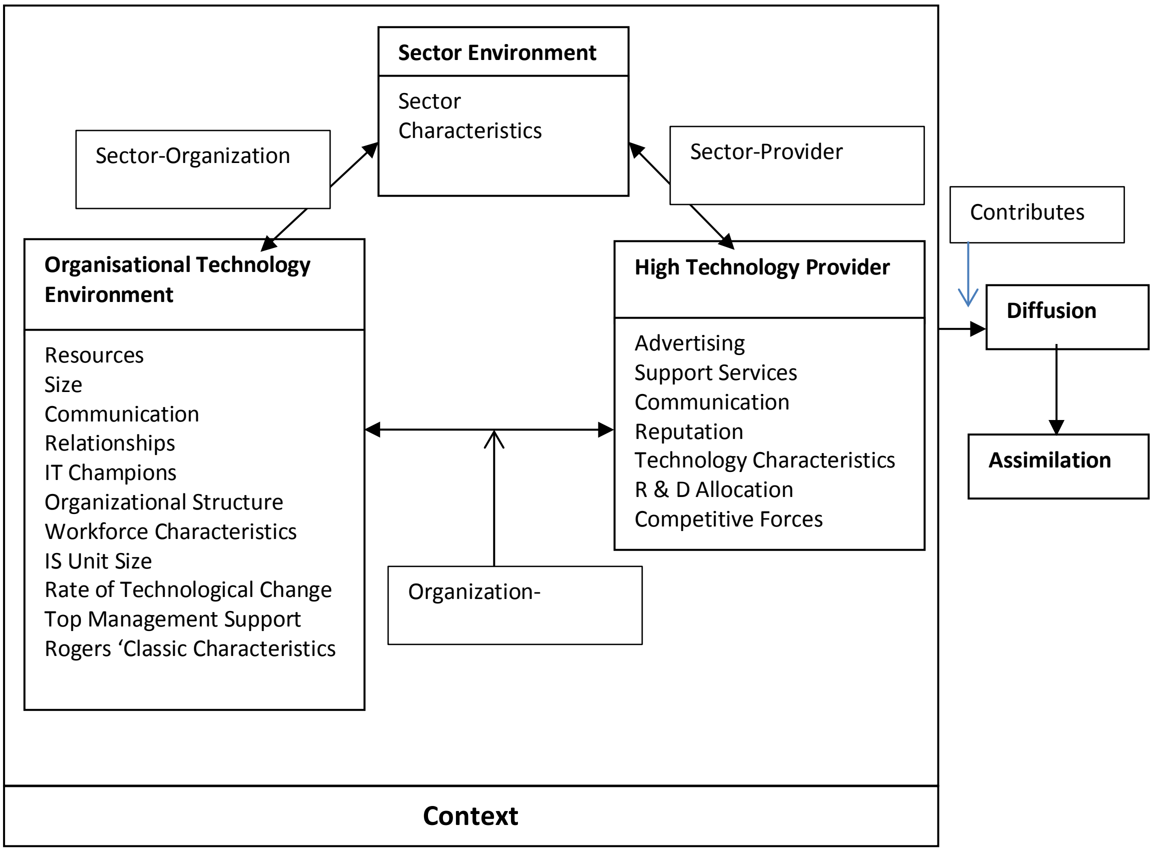


Figure 9.3: **Initial Conceptual Model (as shown in Figure 3.1)**

This model includes those characteristics previously validated in prior diffusion research but also incorporates supply-side characteristics, relationships and sector characteristics to represent a contextualized model. Two constraints must be considered in utilizing such a model: the first is that sector characteristics must be determined with the use of expert industry sector knowledge; the second consideration is that it is a diffusion model that depends on the use of specific classes of technologies that are relevant to the industry sector and are unlikely to be found in general use outside the context. Such a model must be researched, analysed and defined to be relevant across a specific sector or context.

The following section specifically addresses the outcomes of this research in terms of addressing the research questions.

9.4 How the Minerals Mining Industry of Australia addresses the Research Questions

The Minerals Mining Industry of Australia was selected for this research study as it specifically met the criteria suggested by Fichman (1992, 2000, 2004), combined with recommendations from Newell et al. (2000) and Robertson and Gatignon (1984). The Minerals Mining Industry of Australia not only provided a defined context within which the industry operates, but provided a layering where the extent of the participation required and limited specific classes/types of technologies. The research questions proposed in Chapter 1 were:

1. How important is context in the diffusion of high technology products/systems?

2. How influential are supply-side institutions in diffusing a technological solution/system?

3. What are the implications for understanding a diffusion model where context and supply-side institutions are present?

The first question specifically examined the effect of context on a diffusion model. Context within the model consisted of the "Sector Characteristics", "Organizational Technology Environment" and "High Technology Providers". A context is also a dynamic environment and so the relationships between factors were also included to better examine the dynamism within a business environment. In this research, the context was the Minerals Mining Industry of Australia and included those organizations (organizational technology environments) that are involved in mining and utilize specific (high) systems/technologies to provide necessary functionalities (provided by high technology providers) for sector operations. Each of the factors is subject to sector influences (beyond their control) in the industry sector. In the minerals mining industry of Australia, the sector characteristics described forces or events that impact on other factors and to which those factors must respond. Given that each context and sector is unique in its operations, the characteristics of "Sector Characteristics" must be defined specifically for each context. The data derived from this study indicated that the characteristics defined within the factor, had the capacity to affect the context, and where the impact was negative (as in sustained low commodity prices), this influenced the decision-making of the OTEs, producing a flow-on effect on everyone in the sector. A decline in commodity prices restricted future resource investment, reducing the need for adoption of systems/technologies and their diffusion throughout the industry sector. In this research study, although outside the immediate context, the impact of a change in a context may also extend to the Australian economy in terms of resource exports as has been reported both at state and federal levels. This research study therefore responds to the first research question: that the importance of the context may be significant where an event is affective across the context and that that sector characteristics may produce less evident but nevertheless influential effects across the sector through variations in sector activity. Importantly, the effect of the context is not limited to the internal perspective of the organizations within the sector, but also provides a dynamic between factors within the sector. This creates dynamic relationships that provide a counter or utilise the effects of the sector to their mutual benefit.

The second question addressed the importance of supply-side institutions in diffusing a system/technology. Supply-side institutions have attracted little attention in prior information systems research in respect of diffusion studies. The contractual agreements appeared to be considered the extent of the relationship with little or no importance accredited to the supply-side institution as a driver of adoption or diffusion. However, this research study demonstrated that a dynamic relationship exists between the OTEs and HTPs and produces a synergy that benefits and is actively maintained by the HTPs. A major benefit for the HTPs is feedback from OTEs that provides accurate research and development opportunities for the HTPs. The HTPs are better able to drive new products to OTEs by this synergistic relationship that responds directly to their needs, thus acting as a catalyst for diffusion. The strength of a relationship between the HTPs and OTEs also provides a barrier to entry by competing providers. Within this research, we can state that given a synergistic relationship exists between the HTPs and OTEs, and that the HTPs may have significant influence on the diffusion of a system/technology throughout the mining sector, thereby limiting and controlling the marketplace.

The third question sought to understand the implications that are present when modelling for inclusion of both context and supply-side institutions in respect of diffusion. It was stated in Chapter 1 that the first two questions were the foci of the research study; however, the third question has proven to be the most challenging of all given the information and knowledge acquired during the various phases of the study. The use of qualitative methods provided a richer picture of the relationships and dynamics present in this particular context than could be acquired through an intra-organizational study. The discussion presented throughout the research study has shown relationships and subtleties that a quantitative methodology approach would not reveal. The diffusion model as shown in Figure 9.3 has attempted to develop a diffusion model appropriate for this specific context which incorporates those outcomes not evident in previous models. This model is more holistic as it includes the context and the interplay of factors and culture, and is therefore more realistic. However, given the specificity of the context, it has limited generalizability outside the context of this study.

