ORGANISATIONAL EVALUATION OF TECHNOLOGICAL INNOVATIONS: CASE STUDIES FROM AUSTRALIA AND THAILAND

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ABSTRACT

This paper reports on an exploratory study into what decision-making processes are followed and what criteria are used in evaluating manufacturing technologies for potential adoption. The literature review revealed that there are four major perspectives that need to be considered; the innovation, adopter and supplier aspects, as well as the environmental conditions. The analysis of qualitative data showed that the size of the organisation has a direct relationship with the formality and complexity of the innovation evaluation process. The majority of the key criteria identified through the literature review were used by the four firms studied. However, there were several other criteria were considered important by practitioners. As such, the framework developed can be modified for use in future studies.

Keywords: technological innovation, manufacturing technology, innovation evaluation process

INTRODUCTION

Innovation can be classified based on the adopter category, such as individuals, households or consumers versus organisations or industries. As Day and Herbig (1990) have stated, there are differences in the adoption process between consumer innovations and industrial innovations. They concluded that the decision process behind the adoption of industrial innovations is longer and almost always involves a multi-decision-making unit and a very large commitment of funds compared to the adoption of consumer innovations. Furthermore, adoption of industrial innovations typically involves a long-term commitment and therefore greatly increases the levels of perceived risk. Decisions relating to the adoption of technological innovations in an organisation can also impact other organisations in its supply chain, whereas consumer innovations tend to be limited to the single consumer who uses the innovations. Overall, it can be noted that the adoption process for industrial or organisational innovations is more complex and more disruptive than the adoption process for consumer innovations. The focus of this research is organisational innovations, in order to better understand this complex decision-making process.

Moreover, innovations are also classified based on the type of idea itself, such as technological innovations and cultural or social innovations. However, technological innovations have long been recognised as the basis for improving a firm's competitiveness (Henriksen, 2006; Boyer and Verma, 2010), because technological innovations are strongly associated with organisations' growth (Bessant and Tidd, 2007). It is the technological innovations in forms ready to be adopted by the adopter units in organisations that have been chosen as the subject of this study.

In many organisations, technological innovations are adopted in order to improve the performance of their manufacturing processes. However, it is recognised that the decision-making processes and the key criteria used for evaluating new technological innovations are very complex and the roles, perceptions and expectations of each decision-maker also might be different (Bessant and Tidd, 2007). As Olshavsky and Sprong (1996) have pointed out, an innovation is highly unlikely to be adopted if the innovative concept is rejected at the stage of initial evaluation. It can be stated that the evaluation of innovations is the most important stage in the innovation diffusion process; however, there is a need to improve our current understanding of this evaluation process. This study focuses on the organisational evaluation of technological innovations in order to develop a better understanding of how organisations evaluate technological innovations, what decision-making processes are involved in practice and what criteria are defined and used in both theory and practice. This paper is presented in four sections as follows: (i) literature review; (ii) methodology; (iii) analysis and discussion of findings; and (iv) conclusions, including limitations.

LITERATURE REVIEW

Literature on innovation adoption and diffusion has identified a vast array of factors that positively and negatively influence innovation evaluation decisions. In this section, these factors are

summarised under four main categories: Supplier side influences; adopter characteristics and performance; the characteristics of the innovation itself, including relative advantages and usage concerns; and the conditions in the broader organisational environment.

Supplier side influences

Marketing strategy: The supplier's marketing strategy has been recognised as a direct influencing factor that affects the organisation's innovation evaluation decision process. When organisations intend to adopt technological innovations, the marketing strategy of suppliers is the first factor that can trigger adopters to make an initial evaluation or preliminary screening of the innovations. Frambach (1993) has divided these marketing strategies into four groups; cooperation with other suppliers, positioning of the innovation in the market, risk reduction, and winning market support.

The innovation development process: The three main factors in the suppliers' innovation development processes that can influence adopters' decision-making processes have been summarised as: (i) management support and involvement from the corporate level in the long term; (ii) innovative organisations, particularly with reference to the interactions between all functions in the organisation, especially the R&D–manufacturing–marketing interaction and the synergistic effect between production and R&D; and (iii) execution of development, including user benefits and the uniqueness or relative superiority of the innovation (Frambach, 1993). These aspects can ensure timely development of new technology that meets the needs of potential adopters.

Supplier characteristics: Johnson (2009) has explored a range of factors that affect innovation adoption: knowledge deficits, firm size, and the readiness of the supplier side. Frambach (1993) has pointed out that the experience of the supplier is the main factor influencing the assessment of innovations. Zhu *et al*. (2006) have identified the technological competence of the supply side as a contextual factor that influences innovation diffusion. Moreover, technological innovativeness may be conditioned by exposure to the media and other communication behaviours of an innovator, which is considered to be a personality factor of the innovator that indirectly affects the likelihood of the adoption of technological innovations (Vishwanath, 2005).

Environmental factors on the supply side: Frambach (1993) and Kim and Srivastava (1998) have explored competitive intensity, or the degree of competition in the market on the supply side, and shown that this is a key variable that determines the success of an innovation in the marketplace. Additionally, Kim and Srivastava (1998) have pointed out that vendor support is a factor that affects the intra-organisational diffusion of technological innovations. Alange *et al*. (1998) have claimed that the technological opportunities of the supplier influence the diffusion of organisational innovations.

