

KNOWLEDGE EXPLORATION AND EXPLOITATION: THE ABSORPTIVE CAPACITY FOR CONTINUOUS INNOVATION

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ABSTRACT

In rapidly changing environments, organisations require dynamic capabilities to integrate, build and reconfigure resources and competencies to achieve Continuous Innovation. Although tangible resources are important to promoting the firm's ability to act, capabilities fundamentally rest in the knowledge created and accumulated by the firm through human capital, organisational routines, processes, practices and norms. The exploration for new technologies, knowledge and exploitation of existing and new knowledge is essential in continuous innovation (Boer, 2002; March, 1991). Firms need to decide how best to allocate their scarce resources for both activities and at the same time building dynamic capabilities to keep up with changing market conditions. This in turn, is influenced by the absorptive capacity of the firm to assimilate knowledge. This paper presents a case study that investigates the sources of knowledge in an engineering firm in Australia, and how it is organised and processed. As information pervades the firm from both internal and external sources, there is integration of knowledge using both exploration and exploitation methods. The findings illustrate the absorptive capacity as encouraging greater leverage for exploration potential leading to radical innovation; and reconfiguring exploitable knowledge for incremental improvements. This study provides insight for managers in quest of improving knowledge strategies and continuous innovation. It also renders significant theoretical contributions to the literature through extending the concepts of absorptive capacity and how knowledge constructs capabilities for innovation.

Keywords: Absorptive capacity, knowledge, dynamic capabilities, exploration, exploitation, Continuous Innovation.

1. INTRODUCTION

In rapidly changing environments, organisations require dynamic capabilities to integrate, build and reconfigure resources and competencies to achieve superior performance (Teece *et al*, 1997). These include the human and organisation assets, abilities, and competencies to create value-adding strategies, systems and routines. Although tangible resources are important to promoting the firm's ability to act, capabilities fundamentally rest in the active involvement of human actors as 'knowledge subjects' and 'doers'. Knowledge and human actors are the main building blocks of organisational capabilities (Spanos and Prastacos, 2004). Lei *et al* (1996) define capabilities as being encapsulated by the knowledge created and accumulated by the firm. Knowledge is therefore not only confined to human capital, but also found in organisational routines, processes, practices and norms (Davenport and Prusak, 1998). Organisations are faced with many challenges such as meeting strategic goals,

producing desired objectives, solving problems and efficiently using scarce resources in a competitive environment. Additionally and of increasing importance, organisations need to identify their capabilities and knowledge sources, and assess their value where possible. By being proactive and adapting to a turbulent environment, they could adopt mechanisms that measure their intellectual capital and build appropriate infrastructure that develops knowledge resources in the organisation for Continuous Innovation. This study examines the sources of knowledge in an engineering firm in Australia, and how it is organised and processed. As information from both internal and external sources pervades the firm, there is integration of knowledge using both exploration and exploitation methods. The research additionally examines the absorptive capacity of the organisation perceptible in building capabilities for Continuous Innovation.

2. LITERATURE REVIEW

2.1 *CAPABILITIES IN CONTINUOUS INNOVATION*

Continuous Innovation is the process of successively applying new ideas and methods of improvement in the organisation requiring a methodical, programmed, incremental or radical approach throughout the company involving all employees in the organisation (Soosay, 2005). Continuous Innovation constitutes a substantial range of opinions and ideas and also concerns the learning and improvement of individuals and groups - how knowledge can be acquired, created, diffused, consolidated, and then applied in the organisation (Boer et. al., 2001). The learning and improvement not only involves organisation processes; but covers additional areas such as the products, technology, system, and all other aspects of the business, including radical innovation as well. It creates a product-market-technology-organisation combination that is new to an individual, a group of people, an organisation, a market sector, or even society as a whole (Coughlan et. al., 2000). There is ongoing interaction between operations, incremental improvement, learning and radical innovation aimed at effectively combining operational effectiveness and strategic flexibility, exploitation and exploration (Boer, 2002).

