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Strategic Manufacturing System and Process Innovation
A framework for small and medium sized enterprises

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Engineering

February 2010
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بِسْمِ الْلَّهِ الرَّحْمَٰنِ الرَّحِيمِ
Dedicated to my parents, for their love, with mine
Abstract

This thesis describes the development of a framework for strategic system and process innovation in Small and Medium sized manufacturing Enterprises (SMEs). The developed framework structures the innovation process into three phases of Plan, Prepare and Process. It provides a set of guiding principles at each phase that enables the management of the smaller companies to develop or select appropriate tools and methods for their innovation requirements. The framework is a significant contribution in this area of research as it was developed specifically for the needs of manufacturing SMEs.

SMEs play a crucial role in the national and global economy. They are responsible for most net job creation in OECD countries and make important contributions to productivity and economic growth. However, they are also very vulnerable to changes in their business environment as they have very limited resources and capabilities. In the current business climate, characterised by uncertainty, global competition and high levels of technological change, most SMEs find themselves unable to cope with the requirement to be in a constant state of change and innovation.

Effective management of change and innovation is a critical capability that all manufacturing companies must possess to survive and compete. However, in spite of the importance of SMEs in the economy and their known limitations, there are very few frameworks, tools and methods developed to enable them to effectively manage innovation. It is argued that there are two main reasons for this. The first reason is the absence of in-depth understanding of the specific characteristics of SMEs that govern the dynamics of innovation in their organisations. Second, is that after several decades of research on management of technology and innovation, there is still no comprehensive model of identifying the determinants of successful innovation, especially in the area of system and process innovation.

This study overcomes these issues by firstly adopting an action research approach, through which the researcher was embedded in a manufacturing SME for several years and took part in numerous system and process improvement initiatives. This provided the researcher first hand with a large body of contextual information that is crucial for understanding a complex phenomenon such as system and process innovation. In order to make this knowledge useful
for the development of the framework, a holistic model of organisational determinants of successful innovation was constructed, based on an extensive systems-based review of the related areas of innovation management literature. The model was used to systematically reflect upon the system and process innovation projects that the researcher had been leading in the case company.

The result was the identification of specific characteristics of manufacturing SMEs that impact the success of system and process innovation. These were categorised into three groups. The first group are those characteristics that influence the strategic aspect of innovation in SMEs. The second consists of characteristics that affect the context in which innovation is to take place, while the third group consists of those that affect how the innovation process is carried out. The framework was therefore structured in three phases in order to address the effect of the above characteristics on innovation in SMEs.

Finally, the framework was successfully applied in a manufacturing SME and enabled its managers to apply a strategic approach to system and process innovation. Two system and process innovation programmes were started, which focused on long-term competitiveness of the company while addressing the short-term needs of the business. These were “Environmentally Benign Furniture Design and Production” and “Customer Driven Furniture Design and Production”.

The framework proved instrumental in promoting a systematic approach to strategic development and creative problem solving. It was helpful in directing the innovation drive of the owner/manager towards strategic decision making, while complementing his knowledge with strategically significant information from the company’s business environment. Moreover, the preparation phase of the framework provided a structured and systematic approach to understand the drivers and obstacles of innovation, and to develop mechanisms to use the drivers and overcome the obstacles. It also proved helpful in identifying sources of knowledge and setting up mechanisms to acquire, store and disseminate knowledge.
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Chapter 1. Introduction

1.1. Background

Manufacturing organisations compete in an environment characterised by uncertainty, global competition, and high levels of technological change. The challenging task of managing the chaotic mix of people, machinery and materials must be achieved not only to cater for every need of their demanding and knowledgeable customers, but also to do it profitably, to satisfy shareholders. (Hammer, 2001). To achieve this, companies are increasingly moving towards newer paradigms like lean manufacturing, mass customisation and agility (ReVell, 2002). Successful implementation of these concepts requires manufacturing companies to be in a constant state of change and innovation, as maintaining the status quo will no longer be enough to survive.

A number of studies have demonstrated the impact of innovation on regional and national economic growth (Schumpeter, 1942, Cantwell, 2004). In a recent publication the Ministry of Research, Science & Technology in New Zealand highlighted innovation as one of the six key drivers of economic growth in the country (Mapp, 2009). Numerous studies have also shown business process improvement and innovation enhance the competitive position of the firms that embrace them (Lagace and Bourgault, 2003, Swamidass, 1996). Cantwell (2004) describes this succinctly, stating, “Competitiveness derives from the creation of the locally differentiated capabilities needed to sustain growth in an internationally competitive selection environment. Such capabilities are created through innovation.”