Adopter characteristics and performance

Adopter characteristics: Much of the research in the area of organisational diffusion of innovations has been devoted to investigating organisational characteristics. Firm size, which most studies measure in terms of the number of employees and the level of revenue, has been shown to relate positively to the adoption of innovations (Nguyen *et al*. (2003), and has also been recognised as a basic factor that influences the diffusion process (Meyer and Goes, 1988; Frambach, 1993; Tabak and Barr, 1998; McDade *et al*., 2002; Nguyen *et al*., 2003; Zhu *et al*., 2006; Dewett *et al*., 2007; Vargas, 2008; Johnson, 2009). Organisational structure and structural complexity have also been identified as factors influencing the adoption and diffusion process (Dewett *et al*., 2007). For example, Vargas (2008) has pointed out that the complexity of the firm provides structural inertia which influences the response time of the adoption process. However, Frambach (1993) has argued that higher levels of complexity in an organisation (e.g. large numbers of specialists and their degree of professionalism) may facilitate the adoption of an innovation, while a high degree of formalisation and centralisation in an organisation are negatively correlated with its degree of innovativeness. Wang and Salazar (2005) have investigated the influence of the corporate governance system on the adoption decision process, and Chong *et al*. (2009) have stated that organisational culture is another factor that affects the adoption of innovations. Moreover, a firm's quality standards have been pointed out as another factor which affects the potential benefits of successive modifications of innovations (Gold 1980). Additionally, firm preference has been identified as a key driver of innovation adoption (McDade *et al*., 2002). However, firm preference usually depends upon the potential benefits of the innovation and thus it will be examined from the innovation perspective.

Adopter performance: Many studies have identified leadership and leader characteristics as factors influencing the organisational diffusion of innovations (Meyer and Goes, 1988; Franklin *et al*., 2001; Nguyen *et al*., 2003; Dewett *et al*., 2007). The level of experience and familiarity of both leaders and workers have been recognised as factors that determine the rate and speed of adoption of innovations (Meyer and Goes, 1988; Frambach, 1993; Dewett *et al*., 2007; Vargas, 2008). Other factors related to different aspects of a firm's experience, such as firm readiness and knowledge deficits, have also been identified as key criteria to be considered in the evaluation of new technological innovations (Johnson 2009). A number of researchers have argued that firms decide whether or not to develop new technological innovations based on their resources and resource availability (Meyer and Goes, 1988; Tabak and Barr, 1999; Petrick and Echols, 2004; Henriksen, 2006; Bellas and Nentl, 2007). Moreover, the scale of production has been pointed out as a key factor affecting the potential benefits of successive modifications of innovations (Gold 1980). Thus, a firm's market share, which may reflect the firm's scale of production, is another key criterion that firms should recognise when evaluating new technological innovations.

Adopter network participation: Frambach (1993) has investigated the adopter's network participation, and has shown that their level of interaction, the availability of information, the quality and value of the information available, and their information processing characteristics (in terms of absorption capacity) are the key criteria that organisations must recognise to achieve a higher probability of success when adopting new technologies. Kim and Srivastava (1998) have shown that the adopter's openness of communication affects the diffusion of technological innovations. Furthermore, Tabak and Barr (1999) have pointed out that information processing capacity is associated with strategic decision-makers' intentions to adopt technological innovations. Another influencing factor is partner conflict or readiness, which has an indirect effect on the intention to adopt innovations, which could also influence the organisational diffusion process (Nguyen *et al*., 2003; Zhu *et al*., 2006; To and Ngai, 2007).

Adopter marketing strategy: It has been noted that the strategic moves of competitors, or competitive pressure, is positively related to the rate and speed of innovation adoption (Frambach, 1993; Kim and Srivastava, 1998; Tabak and Barr, 1998; Nguyen *et al*., 2003; Zhu *et al*., 2006; To and Ngai, 2007). According to Kapur *et al*. (2007), the rate of adoption per remaining potential adopter can be changed by a change in marketing strategy. Moreover, Meyer and Goes (1988) have pointed out that marketing strategy can be used to determine the assimilation process of new technologies. For example, Boeker and Huo (1998) have identified firm integration strategies, both forward and backward, and product diversity strategies as factors that affect the adoption of innovations. Further, Gold (1980) has pointed out that product mix is a key factor affecting the potential benefits of successive modifications of innovations. Additionally, other strategic challenges have been recognised as factors that affect decisions regarding the adoption of new technology (Wang and Salazar, 2005).

Innovation characteristics, advantages, and usage concerns

*Technological innovation characteristics**:*** Many studies have found that the compatibility of innovations, "the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters" (Kim and Srivastava, 1998, p.239) as a key variable that determines the rate, speed and success of the adoption of innovations (Meyer and Goes, 1988; Frambach, 1993; Kim and Srivastava, 1998; Tabak and Barr, 1998; Henriksen, 2006; To and Ngai, 2007; Straub, 2009). Moreover, Zhu *et al*. (2006) have shown that compatibility is the strongest factor that influences innovation diffusion. The innovation attributes of uncertainty and complexity have also been investigated by a number of researchers (Meyer & Goes 1988; Frambach 1993; Tabak & Barr 1998; Kim & Srivastava 1998; Franklin *et al*. 2001). Moreover, Meyer and Goes (1988) and Kim and Srivastava (1998) have investigated observability, which refers to "the degree to which the results of an innovation are visible to others" (Kim and Srivastava, 1998, p.239). Gold (1980) has proposed that significant changes in the capabilities of technological innovations may affect their characteristics,

such as reliability. Additionally, Wood and Moreau (2006) have examined the influence of decision-makers' expectations on the evaluation and diffusion of complex technological products.