Whether contemplating radical or incremental innovation, managers need to consider the strategic incentives of investing in innovation and their organisational capabilities. Although in many organisations, individuals engage in innovation without involving or informing management, Pitt and Clark (1999) suggest that the strategic management of innovation is the result of the conscious integration of management understanding of the environment, organisational knowledge and management capabilities. This implies that management must understand the issues and have access to the capabilities for knowledge management and strategy, and decide on the type of innovation that suits their business.

2.2 *KNOWLEDGE AS KEY TO DYNAMIC CAPABILITIES*

The growing intensity of competition has forced many firms to focus on their resources and capabilities to survive and excel in high-velocity markets. Resources are those (tangible and intangible) assets in the organisation (Maijoor and Van Witteloostuijn, 1996); whereas capabilities refer to the firm's ability to exploit, combine and reconfigure resources through organisational routines to accomplish targets (Amit and Schoemaker, 1993). The concept of dynamic capabilities where assets, abilities and competencies are used to create strategies and activity systems addresses specific

markets and customers in distinctive ways (Eisenhardt and Martin, 2000). These are characterised by new knowledge creation, rapid learning, absorptive capacity and adjusting to rapidly changing situations. These capabilities are the driving force for innovation in many firms, because they can generate, evolve and recombine resources into new sources of competitive advantage (Teece *et al*, 1997).

According to Day (1994), organisations that aspire to compete in the marketplace must sustain distinctive capabilities. These are based on superior process management, integration of knowledge and diffusion of learning. These firms yield competitive advantage through superior customer value, and render it impossible for other firms to duplicate in the short-term (Barney, 2001). Day (1994) also categorises these capabilities into three groups. Firstly, outside-in processes capabilities refer to the group of capabilities that enables the company to compete by forecasting and acting on changes in markets through the development of sound relationships with suppliers, channel members, and customers. Secondly, inside-out processes capabilities are those internal capabilities that enable the firm to exploit opportunities in the environment. In other words, they facilitate the company acting on information in a manner that brings value to customers and assures the organisation's viability in the long run. Thirdly, spanning processes capabilities relate to the processes that support the anticipated needs of patrons being fulfilled by the business. They do so primarily through integrating the outside-in and inside-out capabilities (Day, 1994).

The ability to acquire and utilise knowledge effectively is critical for the firm's innovation activities and performance (Cohen and Levinthal, 1990). The way knowledge processes are managed within and between firms has emerged as a major theme in recent research (Jantunen, 2005). Firms are increasingly dependent on their customers, suppliers and even competitors as initiators of product and process improvement and sources of new ideas (von Hippel, 1988). In order to utilise externally generated knowledge, they have to internalise it and then combine the information and new insights with the existing knowledge base.

The dynamic capability view of the firm refers to the firm as a knowledge processing and utilising entity (Teece *et al*, 1997). The organisations are able to recognise changes in the environment and utilise opportunities. Organisations can then make use of processes for acquiring information, assimilating it into their organisational knowledge base and acting on the knowledge.

2.3 EXPLORATION AND EXPLOITATION OF KNOWLEDGE FOR CONTINUOUS INNOVATION

Many authors such as von Hippel (1998), Caloghirou *et al* (2004) and Cohen *et al* (2002) articulate the vital role which external knowledge sources play in innovation activities. However there is a need to be able to match market needs and the firm's capabilities using internal knowledge. Customarily, knowledge acquisition capabilities consist of processes and mechanisms for collecting information and creating knowledge from both internal and external sources. Employees' information and knowledge has to be converted into a transferable form and distributed internally to enhance and maximise business operations. Knowledge is transformed from the tacit to the explicit form through social interaction (Nonaka and Takeuchi, 1995). However in operational effectiveness, the most important aspect involves organisational-learning activities that bring understanding of action-outcomes, causal connections and result in higher-order

learning (Argyris and Schon, 1978). This ability to integrate and transform knowledge is paramount to competitiveness in organisations.