Effective management of change and innovation is therefore a critical capability that all manufacturing firms must possess to survive and compete. The literature of change management contains many studies analysing the factors influencing success and failure of improvement programmes (Al-Mashari and Zairi, 1999, Cao et al., 2000, Cao et al., 2001, Harrington, 1998, Nwabueze, 2001, Todd, 1999). However, it appears that most of the companies who invest a considerable amount of time and money in improving and reinventing their business processes fail to achieve their intended levels of improvement (Harrington, 1998, Nwabueze, 2001). This failure occurs in spite of the managements’ full awareness of the importance of change and innovation and the factors that are critical for
their success (Holman et al., 2000). Holman et al (2000) report that the main difficulty faced by the companies who took part in their survey study was at the implementation stage, caused by the observed lack of management experience and know-how in system thinking, strategic planning and practical change management. Consequently, change in these manufacturing companies remains technology-led and is adopted with relatively little strategic thought.

In the case of small to medium-sized enterprises (SMEs), this problem is compounded by a number of distinct characteristics that differentiate them from most of their larger counterparts. Along with deficiencies in human resources, managerial capabilities and financial resources, SMEs are subject to greater external uncertainty, which forces them to be more reactive and unstructured in their response to the changes in their business environment. Furthermore, their unique internal dynamics, driven by resource shortages and their personalised and entrepreneurial style of management with autocratic and centralized decision-making (Storey, 1994, Barnes, 2002), result in a lack of formal strategic planning and deployment processes (O'Regan and Ghobadian, 2002).

A recent survey study confirms this claim, reporting that SMEs have a reactive rather than proactive attitude to strategic improvement and innovation (Scozzi and Garavelli, 2005). The authors state that, although the SMEs participating in their survey study showed interest in innovative development, they did not develop a strategy to support change, adopt any methods to control or monitor the innovation process and did not record information and knowledge acquired during their developments.

It seems, therefore, that SMEs are not well equipped to formulate and effectively deploy strategic innovation, which can be very costly for them in the current business environment defined by uncertainty and competition. It can also be very costly on a national economy level. SMEs are responsible for most net job creation in OECD countries and make important contributions to productivity and economic growth. Manufacturing SMEs are responsible for a substantial portion of these contributions, generating a considerable share of manufacturing output and over 50% of value added for a number of OECD countries, notably Italy, Portugal, Spain, Japan, New Zealand and Norway (OECD, 2005). While many researchers, practitioners and lawmakers understand the significant contribution SMEs make to the local and global economy, their efforts to assist the SME sector with innovation management have been hindered by a number of factors. Firstly, an analysis of the literature reveals that, after
several decades of research on management of technology and innovation, there is still no comprehensive framework to guide the practice of innovation. This can be attributed to the diversity of research methods and perspectives in this (Lam, 2004, Tidd, 2001). Understanding of complex phenomena such as change and innovation requires in-depth analysis of innumerable interconnected factors. Consequently innovation has been studied from a broad range of individual perspectives and disciplines, such as engineering, psychology, economics, management, geography and sociology. This diversity of research has limited the accumulation and integration of knowledge regarding innovation and associated management practices (Becheikh et al., 2006, Fagerberg, 2004, Tidd, 2001).

Secondly, there is a bias towards quantitative research methods. As a result, the current understanding of innovation is missing in-depth knowledge of contextual information that is crucial to the understanding of the dynamics of a complex phenomenon such as innovation. A comprehensive literature review conducted by Becheikh et al. (2006) on process innovation in manufacturing companies has revealed that an overwhelming majority of studies conducted in this area use surveys and statistical methods to identify and analyse key drivers of innovation. As Thompson and Ackroyd (1995) point out, even when qualitative approaches are used they tend to be superficial: “Sometimes interviewing managers, a tour around the factory and a chat with the union convenor is all that is possible”.

Finally, the majority of strategic innovation approaches found in the literature appear to have been designed primarily for use in a big business context (Hudson et al., 2001). As discussed earlier, SMEs exhibit distinct characteristics that differentiate them from their larger counterparts (Storey, 1994), which consequently exposes them to a unique set of barriers for effective implementation of change and innovation. They, therefore require approaches tailored to their specific needs. Welsh and White (Welsh and White, 1981) succinctly sum up this point, stating that “a small business is not a ‘little’ large business; differences exist in structure, policy making procedures and use of resources, to the extent that application of large business concepts directly to small businesses may border on the ridiculous”. To date, most SME research has focused on factors that contribute to their growth (O'Regan et al., 2005, O'Gorman, 2001, Mambula and Sawyer, 2004) or their survival (Storey, 1994). Others, which studied the process of change and innovation in manufacturing SMEs have mainly reported on success and failure factors identified primarily through survey studies (O'Regan and Ghobadian, 2002, O'Regan et al., 2006, Lagace and Bourgault, 2003, Chu, 2003). Very
few studies have actually proposed practical methods for SMEs to strategically manage and implement their improvement initiatives (Barad and Gien, 2001, Bessant et al., 2001). Even those few studies carried out in this area have been based mainly on survey data and lack in-depth analysis of the requirement of SMEs for successful innovation. As Ram (1996) points out, understanding of small firms is restricted by the “rarity of intensive workplace studies focusing on the actual processes of management”.