Technological innovation advantages: According to Dewett *et al*. (2007), utility, or the degree to which the innovation is actually required to fill a current need, will affect the acceptance of innovations. How great the innovations' relative advantages are, have been considered by a number of researchers as key factors that affect innovation acceptance in organisational evaluation and adoption processes (Frambach, 1993; Tabak and Barr, 1998; Zhu *et al*., 2006; To and Ngai, 2007). Moreover, Gold (1980) has explained the relative advantages of innovations in terms of their operating efficiency and flexibility, their applicability to specialised purposes, and other aspects of their performance quality. Rogers (1983) has identified the sub-dimensions of relative advantage as 'the degree of economic profitability, low initial costs, a decrease in discomfort, a savings in time and effort, and the immediacy of the reward' (pp. 217–218). Moreover, Gold (1980) has shown that for economic evaluations, the most common influential criteria are reductions in man-hours per unit of output and reduction in material requirements per unit of output, which will result in reductions in total unit costs and can lead to increased profits. Additionally, Petrick and Echols (2004) stated that firms decide to develop a new product based on the return on investment that the product is estimated to generate.

Technological innovation usage concerns: Meyer and Goes (1988) have identified that the skills or training needed is a factor influencing the assimilation process for new technologies. Gold (1980) has suggested that numerous significant changes in a technological innovation's capabilities might affect the operational hazards associated with its use. Moreover, Zhu *et al*. (2006) have identified security concerns as an inhibitor that influences innovation diffusion. According to Kirkwood and Longley (cited in Radonjic *et al*., 2006), the diffusion and adoption of new and emerging technologies offers opportunities for conserving natural resources and reducing the overall environmental impact of an organisation. Additionally, Desrochers (2008) has stated that firms can simultaneously improve their competitiveness and contribute to a cleaner environment through the development of 'win-win' innovations. For example, the Life Cycle Assessment (LCA) is undertaken when assessing environmental impact and for selecting new technologies to reduce emissions in the steel industry (Iosif *et al*., 2010).

Costs of the adoption of technological innovations: According to previous research the cost of implementing a technological innovation have been suggested to be an inhibitor of the innovation diffusion process and affect the quality of its implementation (Zhu *et al*. (2006); Dewett *et al*. (2007); Gold 1980). While the details of different types of costs have not been investigated, aspects such as investment requirements and operating costs have been studied (Gold 1980). Therefore, costs should be further investigated, and should be divided into other terms, such as the costs associated with training, management, switching technologies and maintenance.

External environmental conditions

Influence of market and economic conditions: Market conditions have been identified as a critical dimension that must be considered when evaluating Advanced Manufacturing Technologies (Daim, 1997). Additionally, economic conditions have been recognised as influencing factors that affect the success of the innovation adoption process, and ignorance of different economic conditions has been recognised as a basic weakness of many innovation diffusion models (Tabak & Barr 1998; Gold 1980).

Influence of agencies and consultants: The role of agencies and consultants has also been recognised and analysed in previous research on innovation diffusion. The success of change agents in influencing the adopter's decision in a way desirable to the change agency is governed by many factors, such as change agent effort, change agent empathy, compatibility with the adopter's needs and client orientation (Rogers, 1995). Additionally, McLean (2006) has stated that the transfer of new knowledge depends on collaborative activities between educational institutions (consultants) and industrial organisations.

Influence of government policies and regulation: Chong *et al*. (2009) have pointed out that government influence is a factor affecting the adoption of e-commerce by the textile industry in China. Henriksen (2006) has pointed out that organisations' dealings with government agencies is an environmental factor affecting the adoption of innovations in the Danish steel and machinery industry. Wang and Salazar (2005) have stated that tariffs and trade barriers are factors affecting the decision to adopt innovations. Additionally, legitimacy has been identified as a factor that determines the innovation assimilation process (Meyer and Goes, 1988). Therefore, the influence of government and regulations are key criteria that organisations use to evaluate innovations in their adoption and diffusion processes.

Collaborative activities: Because the process of the evaluation and adoption of innovations requires a variety of inputs from diverse sources, the closeness of the relationships and interactions between adopters, suppliers, partners, and other parties is recognised as a factor which affects the evaluation and adoption process. Frambach (1993) has shown that the network of interactions between organisations and other parties provides positive support to the innovation adoption process. For example, in the steel industry, the transfer of new knowledge and the knowledge exchange steps (generation, evaluation, communication) depend on collaborative activities between educational institutions, industrial organisations, government funding agencies and professional societies (McLean, 2006).

An integrated conceptual framework of organisational evaluation of technological innovation

The integrated conceptual framework suggested in this study, shown in Figure 1, attempted to incorporate the key criteria that influence an organisation's decision-making process for evaluating technological innovations. This integrated model shows the breadth of the analysis and presents an

overview of all key criteria that have been examined in previous research and was used as a source for the development of the research questions used in the field study.