The exploration for new technologies and the exploitation of new and existing knowledge is a central theme in the innovation literature. There are discussions on the balancing of exploration and exploitation in the presence of exogenous technological progress through theories of adaptive and evolutionary organisations (Levinthal and March, 1991). As both exploration and exploitation compete with operational effectiveness for scarce resources, organisations need to decide how best to allocate such resources (March, 1991). March (1991) indicated that both exploration and exploitation activities are essential for the sustainable performance of an organisation. The trade off involving the proportion of exploitive and explorative adaptations can define the coevolution of the organisation within and outside its environment (Lewin *et al*, 1999). Similarly, Bessant and Boer (2002) argue that knowledge-based organisations need to engage in continuous innovation that is both operationally effective in exploitation and strategically flexible in exploration. It was often argued that these two capabilities are extremely difficult to combine or balance effectively. Yet recent developments in society, markets, technology and industry suggest that leading organisations need to find configurations of processes, procedures, people, technologies, and organisational arrangements that allow them to continuously innovative.

Since knowledge is one of the most strategically significant resources in the firm (Grant, 1991), one potential strategy is to build capabilities by generating new knowledge and recombining existing knowledge to exploit existing resources (Kogut and Zander, 1992). Maintaining the stock of knowledge can be challenging. As knowledge becomes obsolete or devalued, projects are seen as risky. Innovative knowledge has to be actively applied through the organisation's adaptiveness to environmental changes. A firm that is proactive in recognising changes in the environment and marketplace and able to identify business opportunities can improve their performance only if they possess the necessary capabilities to transform this knowledge into valuable products, services or processes. Knowledge utilisation capabilities will indicate how effectively organisations can exploit acquired knowledge in the form of new or improved products, services and processes. Jantunen (2005) asserts that firms can also seize opportunities without knowledge exploitation procedures, but in order to sustain innovativeness, the firm needs to be able to effectively acquire knowledge to enhance their products, services and processes. Hence successful organisations can reap the benefits through responsiveness to market knowledge (Jaworski and Kohli, 1993), awareness of environment changes (Kirzner, 1997), strategic flexibility (Kogut and Kulatilaka, 2001) and reconfiguring capabilities (Teece *et al*, 1997). This is influenced directly by the absorptive capacity of the firm to utilise new knowledge. The greater the absorptive capacity, the more innovative knowledge stocks and explorative outputs are valued for exploitive conversion activities (Garcia *et al*, 2003).

2.4 ABSORPTIVE CAPACITY FOR DYNAMIC CAPABILITIES AND CONTINUOUS INNOVATION

The ability of a firm to absorb new knowledge and processes is largely determined by its prior related knowledge stock. Their absorptive capacity consists of capabilities to recognise the value of new information, assimilate it, and apply it to commercial ends or to evaluate and utilise outside knowledge (Cohen and Levinthal, 1990). These authors argue that when a potential exploitable knowledge from external sources is closely related to the firm's existing knowledge base, 'by-produced' absorptive capacity may be sufficient for knowledge utilisation. However when there is a need to acquire

knowledge that is different from the existing knowledge base, firms will need to develop and extend their knowledge processing capabilities. Similarly, Levinthal and March (1993) states that new knowledge acquisition is determined by a firm's existing knowledge base. The accumulated prior knowledge enhances the ability to assimilate knowledge related to the existing knowledge base. Therefore, the absorptive capacity can be seen as a potential source of competitive advantage for the firm. When firms develop capabilities through knowledge acquisition, they form strategic knowledge-based assets that cannot be imitated quickly (Jantunen, 2005). Levinthal and March (1993) also postulated that due to the competency trap risk, firms must recognise that there is the need to renew its capabilities because of dynamic turbulent markets in today's competitive business world. Hence, when the market opportunity emerges, firms that have such dynamic capabilities will be able to respond rapidly and reap the benefits (Kogut and Kulatilaka, 2001).