1.2. Problem Statement

In summary, SMEs face extensive and unique challenges for effective strategic innovation. The efforts of many researchers, practitioners, and law makers to assist SMEs with strategic innovation are often hindered by their incomplete understanding of the unique and complex dynamics of the innovation process in SMEs. This results in the scarcity of effective tools for enhancing the prevalence and success of strategic system and process innovation in SMEs. By conducting a comprehensive analysis of the strategic innovation process in SMEs based on intensive workplace studies, an in-depth understanding of the unique requirements of SMEs can be developed. This will be used to develop a supporting framework for strategic innovation tailored to the specific needs of SMEs. The framework will act as a conceptual yet practical model of the innovation process that will assist managers and practitioners in successful planning and implementation of strategic innovation in SMEs. It will have a structure, outlining the necessary phases of the innovation process, as well as a set of guiding principles that can be used to design or select tools and methods suited to the requirements of SMEs at each phase.

1.3. Scope of Research

The study presented in this thesis therefore aims to:

1. Develop a comprehensive model of strategic system and process innovation
2. Identify the unique organisational characteristics that govern strategic innovation in SMEs.
3. Develop a framework for successful planning and deployment of strategic system and process innovation in SMEs, facilitating design, selection and implementation of appropriate methods and tools tailored to the unique requirements of SMEs.
4. Verify the framework through case study application.
1.4. Thesis Structure

This study is represented in the following nine chapters (excluding the introductory chapter): In Chapter 2 a thorough analysis of appropriate methodologies is conducted and the final research design is presented. In Chapter 3 the main research theme of this study, i.e. strategic system and process innovation in a manufacturing environment, is defined and explored. Chapter 4 presents an in-depth analysis of existing literature in the area of innovation management. In this chapter a comprehensive model of key drivers of successful innovation management is developed and presented. In Chapters 5 and 6, innovation management practices at SMEs are examined first through literature analysis and then through a number of longitudinal case studies in a manufacturing SME. The comprehensive model developed in Chapter 4 is used to analyse the case study projects and uncover the dynamics of innovations management at the case company. Chapter 7 describes the framework developed to guide manufacturing SMEs to successful strategic system and process innovation. Chapter 8 presents two case studies illustrating the application of the framework in the case company. Potential areas of improvement are identified and discussed in Chapter 9 based on the findings of the case studies. Finally, Chapter 10 provides a number of conclusions and recommendations for future research.
Chapter 2. Methodology

This chapter presents the research design used in this study. It first describes various issues that impacted the research design. This is followed by presenting the research design and the rationale behind its development.

2.1. Issues in Research Design

2.1.1. Information Requirements

The research problem focuses on two major issues. First issue is the need for developing a better understanding of the nature of system and process innovation. Several decades of research on the management of technology and innovation have created many insights about innovation. However, understanding complex and ambiguous phenomena such as change and innovation requires in-depth analysis of innumerable interconnected factors. Consequently innovation has been studied from a broad range of individual perspectives and disciplines, such as engineering, psychology, economics, management, geography and sociology. This diversity of perspective in research has limited the accumulation and integration of knowledge regarding innovation and associated management practices (Becheikh et al., 2006, Fagerberg, 2004, Tidd, 2001). A broad review of existing knowledge about innovation is therefore required.

The second issue is the need for an in-depth understanding of the characteristics of SMEs and their impact on managing system and process innovation. Previous research in the area of innovation in SMEs has mainly focused on success and failure factors (O'Regan and Ghobadian, 2002, O'Regan et al., 2006, Lagace and Bourgault, 2003, Chu, 2003). Their findings will be useful for developing a general understanding of the requirements of SMEs for successful innovation. However, those few studies carried out in this area have been based mainly on survey data. In order to develop a framework that addresses the organisational issues related to managing innovation in SMEs, more in-depth knowledge of the innovation management in SMEs is required.
2.1.2. Philosophical Stance