9.5 Limitations of the Research and Future Directions

The contextualization of an organizational model for diffusion appears to the researcher to be logical when considering that all industry sectors operate within economic business realities. No single organization can operate without participating within its industry sector and therefore must be subject to specific economic forces or sector events. The effect of the globalization of business is the creation of new business dynamics as global competition increases. Each of the significant contributors to the concepts presented in this research, Fichman (1992, 2000, 2004), Eveland and Tornatzky (1990), Van de Ven (1991), Newell et al. (2000)

and Robertson and Gatignon (1984) saw, in their own times, opportunities for better understanding of how a technological innovation was diffused, and attempted to discover and understand the drivers within and between factors. Changes occur as organizations become multi-faceted and where many businesses seek to integrate with their suppliers. The major limitation of this research is therefore the context itself. Context defines an industry sector and those forces that operate within its boundary, providing meaning only within the context itself. Those subtleties emerging from this context such as a strong community culture and professional network strength combined with a specific workforce profile and strong synergistic relationships impact on the model but without any probable generalizability across contexts.

What is clear, however, is the importance of contexts and that they provide a boundary in which unexpected dynamics may occur which are influential, but are not revealed by utilising only a quantitative approach. Equally true is that the operational complexities of a context are not often fully visible or comprehensible to any researcher from outside the context. Expert knowledge of the industry sector should be a valuable tool for the researcher in developing a model that is meaningful to the industry sector and context.

As we participate in increasingly technologically-supported business environments, some industry sectors are progressively becoming important economically or socially and naturally assume a context based on their activity. These sectors such as health, construction, aeronautics, nano-engineeering, bio-technologies, global supply chains and even education provide opportunities to extend our knowledge of the diffusion of technologies in context.

However, there is also an opportunity for further research that evolves from this study which in its infancy is conceptualized as “Technology Context Dynamics”.

9.6 Recommendations and Conclusion

Diffusion of Innovations research has itself evolved from its conceptualization from the perspective of a social network to be utilized across many disciplines including Information Systems. The viewpoint has changed perspective from social networks to organizational entities with differing units of study. Currently, commercial activities are underpinned by a variety of technologies/systems and software with many organizations attempting to realize benefits from their IS/IT investments and attempting to determine how to make appropriate decisions. Whilst Diffusion of Innovations remains a valuable research theory, this research study has highlighted a number of outcomes that suggest that it may be appropriate to consider alternative conceptualizations in understanding the placement and usage of systems/technologies within a 21st century context. From this study, the following issues emerge for consideration:

- The context itself may include moderators that are unperceived and act upon factors within the context. The intra-organizational perspective which has been most commonly utilized by previous researchers introduces an immediate constraint upon research by excluding context factors. The context should be examined before undertaking research to assess for obvious contextual influences.
- The profile of characteristics of any factor within a context can alter the sector dynamics, thereby affecting the behaviour of both individuals and organizations. Researchers should consider the possibility of relationships between factors that are unseen to those without context expertise. These relationships may exert unseen moderators upon diffusion and/or assimilation of innovations. It is unlikely that a quantitative only approach will expose such relationships and needs to be combined with alternative research methodologies.
- Professional organizations, and therefore a social network, displace organizational loyalty to the extent that a community culture acts as a pervasive force. The extent of influence of networks whether social or

professional should be considered as an active agency in moderating factors, behaviours and other relationships within a close context. The network may also act as a defacto culture thus displacing the organizational culture and loyalty especially where contexts utilize a contract based employees profile.

- Both the organizational culture and the above mentioned community culture produce a balance that is not evident in an intra-organizational perspective. Further research is suggested to understand the implications from the organizational perspective of the balance between organization and the professional/community culture and the effect of significant displacement to a community culture.
- Supply-side organizations may be considered as organizational partners rather than as contractual entity. The depth of engagement with supply-side partners should be considered when understanding the diffusion/assimilation of innovations within organizations. If as in this research much R & D is performed by the supply-side provider there is an underlying binding relationship which fundamentally alters the relationship in the context value chain.
- De facto standards exist based on historical usage patterns. The historical development of industry contexts can create de facto standards and consideration of this as a moderator on factors of diffusion and assimilation should be considered. De facto standards are also promoted through professional networks which become embodied as perceptions of quality and are accordingly difficult to change.
- The industry sector (as in mining) is layered, thereby determining the availability to utilize resources with a layer and correspondingly to utilize technologies. The layering and segmentation of the mining sector demonstrated limitations on adoption of technologies both as a result of the layering but also financial resources constraints. This aspect of a context should be understood prior to research commencing. Expert knowledge is crucial to the researcher unfamiliar approaching a context as subtleties of industry patterns may not be evident.

- The relationships between factors may not be simple but may involve synergies that provide benefits to both sides of the relationship. The relationship between factors should consider the type of relationship and the benefits that may accrue between factors thus creating bi-directional opportunities and synergies.
- Technology usage and high technology providers determine interoperability and modularity based on creating barriers to entry into the market. Proprietary technologies often rest within the proprietary relationships thus reducing opportunity for entry into markets and reducing competition. Historical evolution of technology also demonstrates a 'lock-in" effect which sees the client organizations unwilling to change providers based up perception of technological tie-in and the need for continuity for the business organization.
- Research and Development devolves to the high technology providers based on a synergistic relationship between themselves and their organizational market. This produces barriers to entry for competitors and benefits between both provider and organization and produces relationship ties that become strengthened the longer the tie-in period.
- The workplace and organizational structure which is an outcome of the research presents opportunities for understanding the impact of and long term consequences for knowledge retention and absorptive capacity when change to what have been long held work practices become entrenched. This particular point is may prove to be crucial to future studies as a lack of no existing studies appear to consider the impact of a lack organizational loyalty and culture displacement bought about by a contracted workforce.

More research is required on other contexts to determine the uniqueness or commonality of these outcomes. The suggestion of an alternate conceptualization, as proposed in the previous section, developmentally labelled as "Technology Context Dynamics" is asking how to consider the utilization, benefits, usage and diffusion as well as a solution of the outcomes listed above for technologies/systems as they become critical to commercial viability in an increasingly dynamic environment .

Finally, an acknowledgement and thanks to you the reader and reviewer for your consideration and comments of the material presented to you within this research.

Bibliography

ABC. (2010). Market spooked by mining super tax. Retrieved 03/05/2010, 2010, from www.abc.net.au/news/stories/2010/05.03/2888632.htm

Abrahamson, E. (1991). Managerial fads and fashions: The diffusion and rejection of innovations. *Academy of Management Review*, *16*(3), 586-612.

Afuah, A. (1998). *Innovation Management: Strategies, Implementation and Profits*. New York: Oxford University Press.

Alavi, M. & Carlson, P. (1992). A review of MIS research and disciplinary development. *Journal of Management Information Systems*, 45-62.

Argote, L. & Ophir, R. (2002). Intraorganizational Learning. In J. A. C. Baum (Ed.), *Companion to Organizations* (pp. 181-207). Oxford, U.K.: Blackwell.

Attewell, P. (1992). Technology Diffusion and Organizational Learning: The Case of Business Computing. *Organization Science, 3*(1), 1-19.