RESREACH METHODOLOGY

The research study reported in this paper was completed in two parts. Part I was an extensive literature review on organisational evaluation, adoption, and diffusion of technological innovations, covering scholarly journal articles, books, and other related material, such as public documents from the Internet and company' archives. The aims of the literature review were to synthesise the existing knowledge on the phenomenon and to identify the gaps in previous research so that they could be addressed in this study. The output of the literature review, a conceptual framework, was used as a basis for conducting the interviews to examine the practical approaches used in the case study organisations. Part II, the field study, included two steps. First, data was collected by conducting semi-structured interviews (Wengraf, 2001) with senior managers or other key players involved in the strategic decision-making process in the four case study organisations. These interviews were tape-recorded where this was permitted otherwise they were recorded by note-taking. Second, for the data analysis, the recorded interviews were transcribed and analysed to identify patterns in the decision-making processes and key criteria used. These patterns were then compared across the case study organisations and the conceptual framework by using descriptive analysis, explanatory analysis or pattern matching methods (Silverman, 1997). These patterns were then used to assess the effectiveness of the conceptual framework. The findings are discussed in the context of the extant literature.

Case study organisations: Many researchers have indicated that firm size is a basic factor that influences the diffusion process of technological innovations (Meyer and Goes, 1988; Frambach, 1993; Tabak and Barr, 1998; McDade *et al*., 2002; Nguyen *et al*., 2003; Zhu *et al*., 2006; Dewett *et al*., 2007; Vargas, 2008; Johnson, 2009). Additionally, firms in different countries, which have different cultures and environmental conditions, such as economic conditions, may use different decision-making processes and key criteria for evaluating technological innovations (Chong *et al*., 2009; Tabak & Barr, 1998). Therefore, this field study focused on the actual decision-making processes used in the specific cases of acquiring technological innovations in four firms from Australia and Thailand, as shown in Table 1. This was in order to explore whether different firm sizes, large and SMEs, and firms in different countries, which are developed and developing countries, have significant differences in their technological innovations evaluation processes.

The interview respondents: It was crucial to obtain reliable information from the case study companies. Therefore, the interview respondents were all people who held key roles in each company's technological innovation evaluation process. The interview respondents for this field study and their roles are shown in Table 2.

KEY FINDINGS AND ANALYSIS

Overview of management practices and broad perspectives

The field study results present some important factors that influence an organisations' intention to acquire or invest in new technologies which consist of (i) external market pressures, (ii) the organisation's internal readiness and (iii) the organisation's perceived value of the relative advantages of investment in new technology

External market forces, such as competitors' actions and rivalry, and the organisation's perception of the value of the relative advantages to be gained from investment in new technology, such as an increase in manufacturing efficiency, were identified as having a direct impact on the Thai organisations' intentions to acquire or invest in technological innovations. For example, the Thai organisations initially needed to increase their competitive performance. They then recognised that an investment in new technologies would provide many manufacturing benefits that could lead to an improvement in their firms' competitiveness. For the Australian organisation, the perceived value of the relative advantages of investment in new technology, such as cost reduction and improved business performance, and the organisation's internal readiness in terms of their ability to comprehend a new technology and the availability of supporting resources, have more direct impacts on the organisation's intention to invest in new technologies. The Australian firm intended to acquire new technologies because it had set a business plan and strategies that represent its readiness for the adoption of new technology.

Decision-making processes relating to the evaluation of technological innovations

Three main aspects of the decision-making process were recognised: the first was the key phases that were followed in the process; the second was the time period required for each stage and along the process; while the third was the key people involved in each stage of the process. The interview participants' responses related to their organisations' decision-making processes were analysed and summarised in the form of flow process charts as to facilitate across-case comparison of the overall processes and their key elements. Many differences are apparent between the decision-making processes followed by the Australian and Thai case study organisations as shown in Table 3.

Key criteria used in the decision-making processes for evaluating technological innovations

The case studies showed that a wide range of criteria were used in the technological innovation evaluation processes of the firms. Analysis and pattern coding of the edited interview transcripts showed that most of the criteria used in practice can be assigned to the four categories shown in the conceptual framework developed through the literature review. However, it was found that some additional criteria were used in the case study organisations that were not present in the framework and that also differed between the case study organisations themselves. Table 4 shows the key criteria shown in the framework and used in the case study companies' decision-making

processes. The criteria used that differed between the case study organisations and the framework and between the case study organisations themselves are be presented in the form of matrix in Figure 2.

It can be seen that the Australian firm assigned greater importance to the innovation's radicalness, whereas the Thai firms paid more attention to the innovation's standardisation, certainty, and observability. This can be explained in terms of the levels of risk acceptable to these companies. The Australian firm, a large organisation, has a higher level of acceptable risk. Moreover, the Thai companies considered only the training needs, the impact on their production processes, and their customers, whereas the Australian company considered all possible impacts in their research, as well as the impacts on their business supply chain and key stakeholders. The Australian company also used the management costs and switching costs as key criteria, whereas the Thai companies paid less attention to these. In terms of the firm's perceived value, the Thai organisations primarily considered the production or manufacturing advantages and the economic advantages, whereas the Australian organisation considered broader aspects including business performance, business opportunities, and benefits to the community.

For the adopter side, the Thai companies considered only firm size: the scale of their market size, market share, and production, whereas the Australian firm considered these factors, as well as their organisational structure, corporate governance system and business experiences.

On the supplier side, the key difference between the Australian and Thai case study organisations was that the Thai firms considered the supplier's support strategies and characteristics in terms of their experience, teamwork, attentiveness and exposure to communication, whereas the Australian firm considered other aspects such as the supplier's development of innovations and their cooperation with other suppliers.