Other authors have suggested the direct relationship between a firm's absorptive capacity and its innovative performance (von Hippel, 1988; Chesbrough, 2003). Zahra and George (2002) describe absorptive capacity as a bundle of dynamic capabilities involving knowledge creation and utilisation that enhance a firm's ability to sustain competitive advantage. This view however focuses not only on knowledge stock, but more on knowledge processes. This capability evolves over time because firms are constantly reconfiguring their knowledge-based assets for improved performance. The ability of a firm to embrace new technologies or embrace new business practices depends on its absorptive capacity (Cohen and Levinthal, 1990; Szulanski, 1996). Daghfous (2004.) points out that acquiring absorptive capacity consists of building the firm's capability to access external knowledge, which requires a knowledge-sharing culture, and the firm's ability to transform and implement external knowledge within the company to enhance its core competencies. The most important role in the activity of knowledge adsorption, by an organisation, depends on the level of research and development. However research and development is not sufficient on its own. Other factors such as training and education are also important for the increase of knowledge transfer and absorption (Daghfous, 2004). Hence, there must be knowledge utilisation capabilities in place for organisations to explore and exploit knowledge from internal and external sources. The absorptive capacity could be regarded as the key ingredient to transforming various knowledge into dynamic capabilities, and eventually to enable continuous innovation in the firm.

3. METHODOLOGY

Given the exploratory nature of this research, as well as the importance of the context and the need to understand the absorptive capacity for knowledge exploration and exploitation, the research uses ethnographical techniques in the form of fieldwork. The observations were recorded in a fieldwork diary. The fieldwork entails observing the work taking place in different settings, and where possible, using directed questioning of participants to clarify issues. A stratified sampling technique was used to ensure that an adequate representation was achieved. The specific characteristics that were of interest were branch and sub-branch affiliation, gender, level in the organisation and duration of employment.

The research questions are 'What are the knowledge strategies and how do they facilitate exploration and exploitation of knowledge?' 'How does the absorptive

capacity and integration of knowledge enable capabilities for continuous innovation?' The contemporary nature of the research, the strategy for a knowledge environment and the lack of control over the events make case study an appropriate methodology (Yin, 2003). The dominant mode of analysis used in this research is explanation-building (Miles and Huberman, 1994). Data were obtained from semi-structured interviews conducted with employees at all levels in the organisation and secondary sources of information were used to triangulate findings.

The case study approach was adopted because it is exploratory in nature. According to Yin (2003), the research must identify some situations in which all research strategies might be relevant. The 'how' and 'what' questions are asked about a contemporary set of events over which the investigator has little or no control. This exploratory approach allowed the capture of data rich in detail about the research problem; and gave the researchers the flexibility to explore additional issues raised by participants. The exploratory study gains originality and provides new knowledge that can consequently add to the body of literature on the exploration and exploitation of knowledge for continuous innovation. The conceptual framework for the study that emerges from the literature is illustrated in figure 1.