Attewell, P. & Rule, J. B. (1991). Survey and other methodologies applied to IT impact research: experiences from a comparative study of business computing. *The Information systems research challenge: survey research methods*, *3*, 299-315.

Australian Bureau of Agriculture and Resource Economics .(2011). *Australian Mineral Statistics 2011.* Retrieved from: http://data.daff.gov.au/data/warehouse/pe_abares99010607/AMS11.2_Marchqtr_2011_lowres_REPORT.pdf

Austmine. (2013) Australia's new Driver for Growth. Retrieved from: http://www.austmine.com.au/Portals/25/Content/Documents/Austmine%20Survey%20Highlights.pdf

Austrade. (2013). Mining Software and Specialised Technologies. Retrieved from : https://www.google.com.au/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=mining+software+and+specialised+technologies

Baker, J. (2012). The technology–organization–environment framework. *Information systems theory* (pp. 231-245). Springer New York.

Baxter, P & Jack, S. (2008). Qualitative Case Study Methodology and Implementation for Novice Researchers. The Qualitative Report, 13 (4), 544-559.

Beath, C. M. (1991). Supporting the information technology champion. *MIS Quarterly*, 355-372.

Benbasat, I. & Weber, R. (1996). Research commentary: Rethinking “diversity” in information systems research. *Information Systems Research*, *7*(4), 389-399.

Bernstein, R.J. (1983). *Beyond Objectivism and Relativism.* University of Pennsylvania Press. Pennsylvania.

Benbasat, I., Goldstein, D. K. & Mead, M. (1987). The case research strategy in studies of information systems. *MIS quarterly*, 369-386.

Bisgaard, S. (2008). Geared Toward Innovation. *Quality Progress,* 41(9), 20-25.

Bluedorn, H. http://www.triviumpursuit.com/articles/two_methods_of_reasoning.php

Boeker, W. & Huo, Y. P. (1998). Innovation adoption by established firms: unresolved issues. *The Journal of High Technology Management Research*, *9*(1), 115-130.

Borgatti, S.P. & Cross, R. (2003). A relational view of information seeking and learning in social networks. *Management Science, 49*(4), 541-568.

Bouchard, L. (1993). Decision Criteria in the Adoption of EDI*. Paper presented at the 14th Annual International Conference on Information Systems*, Orlando, Florida.

Bourner, T. (1996). The research process: four steps to success. *Research methods: guidance for postgraduates.* London: Arnold.

Boynton,A.C., Zmud, R.W. & Jacobs, G.C. (1994). The IT Management practice on IT use in large organizations. *MIS Quarterly, 18 (3), 299-318.*

Brancheau, J. C. & Wetherbe, J. C. (1990). The adoption of spreadsheet software: testing innovation diffusion theory in the context of end-user computing. Information Systems Research, 1(2), 115-143.

Buckl, S., Ernst, A. M., Matthes, F. & Schweda, C. M. (2009). An information model capturing the managed evolution of application landscapes. In *Advances in Enterprise Engineering III* (pp. 85-99). Springer Berlin Heidelberg.

Carlson, J. R., & Zmud, R. W. (1999). Channel expansion theory and the experiential nature of media richness perceptions. *Academy of Management Journal*, *42*(2), 153-170

Cavaye, A. L. (1996). Case study research: a multi‐faceted research approach for IS. *Information Systems Journal*, *6*(3), 227-242.

Chen, W. & Hirschheim, R. (2004). A paradigmatic and methodological examination of information systems research from 1991 to 2001. *Information Systems Journal*, *14*(3), 197-235.

Chong, A. Y. L., Lin, B., Ooi, K. B., & Raman, M. (2009). Factors affecting the adoption level of c-commerce: An empirical study. *Journal of Computer Information Systems*, *50*(2), 13-22.

Chua, W. F. (1986). Radical developments in accounting thought. *Accounting Review*, 601-632

Cohen, W.M. & Levinthal, D.A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly, 35*(3), 128-152.

Cooper, R. B. & Zmud, Robert W. (1990). Information technology implementation research: a technological diffusion approach. *Management Science, 36*(2), 123-139.

Cross, R. & Sproull, L. (2004). More than an answer: Information relationships for actionable knowledge. *Organization Science*, *15*(4), 446-462.

Daft, R. L. (1978). A dual-core model of organizational innovation. *Academy of Management Journal*, *21*(2), 193-210.

Damanpour, F., & Evan, W. M. (1984). Organizational innovation and performance: the problem of" organizational lag". *Administrative Science Quarterly*, 392-409.

Damanpour, Fariborz. (1987). The adoption of technological, administrative, and ancillary innovations: impact of organizational factors. *Journal of Management, 13*(4), 675-688.

Damanpour, Fariborz. (1991). Organizational Innovation: A Meta-Analysis of effects of Determinants and Moderators. *Academy of Management Journal, 34*(3), 555-590.

Darke, P., Shanks, G. & Broadbent, M. (1998). Successfully completing case study research: combining rigour, relevance and pragmatism. *Information Systems Journal*, *8*(4), 273-289.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

Delhaye, R. & Lobet-Maris, C. (1995). EDI adoption and standard choice: A conceptual model. In *ECIS* (pp. 165-182).

Deroïan, F. (2002). Formation of social networks and diffusion of innovations. *Research Policy*, *31*(5), 835-846.

Downs, G.W. & Mohr, L.B. (1976). Conceptual Issues in the Study of Innovation. *Administrative Science Quarterly,* 21 (4), 700-714.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532-550.

Ettlie, J. E. (1983). Organizational policy and innovation among suppliers to the food processing sector. *Academy of Management Journal*, *26*(1), 27-44.

Eveland, J.D. & Tornatzky, L. (1990). The Deployment of Technology. In L. Tornatzky & M. Fleischer (Eds.), *The Processes of Technical Innovation*. Lexington: Lexington Books.

Fichman, R.G. (1992, December). *Information Technology Diffusion: A Review of Empirical Research.* Paper presented at the International Conference of Information Systems, Dallas.

Fichman, R.G. (2000). The Diffusion and Assimiliation of Information Technology Innovations. In R. Zmud (Ed.), *Framing the Domains of IT Management: Projecting the Future Through the Past*: Pinnaflex Publishing.

Fichman, R. (2004). Going Beyond the Dominant Paradigm for Information Technology Innovation: Emerging Concepts and Methods. *Journal of the Association for Information Systems,* 5, 8, 314-355.

Fichman, R.G. & Kemerer, C.F. (1993). *Toward a Theory of the Adoption and Diffusion of Software Process Innovations.* Paper presented at the Working Conference on Diffusion, Transfer and Implementation of Information Technology, Pittsburgh, PA.

Fichman, R.G. & Kemerer, C.F. (1997). The Assimilation of Software Process Innovations: An Organizational Learning Perspective. *Management Science, 43*(1), 1345-1363.

Fichman, R.G. & Kemerer, C.F. (1999). The Illusory Diffusion of Innovation: An Examination of Assimilation Gaps. *Information Systems Research, 10*(3), 255-275.

Fielden, K. (2003). Fact or fiction: Qualitative research results in information systems. *Proc of Informing Science InSITE'03-" Where Parallels Intersect" June 2003*.

Frambach, R. T., Barkema, H.G., Nooteboom, B. and Wedel. M. (1998). Adoption of a Service Innovation in the Business Market: An Empirical Test of Supply-Side Variables. *Journal of Business Research, 41*, 161-174.

Friedman, A. L., & Cornford, D. S. (1989). Computer Systems Development: History Organization and Implementation. John Wiley & Sons, Inc..

Gable, G. G. (1994). Integrating case study and survey research methods: an example in information systems. *European Journal of Information Systems*, *3*(2), 112-126.