There were other environmental factors that influenced the Australian firm's evaluation of technological innovations, whereas the Thai companies gave these less consideration. These factors included external consultants (technology experts and research bodies), social and cultural factors, legal and regulatory aspects, reputation, and collaborative activities.

However, there was one factor that had a greater influence on the decision-making processes of the Thai case study companies. As for the supplier side, technology agencies played a very important role in the Thai case study firms' innovation evaluation processes. The decision-makers in these companies used the same criteria that they had used for evaluating the supplier characteristics to evaluate the technology agency characteristics, but the agencies' exposure to communication, teamwork, and attentiveness were given greater consideration.

In summary, several other key criteria, which also covered the business, supply chain and key stakeholders, were used in the Australian organisation's technological innovation evaluation process. Thus, the larger Australian organisation recognises a higher level of perceived business risks and perceived value compared to the smaller Thai organisations.

To illustrate the effectiveness of the application of the framework, the percentages of the number of key criteria were calculated, and are shown in Table 5. It is evident that the framework effectively reflects the practice aspects of innovation evaluation, because over 62 per cent of the key criteria shown in the framework were used by the case study firms. Only approximately 16 per cent of the key criteria were shown in the framework but not used by the real firms. However, around 22 per cent of the key criteria used by the case study firms were not shown in the framework. This shows that there are some key criteria that have not yet been recognised in previous research, and therefore the framework will be able to be updated and improved in future studies.

The case studies show that in all organisations, whether Australian or Thai, large or small, the final decision usually depended on the attitude and managerial judgement of the person or group of people who have the power to make final decisions in their organisation. For example, the final decision of the small Thai firms depended on the owners' judgement, while that in the medium Thai firm depended on the general manager's judgement. For the large Thai firm, the managing director was the person who made the final decision, and for the Australian firm, the asset president granted the final approval.

However, the judgements of these decision-makers were influenced by the recommendations and evaluations performed by the broader decision-making team. Other additional influencing factors may be personal characteristics and performances, such as those of the final decision-makers with their different experiences, expertise, and training, which allows for different opinions or assessments that may lead to different decisions.

Additionally, external environmental factors also have a direct influence on the final decisions. As one of the respondent stated:

> 'Although it is presented that this is a high value and low risk project, the investment could be delayed or cancelled because of the final decision-maker's judgement that are influenced by his experience, risk propensity, and external pressures such as country's economic status, and industry-market conditions.'

Other related issues

The interviews involved specific questions that helped explain other issues relating to the decision-making process and the key criteria used in the technological innovation evaluation process as shown in Table 6. Although these issues have not been addressed in detail in the desk study section of this research, they may be useful when conducting a deeper analysis in future research.

CONCLUSIONS AND LIMITATIONS

Based on the analysis of filed study data and in light of the insights drawn through the literature review, **the practical and theoretical implications** can be concluded as follows.

First, it was found that external market pressure and the organisation's perception of value of innovations are the main reasons that influence its intention to invest in or acquire new technologies.

Second, once an organisation intends to invest in new technologies, there are many ways, both formal and informal, that can be used to seek information on new technologies. More formal technical methods, such as benchmarking across and within industries and consulting with research bodies and external experts, were used by the Australian organisation, whereas informal methods such as visiting plants abroad and receiving information directly from suppliers, were used by the Thai organisations.

Third, when organisations intend to acquire new technologies, certain decision-making processes are followed in order to evaluate those technologies. There were substantial differences in the decision-making processes followed by the case study organisations. The decision-making processes followed by the larger case study companies involved more formal steps, formal technical methods, more people or stakeholders, and required a longer time period compared to the decision-making processes followed by the smaller companies. Consistent with the findings of previous studies, the size of the organisation was found to have a direct relationship with the formality and complexity of their evaluation processes.

Fourth, the most important element of the technological innovation evaluation process examined in this study was the key criteria used in the decision-making process. The framework of key criteria developed through the literature review can be considered to be effective, because over 60 per cent of the key criteria identified in the literature review were used by the case study organisations. Moreover, the field study showed that the larger companies recognised a higher level of business risk and a higher level of perceived value compared to the smaller companies. These broader key criteria, which cover the business supply chain and all key stakeholders, were used in the decision-making process followed by the larger Australian company. However, it can be concluded that the final decision usually depended upon the attitude and managerial judgements of the most senior decision-maker involved, in all organisations, regardless of their location or size.

Some limitations of both the desk study and the field study phases can be identified in this research. It will be useful to analyse these limitations and explore them in future studies. For the desk study phase, the framework derived from the literature review was limited by the articles selected for the review and the related issues that were addressed in the field study were not addressed in detail in the desk study phase. These were due to the fact that the literature review was limited to the key criteria used in the technological innovation evaluation process. For the field study phase, it was limited by the number of participating organisations and the number of interview respondents and thus the findings may not be able to be generalised to any population. Thus, the field study results were limited to the case study organisations and may not refer to all Australian or Thai organisations. Although the field study results were relevant because the participants were the key decision-makers in their organisations' technological innovation evaluation processes, the results were limited by the answers of the participants.

In light of these limitations, some recommendations can be made to improve future studies. For the desk study phase, more recent articles relating to the research issues, as well as other related issues, could be studied in order to develop a more complete and comprehensive framework and reach a deeper understanding in future research. For the field study phase, more organisations, and more decision-makers in different roles, should be interviewed in future studies for a more effective and complete understanding, because these research results were limited to the case study organisations, the results from this should be applied to future studies with care.