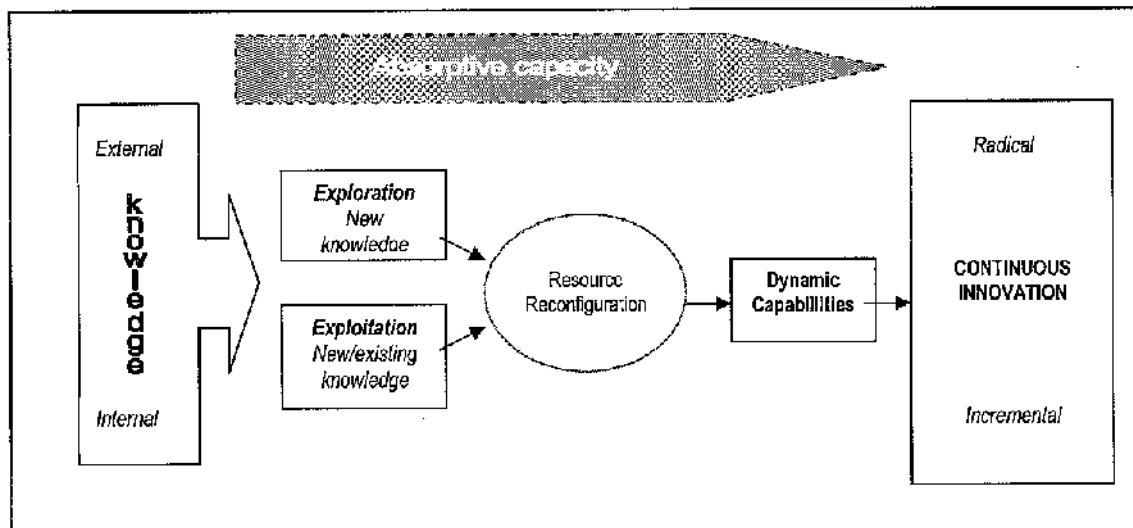


Figure 1: The interplay between knowledge and continuous innovation

The model depicts that an organisation can acquire knowledge from both internal and external sources because the market is continuously changing and there is intense competition. The ability to do this lies in the firm's knowledge utilisation capability before they can embark on exploration and exploitation activities. The acquired information and knowledge has to be converted into a transferable form involving a reconfiguration of resources (knowledge and assets). Dynamic capabilities involve the ability to understand and apply the combination of knowledge for business activities. This then enables continuous innovation which involves both radical and incremental innovation activities.

4. FINDINGS

The case study firm is an engineering company based in New South Wales, Australia, dealing with specialised mining communication technologies. They specialise in the supply of purpose-built communication technologies for underground mines as well as communication infrastructure for surface mines and high-speed data communication networks to link remote mining sites. They have established close working relationships with major mining companies throughout Australia and overseas. The firm is renowned as an innovative company using sound technology to develop products based on industry requirements. In addition, they actively source, develop and apply generic technologies to enhance production and maintenance processes in mining operations.

4.1 SOURCES OF KNOWLEDGE

This section illustrates some sources of knowledge at the firm, though the list is not exhaustive. Knowledge management in the company is handled by a *leadership team* comprising the chief financial officer, office managers and the CEO. A monthly leadership team meeting is held to review performance and projects carried out. It serves as a forum to exchange ideas, manage the operations, re-examine targets and objectives and forecast future obstacles. During this meeting, there is knowledge diffusion and exchange of ideas as they gather intelligence from the marketplace, technologies, government legislation and mines in various regions. Each office manager feeds information on the various departments to senior management. The leadership team pools knowledge across the organisation and takes appropriate action based on that.

In relation to the *employees*, the current organisational structure in the firm encourages communication across the company. This gives rise to knowledge and information flows from top-down, bottom up and across departments. Employees within the firm individually brought external knowledge through training programs, experience and skills. The CEO explained that they utilise the internet for information on market trends, company movement, mineral prices and geographic areas of interest. This information is used to adjust their foci and plans accordingly.

One external source of knowledge is through membership in the Minerals Industry Consultants Association (MICA). The *industry association* holds regular meetings and briefings of various institutions which disseminate information about the mining industry. Employees are encouraged and given the responsibility to educate themselves formally and informally on the industry, materials and quality standards. Another source of knowledge in the firm is *customers*. The manager interviewed reiterated that when the sales personnel visit customers at the mine sites, they try to get an understanding of customers' issues and problems, and look at it as an opportunity for new knowledge, information or problem solving. The *suppliers and sub-contractors* also provide some form of knowledge and information to the firm. In addition to performing agreed responsibilities, suppliers are actively encouraged to suggest other ways of doing things, which try to reduce cost for both parties. Contractors also introduce new technology machinery and equipment to help keep ahead of competitors in the marketplace.

The CEO envisaged that new contractors and suppliers may contribute more spontaneous support and input to maintain relationships. The sourcing and choice of suppliers depends on the operations manager. He seeks advice from engineering and

operations departments on the choice of suppliers pertaining to a technical, logistics and quality view points.