Galliers, R. D. (1991). Strategic information systems planning: myths, reality and guidelines for successful implementation. *European Journal of Information Systems*, *1*(1), 55-64.

Galliers, R. D. (1993). Research issues in information systems*. *Journal of Information Technology*, *8*(2), 92-98.

Gallivan, M. J. (2000, April). Examining workgroup influence on technology usage: a community of practice perspective. In *Proceedings of the 2000 ACM SIGCPR Conference on Computer Personnel Research* (pp. 54-66). ACM.

Gatignon, H. & Robertson, T. S. (1985). A propositional inventory for new diffusion research. *Journal of Consumer Research*, 849-867.

Gatignon, H. & Robertson, T. S. (1989). Technology diffusion: an empirical test of competitive effects. *The Journal of Marketing*, 35-49.

Germain, R. (1996). The role of context and structure in radical and incremental logistics innovation adoption. *Journal of Business Research*, *35*(2), 117-127.

Giddens, A. (1984). The constitution of society: Outline of the theory of structuration. Univ of California Press.

Gill, T.G. (1995). Early Expert Systems: Where are they now? *MIS Quarterly, 19*(1), 51-81.

Glaser, B. G. (1992). Emergence vs forcing: Basics of grounded theory analysis. Sociology Press.

Glasser, B. G, & Strauss, A. L. (1967). The development of grounded theory. *Chicago, IL: Alden*.

Gopalakrishnan, S. & Damanpour, F. (1997). A review of innovation research in economics, sociology and technology management. *Omega*, *25*(1), 15-28.

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, 1360-1380.

Granovetter, M. (1983). The strength of weak ties: A network theory revisited. *Sociological Theory*, *1*(1), 201-233.

Granovetter, M. (1985). Economic action and social structure: the problem of embeddedness. *American Journal of Sociology*, 481-510.

Granovetter, M. (2003). Ignorance, knowledge, and outcomes in a small world. *Science*, *301*(5634), 773-774.

GrantThornton. (2009). Survey of junior mining and exploration companies. Retrieved from http://www.grantthornton.com.au/globalassets/1.-member-firms/australian-website/publications/gtal_2009_er_jumex_survey.pdf

Gregor, S. (2006). The nature of theory in Information Systems. *MIS Quarterly,* 611-642

Grey, C. & Mitev, N. (1995). Re-engineering organizations: a critical appraisal. *Personnel Review*, *24*(1), 6-18.

Haine, I. (2006). Minerals & Energy: Major Development Projects. *Australia Comodities: Forecast & Issues.* 13(4), 713-726.

Hewett, K., Money, R. B. & Sharma, S. (2002). An exploration of the moderating role of buyer corporate culture in industrial buyer-seller relationships. *Journal of the Academy of Marketing Science*, *30*(3), 229-239.

Herriott, R. E. & Firestone, W. A. (1983). Multisite qualitative policy research: Optimizing description and generalizability. *Educational Researcher*, 14-19.

Huberman, A. M. & Miles, M. B. (1994). Data management and analysis methods.

Ingram, P. (2002). Interorganizational Learning. In J. A. C. Baum (Ed.), *Companion to Organizations*. Oxford. U.K.: Blackwell.

Ives, B. & Jarvenpaa, S. L. (1991). Applications of global information technology: key issues for management. *MIS Quarterly*, 33-49.

Janesick, V. J. (2000). The choreography of qualitative research design. *Handbook of Qualitative Research.*, 379-399.

Johnson, R. B., Onwuegbuzie, A. J. & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*(2), 112-133.

Kaplan, B. & Maxwell, J. A. (2005). Qualitative research methods for evaluating computer information systems. In *Evaluating the Organizational Impact of Healthcare Information Systems* (pp. 30-55). Springer New York.

Kautz, K., Henriksen, H. Z., Breer-Mortensen, T. & Poulsen, H. H. (2005). *Information Technology Diffusion Research: An Interim Balance* (pp. 11-34). Springer US.

Kerlinger, F. (1986). Fondations of Behavioural Research. (3rd ed). New York. Hall, Rinehart & Winston.

Kirchner, S. VERSuS CYCLES.

Kwon, T.H. (1990, December). *A Diffusion of Innovation Approach to MIS Infusion: Conceptualization, Methodology, and Management Studies.* Paper presented at the 11th Annual International Conference on Information Systems, Copenhagen, Denmark.

Kwon, T.H. & Zmud, R. (1987). Unifying the Fragmented models of Information System Implementation. In J. R. Boland & R. A. Hirscheim (Eds.), *Critical Issues in Information Systems Research* (pp. 227-252): Wiley & Sons.

Landry, M., & Banville, C.(1992). A discilpined methdological pluralism for MIS research. Accounting, *Management & Information Technologies*, 2(2), 77-97.

Lee, A. S. (1991). Integrating positivist and interpretive approaches to organizational research. *Organization Science*, *2*(4), 342-365.

Leonard-Barton, D. (1988). Implementation Characteristics of Organizational Innovations. *Communication Research, 15*(5), 603-631.

Levin, D. Z. & Cross, R. (2004). The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. *Management Science*, *50*(11), 1477-1490.

Levitt, B. & March, J. G. (1988). Organizational learning. *Annual Review of Sociology*, 319-340.

Liker, J.K. Fleischer, M., & Arnsdorf, D. (1992). Fulfilling the promise of CAD. *Sloan Management Review, 33*(3), 74-82.

Lillis, A. M. (1999). A framework for the analysis of interview data from multiple field research sites. *Accounting & Finance*, *39*(1), 79-105.

Lin, H. F., & Lin, S. M. (2008). Determinants of e-business diffusion: A test of the technology diffusion perspective. *Technovation*, *28*(3), 135-145.

Lind, M. R., Zmud, R. W. & Fischer, W. A. (1989). Microcomputer adoption—the impact of organizational size and structure. *Information & Management*, *16*(3), 157-162.

Lind, M. R. & Zmud, R. W. (1991). The influence of a convergence in understanding between technology providers and users on information technology innovativeness. *Organization Science*, *2*(2), 195-217.

Lyytinen, K. & Damsgaard, J. (2001). What's wrong with the diffusion of innovation theory? (pp. 173-190). Springer US.

Mahajan, V., Muller, E. & Bass, F. M. (1991). New product diffusion models in marketing: A review and directions for research. In *Diffusion of Technologies and Social Behavior* (pp. 125-177). Springer Berlin Heidelberg.

Malhotra, A., Gosain, S., & Sawy, O. A. E. (2005). Absorptive capacity configurations in supply chains: gearing for partner-enabled market knowledge creation. *MIS quarterly*, 145-187.

Martinez-Fernandez, M. Cristina. (2005). Knowledge-Intensive Service Activities (KISA) in Innovation of the Mining Technology Services Sector in Australia. Sydney: AEGIS.

McDade, S. R., Oliva, T. A. & Pirsch, J. A. (2002). The organizational adoption of high-technology products "for use": Effects of size, preferences, and radicalness of impact. *Industrial Marketing Management*, *31*(5), 441-456.

Melville, N. & Ramirez, R. (2008). Information technology innovation diffusion: an information requirements paradigm. *Information Systems Journal*, *18*(3), 247-273.

Meyer, A.D. & Goes, J.B. (1988). Organizational Assimilation of innovation: A multilevel contextual analysis. *Academy of Management Journal, 31*, 897-923.

Miles, M. B. & Huberman, A. M. (1984). Qualitative Data Analysis. Beverly Hills.