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FIGURES AND TABLES

Figure 1: An integrated conceptual framework of organisational evaluation of technological innovation

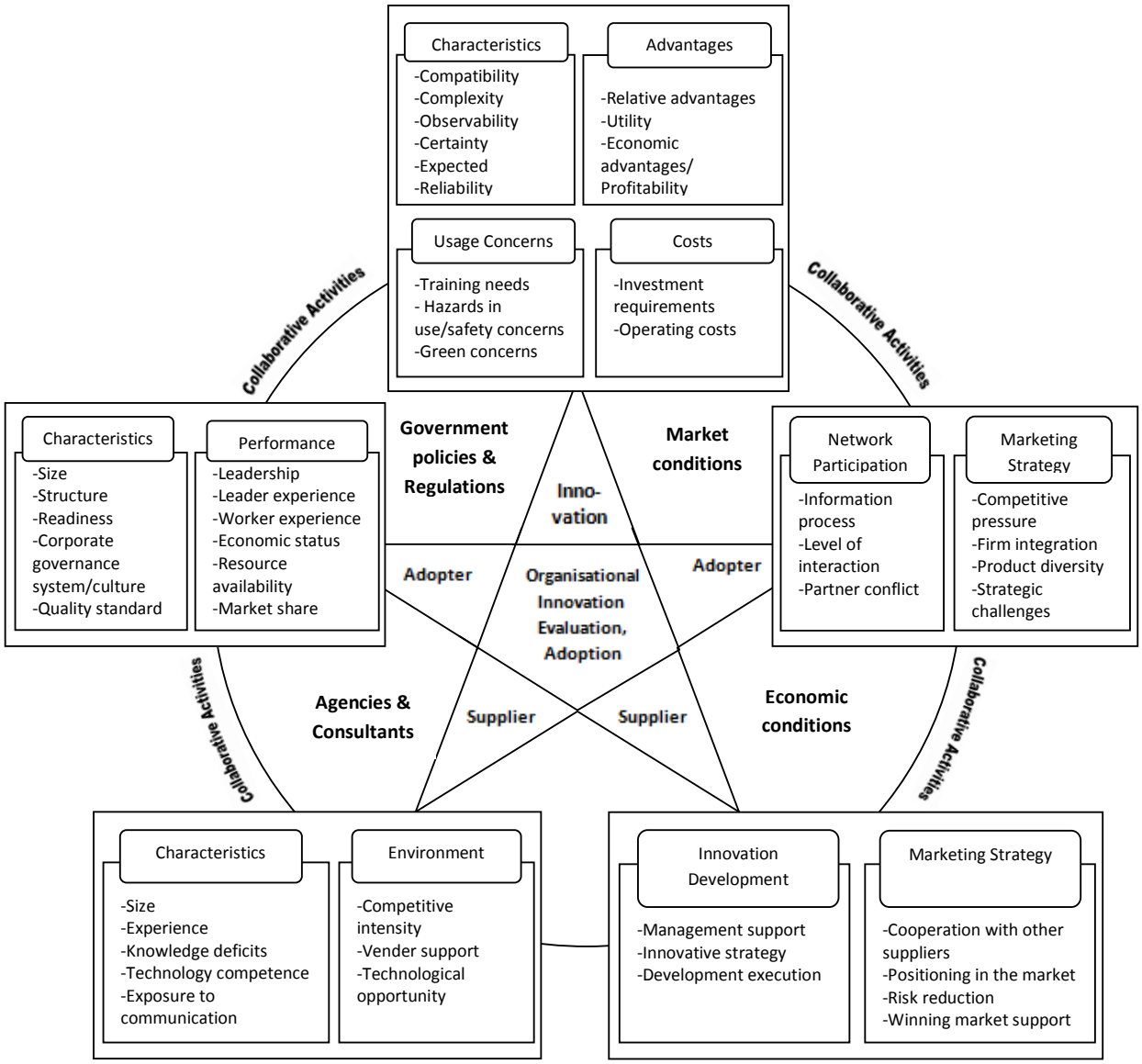

Table 1: Case study organisations

No.	Organisation	Type of business	Operation	Key Products	Case Studies (Size of investment)
1	Large Australian firm	Private	Mining	Iron ore and metallurgical coal	New drilling machine technology (US $1,000,000)
2	Large Thai firm	Private	Steel forming	Steel galvanising, steel grating	Welding robot technology (US $500,000)
3	Medium Thai firm	Private	Sheet metal processing	Rice milling machines; automotive components and spare parts	Laser cutting machine technology (US $300,000)
4	Small Thai firm	Private	Tool steel processing	Cutting tools, grinding tools, carbide end mills	CNC cutter and grinder technology (US $300,000)

Table 2: The interview respondents

No.	Organisations	Respondent's Position	Respondents' Roles in the Decision-making Process
1	Large Australian firm	General Manager	Business case assessment, technical risk assessment, investment approval
2	Large Thai firm	Assistant Managing Director (acts as Chief Financial Officer)	Risk assessment, financial assessment, supplier assessment and selection, reporting to Board decision-makers
3	Medium Thai firm	General Manager	Technology research, supplier assessment and selection, making a final decision
4		Process Engineer	Provide opinions in term of technical assessment
5	Small Thai firm	Assistant Manager (acts as Financial Manager)	Technology research, financial assessment, supplier assessment and selection
6		Sales Manager	Providing opinions in terms of relative advantages of new technology