This thesis has a focus on subjective reality, which is context specific, recognising that an organisational phenomenon such as innovation is a social construct and embedded in that context. It is acknowledge that there is an objective external “reality”, which can be researched. However it is argued that a socially constructed view of reality is more appropriate for research related to complex, contextual processes involving multiple participants. Thus, the underlying research paradigm in this study is realism (as opposed to constructivism or positivism), which can be characterised as follows:

- Nature of reality: There is a researchable external reality, however, it is difficult to apprehend fully. This “reality” is therefore subjectively constructed by those who apprehend it.
- Nature of findings: The findings are probably “true”, rather than wholly “true”
- Typical methodologies: case studies, action research, etc

2.1.3. Methodological Pluralism

Traditionally, research in engineering and science follows a technical and rational process in which theoretical models are developed and validated under controlled experimental settings. Such approach to research has also been quite prevalent in the area of change and innovation in SMEs. Under this paradigm the researcher mainly applies a single quantitative (sometimes qualitative) method of analysis to uncover the cause and effect relationships that govern the subject of study in a way that they can be generalised to other similar situations.

However, innovation is a complex (Bernstein and Singh, 2006), ambiguous (Boer and During, 2001), paradoxical (Riis et al., 2001) and diverse organisational phenomenon. Developing deep understanding of such complex subject of study, calls for a complex and creative research design. This cannot be achieved through preserving methodological purity (Huberman and Miles, 2002). Thus, this thesis takes a pluralistic perspective at the practical level, i.e. taking a multi-method approach.

Each methodology has a substantial value and indeed could arguably stand alone in a research project. However, as Hill and McGowan (1999) argue no one methodology is particularly suitable on its own when studying complex contextual phenomenon. What is therefore proposed, is a research approach which borrows from the full menu of possibilities
when and where required. Such pluralistic approach offers potential for creativity in research design, and for richer and more practical outputs (Little, 2004). This is eloquently expressed by Langley et al. (1995) when discussing research methods used to study the complex process of organisational decision making:

“...we argue for more varied approaches to research so that justice can be done to the histories of organisations, the people involved in them, and the intricate webs of issues they experience... today’s conceptual world of organisational decision making looks awfully black and white. Is it not time to open it up to the rich world of colour?”

2.1.4. Systematic and Holistic Approach

As mentioned earlier, innovation has been studied from a broad range of individual perspectives and disciplines. This has resulted in deep understanding of individual facets of innovation, but shallow and incomplete understanding of innovation as a whole. Complex systems theory states that complex systems have “emergent” characteristics that do not equate to the sum of the characteristics of their parts. To better understand them, they must therefore be analysed holistically and systematically. This can be achieved by using multiple-view analysis. This is a powerful technique used in organisational research to handle the ambiguity and complexity of organisations, their systems and processes. Multiple-view analysis is based on the notion that our cognitive model of an external reality is inherently limited by the perspectives used in its construction. Morgan (1986) likens such limitation to that experienced by the subjects of the old Indian tale of “the blind men and the elephant”. He concludes that, much like the men in this story, those trying to understand organisational realities are limited by their perspectives (Figure 2.1). It is only through the synthesis of these multiple-views that a more complete model of reality can be constructed.

Figure 2.1. Artistic illustration of “the blind men and the elephant”
Such approach should be applied to all aspects of this study, be it inquiry into the available literature or investigating dynamics of innovation within a case company.

2.1.5. Depth versus Breadth

There exists a trade-off between the depth and breadth of analysis in the research design. By increasing the breadth of analysis, and considering limitation of resources and time, the researcher will not be able to have an in-depth engagement with the participating companies. As a result the researcher stays outside the research field gathering information through surveys or interviews. The limitations associated with data collection through surveys and/or conversational interviews commonly lead to a superficial view of the participating firms; missing in-depth understanding of contextual information, that is crucial to the understanding of the dynamics of the complex phenomenon which is innovation. However, on the upside, generalisation of the claims to knowledge is better supported using statistical analysis of quantitative data.

On the other hand by increasing the depth of analysis the researcher must engage with a smaller number of case-companies on a more long term basis. Appropriate methodologies for this type of research include longitudinal case study research or participatory action research. These methodologies will provide the researcher with rich contextual data needed to understand complex organisational phenomena. It will also provide the researcher with the opportunity to capture inherent elements of a dynamic system, such as time delays, feedback, history dependence and non-linearity of the cause and effect relationships (Sterman, 2000). However, the smaller sample size results in the larger bias of the findings towards the context of the participating companies. As a result it will be harder to generalise the claims to knowledge. In order to avoid the generalisation problem, it is critical that any claim to generalisation is made based upon a structured analytical approach with clearly presented theoretical reasoning. It is also important to use the results of empirical research in the literature to verify the findings.