Mingers, J. (2001). Combining IS research methods: towards a pluralist methodology. *Information Systems Research*, *12*(3), 240-259.

Moore, G. A. (2002). Crossing the chasm.

MTSAA. (2002). *Technology Transfer and R & D Coordination Working Group Industry Issues Paper.* MTSAA Retrieved from www.industry.gov.au.

Mumford, E., Hirschheim, R., Fitzgerald, G. & Wood-Harper, A. T. (1985). Research methods in information systems. North-Holland Publishing Co.

Mustonen ‐ Ollila, E. & Lyytinen, K. (2003). Why organizations adopt information system process innovations: a longitudinal study using Diffusion of Innovation theory. *Information Systems Journal*, *13*(3), 275-297.

Myers, M. D. (2009). Qualitative Research in Business & Management.

Nelson, R.R. & Winer, S.G. (1982). An Evolutionary Theory of Economic Change. Harvard Press, Cambridge. MA.

Neuman, W. L. & Neuman, W. L. (2006). Social research methods: Qualitative and quantitative approaches.

Newell, S., Swan, J. A. and Galliers, R. D. (2000), A knowledge-focused perspective on the diffusion and adoption of complex information technologies: the BPR example. *Information Systems Journal*, 10: 239–259.

Nilakanta, S. & Scamell, R. W. (1990). The effect of information sources and communication channels on the diffusion of innovation in a data base development environment. *Management Science*, *36*(1), 24-40.

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review*,*69*(6), 96-104.

Nystrom, P. C., Ramamurthy, K., & Wilson, A. L. (2002). Organizational context, climate and innovativeness: adoption of imaging technology. *Journal of Engineering and Technology Management*, *19*(3), 221-247.

Oliveria, T., & Martins, M.F. (2011). Literature Review of Information Technology Adoption Models at Firm Level. *The Electronic Journal Information Systems Evaluation*, 14(1).

Orlikowski, W. J. & Baroudi, J. J. (1991). Studying information technology in organizations: Research approaches and assumptions. *Information Systems Research*, *2*(1), 1-28.

Pan, G. (1989). Concepts and methods of multivariate information synthesis for mineral resources estimation.(Doctoral Dissertation). Tuscon, AZ: Univeristy of Arizona.

Pan, G. & Harris, D. P. (1992). Estimating a favorability equation for the integration of geodata and selection of mineral exploration targets. *Mathematical Geology*, *24*(2), 177-202.

Pan, G. & Harris, D.P. (2000). Information Synthesis for mineral exploration. (vol 461). Oxford University Press.

Pavlou, P. A., & El Sawy, O. A. (2006). From IT leveraging competence to competitive advantage in turbulent environments: The case of new product development. *Information Systems Research*, *17*(3), 198-227.

Penney, J., Austin, A., Runley, C. & Curlotti, R. (2007). Sustainable Development of the Minerals Sector in the APEC Region. Canberra: Department of Industry, Tourism and Resources.

Pennings, J. M., & Buitendam, A. (1987). New technology as organizational innovation: The development and diffusion of microelectronics. Ballinger Pub Co.

Perry, J. L. & Kraemer, K. L. (1978). Innovation attributes, policy intervention, and the diffusion of computer applications among local governments. *Policy Sciences*, *9*(2), 179-205.

Porter, M. & Millar, V.E. (1985). How Information gives you Competitive Advantage. *Harvard Business Review,* July-August 1985, 149-174.

Premkumar, G., Ramamurthy, K. & Nilakanta, S. (1994). Implementation of electronic data interchange: an innovation diffusion perspective. *Journal of Management Information Systems*, 157-186.

Prescott, M.B. & Conger, S. (1995). Information Technology Innovations: A Classification by IT Locus of Impact & Research. *Database Advances*. 25, 2 & 3,pp29-41.

PriceWaterhouseCooper. (2010). Aussie Mine, Rise and Shine. Retrieved http://www.pwc.com.au/industry/energy-utilities-mining/assets/Aussie-Mine-Nov10.pdf

PriceWaterhouseCooper. (2014). Aussie Mine, Rise and Shine. Retrieved http://www.pwc.com.au/industry/energy-utilities-mining/assets/Aussie-Mine-Nov14.pdf

Purvis, R. L., Sambamurthy, V. & Zmud, R. W. (2001). The assimilation of knowledge platforms in organizations: An empirical investigation. *Organization Science*, *12*(2), 117-135.

Ramiller, Neil C. (1994). Perceived compatibility of information technology innovations among secondary adopters: Toward a reassessment. *Journal of Engineering & Technology Management, 11*(1), 1-23.

Roberts, N., Galluch, P. S., Dinger, M., & Grover, V. (2012). Absorptive Capacity and Information Systems Research: Review, Synthesis, and Directions for Future Research. *MIS quarterly*, *36*(2), 625-648.

Robertson, T.S. & Gatignon, H. (1986). Competitive Effects on Technology Diffusion. *Journal of Marketing, 50*, 1-12.

Robey, D. (1996). Research commentary: diversity in information systems research: threat, promise, and responsibility. *Information Systems Research*, *7*(4), 400-408.

Rogers, E. M. (1962). *Diffusion of Innovation*. New York: Free Press

Rogers, E.M. (1983). *Diffusion of Innovation* (3rd ed.). New York: The Free Press.

Rogers, E.M. (1995). *Diffusion of Innovation* (4th ed.). New York: The Free Press.

Rogers, E.M. (2003). *Diffusion of Innovation* (5th ed.). New York: The Free Press.

Roman, R. (2003). Diffusion of Innovations as a Theoretical Framework for Telecenters. *The Massachusetts Institute of Technology Information Technologies and International Development, 1*(2), 53-66.

Rosenberg, N. (1982). *Inside the Black Box: Technology and Economics*. Cambridge: Cambridge University Press.

Senior, A.B. & Huleatt, M. 2012. *Australian Mineral Exploration Review 2011.* Geoscience Australia, Canberra.

Senior, A.B. & Huleatt, M. 2014. *Australian Mineral Exploration Review 2013.* Geoscience Australia, Canberra.

Shanklin, W. L. & Ryans, J. K. (1984). Organizing for high-tech marketing. *Harvard Business Review*, *62*(6), 164-171.

Sharma, R. & Yetton, P. (2003). The contingent effects of management support and task interdependence on successful information systems implementation. *MIS Quarterly*, 533-556.

Sharma, R. & Yetton, P. (2007). The contingent effects of training, technical complexity, and task interdependence on successful information systems implementation. *Mis Quarterly*, 219-238.

Smith, S. (1988). How much change at the store? The impact of new technologies and labour processes on managers and staff in retail distribution. *New technology and the Labour Process.* Basingstoke: Macmillan, 143-62.

Sorenson, O. (2003). Interdependence and adaptability: Organizational Learning and the long-term effect of integration. *Management Science, 49*(4), 351-365.

Stasser, G. & Titus, W. (1985). Pooling of unshared information in group decision making: Biased information sampling during discussion. *Journal of Personality and Social Psychology*, *48*(6), 1467.

Stevens, M. (2010, 17 June, 2010). Miners united against faux super tax consultation, *The Australian*. Retrieved from www.theaustralian.com.au/business

Swanson, E.B. (1994). Information Systems Innovations Among Organizations. *Management Science, 40*(9), 1069-1092.

Tabak, F. & Barr, S. H. (1999). Propensity to adopt technological innovations: the impact of personal characteristics and organizational context. *Journal of Engineering and Technology Management*, *16*(3), 247-270.