4.2 EXPLORATION OF NEW KNOWLEDGE

The firm has established a niche market for safety products and systems, such as the personnel evacuation devices and communications systems underground. Their equipment currently has the ability to broadcast to all workers underground in the mines within a few seconds of a situation occurring. They have also developed a state-of-the-art communication technology using ultra low-frequency to transmit through rock, very similar to the way that submarines communicate. The exploration of new technology through R&D has enabled the firm to excel in design and development techniques as well as in using automate design tools for application in decision making and product lines. This new knowledge has resulted in various radical innovations for their new product development.

Another form of new knowledge is through external training programs concerning the use of products, machinery, multi-level selling, managing key-customer relationships and commercial negotiation. A training plan was developed targeting each employee to be trained at least 5 days per year with a total annual budget of \$100,000. This assimilation of new knowledge and development of skills is evaluated operationally, financially and administratively. The managers interviewed also felt that the skills and knowledge developed contributed mainly to new product development (which was perceived internally as radical innovation).

The organisation also works closely with Cooperative Research Centres (CRC) in Australia (quasi-government technology organisations in scientific research). The new breakthrough ideas from the collaboration have assisted in new product development, technology transfer and radical innovation.

4.3 EXPLOITATION OF NEW OR EXISTING KNOWLEDGE

Employees gain knowledge from external sources through external training, block release training in a particular technology discipline and quality teams. This is considered exploitation of new knowledge from internal sources via the employees. The recruitment strategy in the firm targets assimilating new skills in communication and Information Technology. There are no formal knowledge management programs in the organisation. However, there are quality programs and a business plan that facilitate the development and management of knowledge throughout the organisation. The business plan is a document that clearly defines the contents and methods of all operations, processes and systems. It contains information, the potential of the market, pre-requisites for the business goals and plans for achieving outputs. It also includes aspects of technologies, procedures, culture and training.

There is also exploitation of knowledge from both internal and external sources. These include knowledge in technical areas (such as industry, product, market, systems and process), industry development, marketing, intellectual property, legal and accounting, industry-related training, recruitment and human resource issues, strategic and business development, and occupational health and safety issues. Many of them have led to incremental innovation in the firm.

4.4 RESOURCES AND CAPABILITIES FOR CONTINUOUS INNOVATION

Knowledge is generated and needed for a multitude of areas in the business operations. The firm tries to integrate and organise knowledge to be proactive in driving business operations and continuously innovating. New product development depends on the marketing personnel who survey customers, conduct market research and trial new products. Knowledge is transferred through both formal methods (such as business processes, regular meetings, feedback sessions and through supervision) and informal methods (such as feedback, non-conformance reporting, site meetings and social events). The firm adopts a team approach that enables the incorporation of both internal and external knowledge. Specifically in R&D, if there is an expert consultant, they are delivering output to fit into their systems. If they are implementing a new process system, there is a need to set the parameters and timeline. The managers believe that they should focus on their core competencies and subcontract non-core activities. The linkages between exploration and exploitation activities, the sources of knowledge and types of innovation they add to are presented in Table 1.

Type of Knowledge	Int	Ext	Exploration	Exploitation	type of innovation enhanced
Organisational aspects of New Product Development		X		Y	Radical
Engineering related to product/process development		X	Y	Y	Radical
Design and engineering (product support)	X	X	Y		Radical
Scientific research (laboratory)		X	Y		Radical
Research and development (testing)	X		Y		Radical
Technical (industry, product, market, etc)	X	X		Y	Radical
Technical (systems, process)	X	X	Y	Y	Radical
Industry development		X		Y	incremental
Marketing	X	X		Y	incremental
Intellectual property		X		Y	incremental
Legal and accounting		X		Y	incremental
Industry-related training	X	X	Y	Y	incremental
Recruitment/HR issues		X		Y	incremental
Strategic and business development	X	X		Y	incremental
Occupational health and safety	X	X		Y	incremental