Table 3: Differences between the decision-making processes followed by the Australian and Thai case study organisations

Elements	The Australian Company	The Thai Companies
Key stages in the decision-making processes	The process involved a formal system in which defined steps were followed.	The processes did not involve formal systems. No formal evaluation processes were established in advance.
	Formal technical methods were used in the decision-making process, such as business case assessment (economic evaluation) and risk assessment using probabilistic and sensitivity analyses.	No formal technical methods were used in the decision-making processes, except a risk assessment in terms of the cost and usage concerns by the large company.
	The company devoted considerable attention to a technical evaluation of the innovation. Most steps in the process involved the technical assessment of the innovation itself.	Only a few simple steps were involved in the assessment of the innovation, whereas the assessment of the agencies and suppliers was given greater consideration in the evaluation process.
	The economic evaluation in terms of net present value was the most important criterion that the firm used in its decision-making process for evaluating the innovation.	The advantages of the technology were the most important criterion that the firms used in their decision-making processes for evaluating innovations.
Time period required	The time period required depended on the complexity of the technology.	The time period required depended on the communication and information flows between the organisations, agencies, and suppliers involved.
	The longest key stage was the risk assessment by probabilistic and sensitivity analyses.	The longest key stage was the assessment of agencies and suppliers.
	The approximate total time period required was 3–12 months.	The approximate total time period required was 3–6 months.

Table 3: Differences between the decision-making processes followed by the Australian and Thai case study organisations (continued)

Elements	The Australian Company	The Thai Companies
Persons involved	Many stakeholders were involved in the decision-making process, both internal and external to the organisation.	Only a few persons within the organisations were involved in the decision-making processes.
	The technical working group, consisting of technical experts within the organisation and external consultants with an excellent understanding of the business risks, played a crucial role in the evaluation and decision-making processes.	The key decision-makers within the organisation: i.e., general managers, manufacturing/process managers, engineers, sales managers, and owners or managing directors, were the key people involved in the decision-making processes.

Table 4: Key criteria shown in the framework and used by the case study companies

Code	Criteria	F&A&T	F&A	F&T	A&T	F	A	T
I1	**Innovation side: characteristics**							
I1-1	Radicalness						x	
I1-2	Compatibility	x						
I1-3	Complexity	x						
I1-4	Observability			x				
I1-5	Certainty			x				
I1-6	Standardisation							x
I1-7	Expected	x						
I1-8	Modernisation							x
I1-9	Reliability	x						
I2	**Innovation side: advantages**							
I2-1	Increase manufacturing efficiency			x				
I2-2	Increase product quality			x				
I2-3	Increase business performance		x					

Table 4: Key criteria shown in the framework and used by the case study companies (continued)

Code	Criteria	F&A&T	F&A	F&T	A&T	F	A	T
I2-4	Promote organisation's image			x				
I2-5	Increase business opportunities		x					
I2-6	Increase organisation's competitiveness	x						
I2-7	Applicability to specialised purposes						x	
I2-8	Utility	x						
I2-9	Cost reduction	x						
I2-10	Increase revenue				x			
I2-11	Increase profits	x						
I3	**Innovation side: usage concerns**							
I3-1	Training needs			x				
I3-2	Hazards in use	x						
I3-3	Green concerns	x						
I3-4	Impacts on production process							x
I3-5	Research needs						x	
I3-6	Impacts on customers				x			
I3-7	Impacts on all key stakeholders						x	
I4	**Innovation side: costs**							
I4-1	Investment requirement	x						
I4-2	Operating costs	x						
I4-3	Training costs				x			
I4-4	Management costs						x	
I4-5	Switching cost						x	
I4-6	Maintenance costs				x			
A1	Adopter side: characteristics							
A1-1	Size	x						
A1-2	Structure		x					
A1-3	Readiness	x						
A1-4	Corporate governance system and culture		x					

Table 4: Key criteria shown in the framework and used by the case study companies (continued)

Code	Criteria	F&A&T	F&A	F&T	A&T	F	A	T
A1-5	Quality standard	x						
A2	**Adopter side: performance**							
A2-1	Leadership					x		
A2-2	Business experience		x					
A2-3	Technical experience	x						
A2-4	Knowledge deficits					x		
A2-5	Economics	x						
A2-6	Resource availability	x						
A2-7	Market share			x				
A3	**Adopter side: network participation**							
A3-1	Information process					x		
A3-2	Partner conflict	x						
A3-3	Level of interaction					x		
A4	**Adopter side: marketing strategies**							
A4-1	Competitive pressure	x						
A4-2	Firm integration					x		
A4-3	Product diversity			x				
A4-4	Strategic challenges	x						
A4-5	Market size							x
S1	**Supplier side: characteristics**							
S1-1	Size					x		
S1-2	Experience	x						
S1-3	Technological competence	x						
S1-4	Exposure to communication	x						
S1-5	Teamwork							x
S1-6	Economics				x			
S1-7	Knowledge deficits	x						
S1-8	Attentiveness							x

Table 4: Key criteria shown in the framework and used by the case study companies (continued)