Tasker, Sarah-Jane. (2010, 5/08/2010). Rudd's mining super-tax has damaged Australia's image, says Albanese. *The Australian.* from www.theaustralian.com.au/business/mining-energy

Tedesco, L. & Curlotti, R. (2005). Mining Technology Services a review of the sector in Australia: Australian Bureau of Agricultural and Resource Economics.

Teece, D. J. (1996). Firm organization, industrial structure, and technological innovation. *Journal of Economic Behavior & Organization*, *31*(2), 193-224.

Tornatzky, L. G., Fleischer, M. & Chakrabarti, A. K. (1990). Processes of technological innovation.

Tornatzky, L. & Klein, K. (1982). Innovation Characteristics and Innovation Adoption-Implementation: A Meta-Analysis of Findings. *IEEE Transactions on Engineering Management, EM-29*(1), 28-45.

Utterback, J. M. (1971). The process of technological innovation within the firm. *Academy of Management Journal*, *14*(1), 75-88.

Uzzi, B. & Lancaster, R. (2003). Relational embeddedness and learning: The case of bank loan managers and their clients. *Management Science*, *49*(4), 383-399.

Valente, T. W. (1996). Social network thresholds in the diffusion of innovations. *Social Networks*, *18*(1), 69-89.

Valente, T. W. & Davis, R. L. (1999). Accelerating the diffusion of innovations using opinion leaders. *The Annals of the American Academy of Political and Social Science*, *566*(1), 55-67.

Walker, J. L. (1969). The diffusion of innovations among the American states. *American Political Science Review*, *63*(03), 880-899.

Walsh, J.P. & Ungson, G.R. (1991). Organizational Memory. *Academy of Management Review, 16*, 59-91.

Wang, Y. M., Wang, Y. S., & Yang, Y. F. (2010). Understanding the determinants of RFID adoption in the manufacturing industry. *Technological forecasting and social change*, *77*(5), 803-815.

Wildemuth, B.M. (1992). An empirically grounded model of the adoption of intellectual technologies. *Journal of the American Society for Information Sciences, 43*, 210-214.

Wilson, A. L., Ramamurthy, K. & Nystrom, P. C. (1999). A multi-attribute measure for innovation adoption: the context of imaging technology. *Engineering Management, IEEE Transactions on*, *46*(3), 311-321.

Yin, R. (1994). *Case study research: Design and methods* . Beverly Hills.

Yin, R. K. (2003). Case study research design and methods third edition. *Applied Social Research Methods series*, *5*.

Zaltman, G., Duncan, R. & Hobek, J. (1973). *Innovations and Organizations*. New York: Wiley.

Zander, U. & Kogut, B. (1995). Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. *Organization Science*,*6*(1), 76-92.

Zmud, R. W. (1982). Diffusion of modern software practices: influence of centralization and formalization. *Management Science*, *28*(12), 1421-1431.

Zmud, R. (1984). An Examination of “Push-Pull” Theory Applied to Process Innovation in Knowledge Work. *Management Science*. 30,6, pp727- 738.

Zhu, K., Kraemer, K. L., & Xu, S. (2006). The process of innovation assimilation by firms in different countries: a technology diffusion perspective on e-business. *Management science*, *52*(10), 1557-1576.

"Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged"

Appendices

Appendix i : Table 1 from Fichman

Appendix ii : Research Instrument for Mining Technology Provider

Appendix iii : Research Instrument for Mining Technology Client Organization

Appendix iv : Research Instrument for Mining Consultant

Appendix I Table 1 : Fichman, 2000.

TABLE 1: COMPONENTS OF THE CLASSICAL DIFFUSION MODEL

Component	Definitions/Generalizations
Definition of Diffusion	The process by which an innovation is communicated through certain channels over time among the members of a social system.
Typical Diffusion Pattern	Process starts out slowly among pioneering adopters, reaches "take-off" as a growing community of adopters is established and the effects of peer influence arise, and levels-off as the population of potential adopters becomes exhausted, thus leading to an "S-shaped" cumulative adoption curve.
Innovation Characteristics	Innovations possess certain characteristics (relative advantage, compatibility, complexity, trialability, observability) which, as perceived by adopters, determine the ultimate rate and pattern of adoption.
Adopter Characteristics	Some potential adopters are more prone to innovate than others, and can be identified as such by their personal characteristics (education, age, job tenure etc.). Adopters can be usefully classified according to where they adopt relative to others (innovators, early majority, etc.).
Adoption Decision Stages	The adoption decision unfolds as a series of stages, flowing from knowledge of the innovation through persuasion, decision, implementation and confirmation. Adopters are predisposed towards different kinds of influence (e.g., mass market communication versus word-of-mouth) at different stages.
Opinion Leaders and Change Agents	The actions of certain individuals (opinion leaders and change agents) can accelerate diffusion, especially when potential adopters view such individuals as being similar to themselves.

Appendix II Case Study Protocol

Case Study Protocol and Research Instrument

Sharyn Curran

1 GENERAL SECTION

This section provides an overview of the research providing perspective with regard to:

- Research Objectives.
- Contribution of the research to community.
- Research methodology relevant to the current research phase.

1.1 Research Overview

This aim of this research is to provide both conceptual understanding and best practice guidance in the application of information systems in geophysical exploration. In doing so, it will seek to demonstrate the relationship between the assimilation and diffusion of technological innovation within the specific organizational context of a Mining Technology Service to the Mining Industry.

Diffusion of Innovations theory is a conceptual paradigm for understanding the process of diffusion. As a theory it seeks to explain the rationale for adoption of an innovation and its spread through a social system. Rogers (1996) regarded diffusion as the process by which an innovation is communicated through certain channels over time among members of a social system. The four fundamental theoretical elements were originally identified as innovation, time, communication channels and the nature of social system. Diffusion researchers have attempted to explain how and why an innovation is adopted and diffused through a field of activity in such diverse fields of endeavor ranging from medicine, agriculture, economics, political science and communication.

The advent of technology and its widespread consumerization has seen the application of Diffusion of Innovation Theory to explore and explain the factors that influence the adoption, sustainability and diffusion of a technology(either hardware or software) in an increasingly technology driven society. This theory also makes conceptualizations with regard to the characteristics of innovations, the types of media channels, the decision process and the characteristics and diversity of adopters. Diffusion of Innovations research may be adopted at both micro and macro level of analysis and although the unit of analysis had originally been based around an individual; an increasing number of studies have the organization as the unit of analysis.

The diversity of the application of technology within organizations has indicated to researchers that some variables will generalize more broadly than others and that the organizational sector represents a framework in which a technological innovation should be understood. Fichman (1999) suggests that researchers should develop theories of a middle range – that is, theories tailored to a specific class of technology, and/or to a particular adoption context. The application of diffusion studies currently and historically with the mining sector has had a primary focus on the diffusion of technologies related to chemical extraction or advances in the physical process of mining. To date there appears no significant research in the diffusion and assimilation of specialist technologies related to exploration in this sector.

The objective of this research is to therefore focus not only on contributing to the academic body of literature on diffusion and assimilation, but also to contribute to the mining community and its service providers an understanding of the key factors that provide organizational benefits from technology as a strategic investment.

Specifically, the major outcome addressed in this research is:

- The identification of the key factors that contribute to the successful assimilation of a geophysical technology and its subsequent diffusion across the mining sector within Australia.

Minor outcomes are:

- Understanding the impact of organizational size in the ability to assimilate an innovation.
- The influence of diversity of technical knowledge and it moderation in the speed of assimilation.
- The impact of related knowledge in the decision making process.
- The importance of communication channels within the diffusion process.
- Understanding the influence and impact of supplier side institutions within the diffusion of a technological solution.
- Identifying key organizational drivers that determine early or late adoption.