Table 1 The sources and nature of knowledge in innovation

The firm is currently moving from an entrepreneurial stage to a more mature stage. They are focussing on aspects of improving quality management, project management, new product development and operations systems and processes. The human resource strategy besides training to gain new knowledge, is to recruit multi-skilled employees from various industries. Employees are experienced with military, general management and mining industry skills. For example those personnel with military background are adapted to operating in harsh environments, such as underground mine sites and technically skilled with modern technology and equipment. The human resource manager interviewed reiterated that by having a diverse range of employees it helps the dynamics of the group and contribute to new ideas for innovation.

Dynamic capabilities have been developed over the years by constantly keeping up with the mining industry, proactive relationship building with customers and suppliers, recruiting and developing employees as well as continuous research and development of products, processes and systems in the organisation. Knowledge flows from external

sources such as industry association, consultants, government research organisations and the supply chain have contributed to building dynamic capabilities. Management is committed to constant improvement and renewal, and as such promoted exploration and exploitation of knowledge from a wide variety of sources.

5. DISCUSSION

The case study served as an exploratory study to investigate the exploration and exploitation of knowledge in an engineering firm to build dynamic capabilities for continuous innovation. In answering the research questions, the concept of dynamic capabilities in the firm involved integrating management capabilities, organisational, functional and technical skills, R&D, product and process development, technology transfer, intellectual property, manufacturing, human resources and organisational learning to address changing environments. This is in line with the resource-based perspective of competitive advantage (Teece *et al.*, 1997) since the non-imitable resources (such as knowledge, assets and processes) are considered as distinctively reconfigured in an intricate manner unique to the firm to enable continuous innovation. Secondly, the absorptive capacity of the firm enabled it to acquire, assimilate, transform and exploit knowledge. Firstly, they recognised, valued, and acquired external knowledge critical to their operations in the mining industry in Australia. Their acquisition was facilitated by investments in R&D, prior knowledge, inter-firm collaboration, speed and timing to acquire the right knowledge, and strategic direction from management. The assimilation of new knowledge in the firm was expedited through routines and processes that allowed it to understand, analyse, and interpret information from various sources. The transformation ability in absorptive capacity enabled them to develop routines to reconfigure and combine knowledge (Zahra and George, 2002). This was evident through the new technology products and processes introduced over the years. Exploitation as defined by Lane and Lubatkin (1998) is the firm's ability to apply new external knowledge commercially to achieve organisational objectives. The firm has established processes to refine, extend, and leverage existing competences by incorporating acquired and transformed knowledge into its operations and building dynamic capabilities. It was also found that external new knowledge through exploration activities tended to result in radical innovation, whilst most in-house or developed new knowledge contributed to incremental innovation.

The overarching managerial implication arising from this study is that managers need to be aware of the need for specific capabilities that enable continuous innovation, and to assess the presence or otherwise of such capabilities in their organisations. To be able to effectively explore new knowledge or exploit new or existing knowledge, the firm has to establish knowledge utilisation capabilities beforehand. Managers should understand the knowledge required and how to effectively apply it in the organisation. This application may entail the capability to combine with other resources in the organisation or developing new ones. This study also provides insight on the absorptive capacity of the firm which has enabled it to effectively acquire and utilise external and internal knowledge, which, in turn, affected the firm's ability to innovate and adapt to its changing environment and be competitive (Daghfous, 2004).

The limitations to this study are its exploratory nature and concentration on a single case study. It is expected that the capabilities and strategies of firms will be apparent, but in varying degrees and in unique ways for each firm; and the responses from

managers, being subjective in nature, were difficult to quantify. It is recommended that further studies incorporate a comparison of firms, with quantifiable results and conducted longitudinally. Given these reservations, this study has demonstrated that through careful planning and analysis of existing resources, managers can embark on knowledge strategies to build capabilities conducive to continuous innovation through comprehending the concepts of absorptive capacity and how knowledge constructs capabilities for innovation.

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