Code	Criteria	F&A&T	F&A	F&T	A&T	F	A	T
S2	**Supplier side: innovation development**							
S2-1	Management support					x		
S2-2	Innovation strategy					x		
S2-3	Development execution		x					
S3	**Supplier side: marketing strategies**							
S3-1	Cooperation with other suppliers		x					
S3-2	Position in the market			x				
S3-3	Risk reduction	x						
S3-4	Winning market support	x						
S4	**Supplier side: environment**							
S4-1	Competitive intensity					x		
S4-2	Vender support					x		
S4-3	Technological opportunities					x		
E	**Environmental factors**							
E1	Market conditions	x						
E2	Economic conditions	x						
E3	Agencies and consultants	x						
E4	Government policies	x						
E5	Social/cultural						x	
E6	Reputation						x	
E7	Legal/regulatory		x					
E8	Collaborative activities		x					

F = Framework A = Australian firm T = Thai firms

Figure 2: Key criteria shown in the framework and used by the case study companies

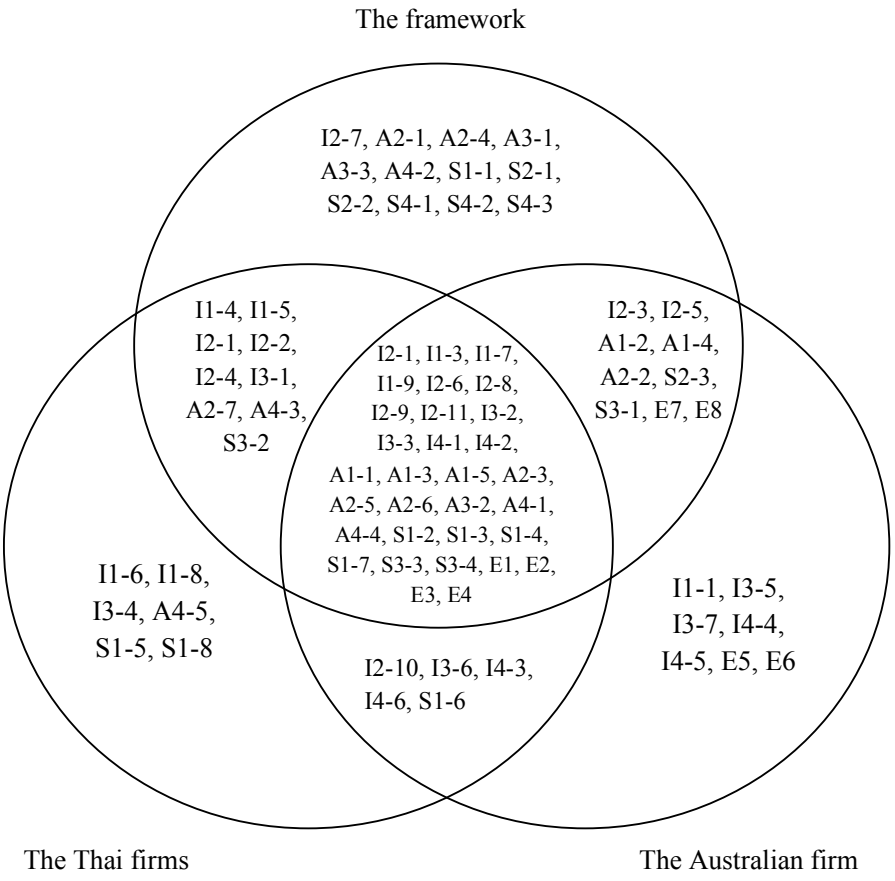

Table 5: The effectiveness of the framework shown by percentages of number of key criteria

Key Criteria	N	Shown in the framework & used by the real firms		Shown in the framework, but not used by the real firms		Used by the real firms, but not shown in the framework	
		N	per cent	N	per cent	N	per cent
Innovation side	33	20	60.61	2	6.06	11	33.33
Adopter side	20	14	70.00	5	25.00	1	5.00
Supplier side	18	9	50.00	6	33.33	3	16.67
Environmental side	8	6	75.00	0	0.00	2	25.00
Total	**79**	**49**	**62.03**	**13**	**16.45**	**17**	**21.52**

Table 6: The differences between the Australian and Thai organisations in three related issues

The Australian Organisation	The Thai Organisations
How did the organisations develop key criteria for evaluating technological innovations?	
-Patterns of key criteria were used in each stage of the decision-making process, such as business case assessment and risk management. -Key criteria were developed by a group of technical experts or a technical working group, which consist of both internal and external persons.	-No formal patterns were used for developing the key criteria. -Key criteria were developed from the information given by the suppliers. -Key criteria were developed by a small group of decision-makers (i.e., general managers, manufacturing/process managers, engineers, sales managers, and owners or managing directors).
How were the probable effects/results of the technologies determined?	
The technology's results were determined using formal technical methods such as: • Assumption protocol • Sensitivity analysis • Probability analysis	-No technical methods were used in the decision-making process for determining the technologies' results. -The technologies' results were determined from the information given by the suppliers and the real cases in other organisations that used those technologies.
How were the key criteria weighted when formulating the evaluation?	
-This step was conducted by a group of experts using probabilistic analysis. -The most important term was the technical term, by giving a higher weight on the innovation side. The second most important term was the economic term, and the least important was the environmental term.	-The three Thai case study organisations gave the highest weight to the technical term, and weighted the innovation side and the supplier side similarly, followed by the economic term then the environmental term.