1.2 Research Methodology

A combination of both quantitative and qualitative research methodologies will be utilized within this research study. A combination of methods not only addresses the differing research questions, but provides a richer understanding of the issues and factors within the study. The use of case study as a research tool should provide strength and empirical validity arising from intimate linkage with empirical evidence (Eisenhardt, 1989).

It is envisaged that this study will progress with a number of specialist interviews followed by multiple case studies and a large scale survey.

The provision of this protocol ensures to participants the procedures and rules that govern the conduct of this research. The questions contained within the document are directed towards the unbiased validation of the conceptual model and contains the detailed data collection instrument for the research.

2. Procedures

This section details the code of conduct undertaken by the researcher during the course of this study. Participants are assured that this research has received ethics approval from Curtin University of Technology.

2.1 Selection of Cases

Theoretical sampling has formed the basis of the selection process. The study will be dually focused with representation from both mining technology providers and the mining industry that form their client base. The goal of theoretical sampling is to extend our theoretical knowledge and choose cases which are of diverse interests, thus enhancing the generalisability of the theoretical model.

2.2 Interviews with Technology Providers and Client Organizations.

Interviews will be conducted with key individuals involved with the provision and enabling of technology services to the minerals mining industry specifically associated with the exploration services. The study seeks to conduct cases with three technology providers and at least three client organizations. It may prove to be desirable to increase the number of client organizations included to provide diversity within the sample and increase the generalizability of results.

2.3 Establishing Contact

Interviews will be sought with key individuals from both providers and clients within the study. It is envisaged that a key contact be established within each organization (at the discretion of the organization) who will be fully apprised of the purpose of the study, the envisaged contribution organizationally and the conduct of the case study.
To assist prospective interviewees a copy of this protocol will be provided prior to each interview.

2.4 Confidentiality of Information

This research may necessitate the collection of confidential information concerning organizational relationships, contractual information/determination and data ownership. All normal safeguards to ensure confidentiality and protection of participating organizations will be followed. Data will be collected and stored according to the guidelines for research as published at:

http://www.nhmrc.gov.au/publications/synopses/r39syn.htm

These are the general guidelines for research as recommended by Curtin University of Technology.

If required, the researcher will sign declarations of confidentiality.

2.3 Interviews

Upon agreement of participation, the researcher will co-ordinate with the key contact to arrange appropriate meeting schedules with potential participants. Where feasible technology suppliers should provide an introduction to the technology product, client organizations will be requested to provide background to the decision-making process that led to engagement of the technology product.

2.3.1 Length of Interviews

Interviews will have an anticipated duration of approximately one hour. Should circumstances require some interviewees may be requested to participate in a follow-up interview session to clarify any matters arising from the previous interview.
All interviewees will be provided with a transcript of the interview.

Appendix III Research Instrument for Mining Technology Provider

3 Research Instrument – Mining Technology Provider

This section contains the research instrument that will be used to collect data via the previously outlined interview process and documentary evidence if provided. This section consists of a number of sub-sections each of which contributes to addressing a component of the conceptual model under research.

3.1 Respondent Details

The following questions are designed to provide background to the mining technology
services sector and will be utilised in providing a staffing profile for the researcher in understanding the client-organizational relationships.

Q1.1 What is your job title?
Q1.2 What duties does your role encompass in relationship to the your organizational role?
Q1.3 From the duties previously described, is there a primary role?
Q1.4 Have you previous experience in the provision of technology services prior to your current position.

One or more of sections may be only partially completed dependent upon the role of the interviewee within the organization.

3.2 Understanding the Technology

This section provides a description of technology as perceived by the technology service provider.

Q2.1 Could you provide a description of the technology characteristics which believe provide a perceived maximum potential for clients.
Q2.2 Is there direct competition for the technology product within the minerals mining sector?
Q2.3 If there is a direct competitor, which provider has an historical dominance?
Q2.4 How long has the technology/service been in existence and in its current version?
Q2.5 Is the technology deployed only as a complete package or can it be utilized and integrated with other systems?
Q2.6 How is the technology/service differentiated from competitors?

Q2.7 In respect of pre-implementation of the technology product, how would you describe the organizational cost associated with the implementation and deployment of the product (these may be time, provision of staff, training, integration of services etc).
Q2.8 Does the technology product maintain a substantial reputation within Australia?
Q2.9 Is the technology product continuing to undergo development or revisions?

3.3 Positioning of the technology within the market.

This section seeks to assist the researcher in understanding the positioning of a technology product within the market space.

Q3.1 What mechanisms does the technology provider utilize to raise awareness of the technology product/service e.g trade fairs, magazines, direct contact?
Q3.2 What primary methods of communication does the vendor employ with prospective clients and with existing clients?
Q3.3 Using the description of the market segment provided, how are existing clients distributed within this demographic.
Q3.4 Does the technology provider extend flexibility to prospective clients in terms of contractual arrangements and/or provision of outsourcing activities?
Q3.5 Has the mining boom in Western Australia had a direct impact on the organization in terms of market demand?
Q3.6 Has legislation within Australia had any impact in terms of the technology product/service requiring revisions?

3.4 The Vendor- Client Relationship

This section explores the vendor – client relationship from the vendor perspective.

Q4.1 What time frames are given for implementation and deployment of the technology/service?
Q4.2 Is training provided by the vendor on implementation and deployment of the technology/service?
Q4.3 If provided, is training normally provided direct to the users, a centralized IT area or both?
Q4.3 If provided, is the training offered customizable to the needs of the client?
Q4.4 Post-implementation, could you describe the strategy in maintaining a relationship with the client?

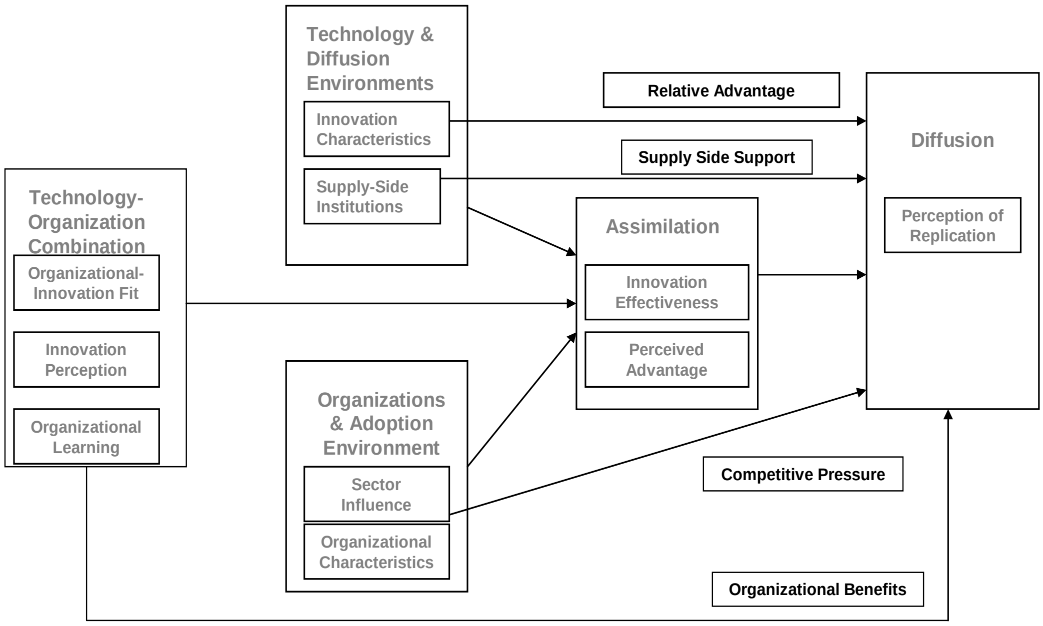
3.5 Summary

Q5.1 What do you feel are the key issues that attract a client to the technology/service?

3.6 Open Discussion

Your clarification and any other discussion in respect to the subject matter is appreciated. Your expert knowledge is keenly sought to enable this research to be fully informed.

Appendix A Research Model



Appendix B Description of Market Segments

A junior company as one that is yet to generate revenue and is usually financing exploration projects via raised capital; the observations and measurements collected by this type of exploration company form the basis of a mineral reserve that will subsequently be sold, shelved or evaluated for mining.

A mid-size company is one which is generating revenue and consequently has both exploration and mining operations.

A major company is one that has a significant exploration budget and also a large number of operations. They are involved in mining a range of commodities and often have projects in many countries.

Appendix IV : Research Instrument for Mining Technology Client Organization

3 Research Instrument – Mining Technology Client Organization

This section contains the research instrument that will be used to collect data via the previously outlined interview process and documentary evidence if provided. This section consists of a number of sub-sections each of which contributes to addressing a component of the conceptual model under research.

3.1 Respondent Details

The following questions are designed to provide background to the mining technology
services sector and will be utilised in providing a staffing profile for the researcher in understanding the client-organizational relationships.

Q1.1 What is your job title?
Q1.2 What duties does your role encompass in relationship to the your organizational role?
Q1.3 From the duties previously described, is there a primary role?
Q1.4 How long have you occupied your present role?

One or more of sections may be only partially completed dependent upon the role of the interviewee within the organization.

3.2 Background to the Product/Service Adoption

This section seeks to assist the researcher in understanding the adoption environment and identify any factors that may influence the adoption of a technology.

Q2.1 Could you outline the key factors in the decision to adopt this particular technology/service?
Q2.2. Was the adoption process influenced at all by pre-existing relationship with the vendor?
Q2.3 Was the adoption process influenced at all by trends in the industry sector?
Q2.4 Would you describe the adoption of the technology/service as an innovation

for the organization?

Q2.5 If the technology/service represents an innovation, would you describe it as a strategic innovation?

Q2.6 Did the introduction of the technology require a process re-design to maximise possible benefits?

Q2.7 If process re-design was required how was it rolled out and what issues were encountered that required additional resources?

3.3 **The Technology Organizationally**

This section seeks to assist the researcher in understanding the organizational impact of the adoption a technology both in terms of resources human and other costs.

Q3.1 Within the organization could you express an opinion as to how the technology is perceived by the direct users. This may include ease of use, compatibility to needs, cost , even service agreements?

Q3.2 Would you be able to comment as to whether there is a perception elsewhere in the organization of the value, benefits or costs associated with the technology?

Q3.3 Has the technology provided a relative advantage to the organization?

Q3.4 Upon implementation of the technology has the organization required training to be initiated for users?

Q3.5 Has training become an on-going process?

Q3.6 If extended training has been required has it been supported by the vendor?

Q3.7 If vendor support is offered, do the users find this a valuable service?

Q3.8 Does the organization has sufficient diversity of knowledge to support on-going use of the product or adoption of new versions?

Q3.9 Do you perceive that the technology provides a 'good fit' to the current needs of the organization?

3.4 The Technology and the Mining Sector

As a technology/service gains visibility within a sector, it may transform the sector by its
presence as a possible innovation and therefore the probability of a strategic advantage. This section seeks to assist the researcher in understanding the placement of the technology within the sector as viewed by the adopting organization.

Q4.1 Was the technology championed by a particular person/manager within the organization?

Q4.2 Does the technology have a successful visibility within the sector that influenced its organizational appeal?

Q4.3 Are you aware if competitors within the sector have also adopted the same technology?

Q4.4 If competitors are using the technology are there standardized advantages to be gained across the mining sector by its usage?

Q4.5 Can the technology be used more richly by the organization than perhaps as perceived by competitors?

Q4.6 Has the technology been meshed with organizational processes to increase the effectiveness of the data and technology?

Q4.7 Has the technology vendor contributed directly to the ease of implementation and therefore its strategic appeal?

3.5 Technology and Diffusion

Diffusion of a technology may be a result of the perception by competitors that a relative advantage has occurred by its introduction.

Q5.1 Would you be aware if other organizations view the introduction of the technology as providing a relative advantage that may be reproduced by their organization?

Q5.2 Would you regard your organization as an early, middle or late adopter of technology within the sector?

3.6 Open Discussion

Your clarification and any other discussion in respect to the subject matter is appreciated. Your expert knowledge is keenly sought to enable this research to be fully informed.

Appendix V Research Instrument Mining Consultant

2 Research Instrument – Mining Technology Consultant

To the mine planner/manager /consulting engineer,

This interview/questionnaire seeks to understand the usage and value of information software in the performance of your duties within the mining industry. The outcomes of the data will provide a snapshot to respondents of patterns of use and the perceived attributed usefulness across a cohort of your colleagues categorised by both resource and profession.

This section contains the research instrument that will be used to collect data via the previously outlined interview process and documentary evidence if provided. This section consists of a number of sub-sections each of which contributes to addressing a component of the conceptual model under research.

Definition of technology product: A technology product in the terms of this study may be a software product/suite of product or a total software solution. These may be described either by product name or type or e.g. ESRI or GIS, Acquire or data management, Mine planning or Surpac, MineMap, Gemcom etc.

Definition of regular use: regular use implies daily, monthly or quarterly as an envisaged cycle.

2.1 Respondent Details

Q2.1.1 What organizational role do you/did you occupy ?

Q2.1.2 How long have you/did you occupy this type of role?

2.2 Role of Technology Products

Q2.2.1 In your organizational role can you describe the type of products, either by product name or type that you would use on a regular basis?

Q2.2.2 Of the products listed in the previous question can you identify those which you perceive to add significant value in the performance of your oganizational role?

Q2.2.3 Are the products identified above regarded as a minimum requirement in the performance of your role?

Q2.2.4 What feedback in regard to technology products would you find useful?

2.3 Background to the Product/Service Adoption

This section seeks to assist the researcher in understanding the factors that influence the adoption environment and choice of technology.

Q2.3.1 Within your organization is the provision of the technology products listed previously at the discretion of your role or sourced and supplied by another internal department?

Q2.3.2. If within your discretion was the choice of technology vendor influenced at all by a pre-existing product knowledge or past experience with the vendor.

2.4 The Technology Organizationally

This section seeks to assist the researcher in understanding the organizational impact of the adoption a technology both in terms of resources human and other costs.

Q2.4.1 Within the organization could you express an opinion as to how the technology is perceived by the direct users. This may include ease of use, compatibility to needs, cost , even service agreements?

Q2.4.2 Would you be able to comment as to whether there is a perception elsewhere in organization of the value, benefits or costs associated with the technology?

Q2.4.3 Upon implementation of the technology has the organization required training to be initiated for users?

Q2.4.4 For consultants :Is your choice of software product dependant on the requirements set by the clients?

2.5 Data Management and Interoperability

Q2.5.1. Are you aware of processes to ensure the quality of the data from collection to your point of usage?

Q2.5.2 If yes are you satisfied with the processes; if not aware of the processes are you sufficiently satisfied with quality of the data?

Q2.5.3 Does a lack of interoperability between software products present a difficulty in the performance of your duties?

THANK YOU FOR YOUR VALUABLE TIME AND ASSISTANCE.

Sharyn Curran