2.1.6. Implementing Major Change

The eventual deliverable from this thesis is a framework for strategic system and process innovation in manufacturing SMEs. The fourth objective of this study is the verification of this framework. It is therefore necessary for this framework to be implemented in a
manufacturing SME and its success in initiation, development and implementation of strategic innovation assessed. Strategic innovation in systems and processes of a SME is a major change initiative. It impacts all levels of the enterprise and would require the support and involvement of the company’s top management. Thus, if the researcher is going to implement such major change, he must be well respected and trusted by the main decision makers in the company for his expertise as well as for his ability to deliver such major change. Such status takes a long time (perhaps years) to be gained and established. The research design, must therefore take into consideration adequate time and planned steps aimed at establishing trust and expert status for the researcher.

2.1.7. Recoverability and generalisation

In presenting the findings of this research, a number of provisions must be made in order to ensure the developments resulting from this study are not seen as anecdotal. Checkland and Holwell (1998) provide an appropriate guideline for this purpose. They contend that the validity of any research design can be assessed based on the criteria of recoverability.

Recoverability means that anyone interested in subjecting the research to critical scrutiny should be able to do so. This is particularly difficult in the case of action research as, due to its contextual nature it is almost impossible to completely repeat the process. However, Checkland and Holwell (1998) argue that,

“Unable to match the complete replicability of experimental happenings which characterize natural science, researchers investigating social phenomena via AR (action research) must at least achieve a situation in which their research process is recoverable by interested outsiders. In order to do this it is essential to state the epistemology (the set of ideas and the process in which they are used methodologically) by means of which they will make sense of their research, and so define what counts for them as acquired knowledge. This gives well-organised AR a ‘truth claim’ less strong than that of laboratory experimentation, but one much stronger than that of mere plausibility”

The research theme under investigation in this study is strategic system and process innovation, the methodology through which the theme is applied is innovation management practices, and the area of application is manufacturing SMEs.
2.2. Research Design

After careful consideration of the issues discussed in the previous section, a multi-phased research design was developed as illustrated in Figure 2.2.

The remaining sections of this chapter describe each phase in more detail and discuss the appropriate methodologies to be used in that phase.

2.2.1. Phase 1

This phase is concerned with the development of a sound theoretical foundation for the research. A thorough systematic and holistic review of literature is carried out in order to address the following two questions:

- What is system and process innovation?
- What key factors influence its success or failure?

The first question is concerned with the definition of system and process innovation. The literature is used to clearly identify the distinguishing elements that define this type of innovation. Each of these elements is then further explored to gain a deeper understanding of system and process innovation (see Chapter 3 for more detail).

The second question is concerned with the identification of the key factors that impact the success or failure of innovation. There is an abundance of existing research in this area. However, as mentioned earlier the challenge is that many of these studies have been conducted from the perspective of various specialisations. A multiple-view approach is used to ensure majority of these perspectives are taken into consideration. Six views were selected, which together provide a holistic perspective of system and process innovation (see Chapter 4...
for more detail). To achieve this systematically, first the available literature on innovation was analysed from each view separately. The findings were then used to construct a relational model for that view, which showed the key influential factors identified in the literature, their direct effect on the organisation and the impact of that effect on success or failure of innovation (Figure 2.3). This was repeated for all the six views, and at the end these relational models were synthesised into a consolidated model that can be used to better understand system and process innovation (see Chapter 4 for more detail).

![Figure 2.3 Elements of the relational model constructed for each viewpoint](image)

### 2.2.2. Phase 2

This phase focuses on the dynamics of innovation management in manufacturing SMEs. A thorough review of literature is conducted to identify key characteristics of SMEs that have impact on success or failure of innovation. However, given that majority of research conducted on SME characteristics has been survey-based, the available literature provides a restricted understanding of innovation management in SMEs. This is evident in the results of a recent comprehensive survey study of innovation in 702 manufacturing SMEs (O'Regan et al., 2006). As illustrated in Figure 2.4, the findings of this study, though useful for understanding loose association between some of the elements influencing innovation in SMEs, fail to capture the dynamic complexity of innovation. This is reflected in the authors’ (O'Regan et al., 2006) concluding remarks that

> “Any future research should consider a more in-depth approach. It would have been beneficial to augment the quantitative data with qualitative in-depth case studies or an ethnographic approach.”

![Figure 2.4 "Fast tracking innovation - a step by step guide" (O'Regan et al., 2006)](image)
The literature research is therefore, complemented in this phase with a number of in-depth longitudinal case studies. Case study research is a suitable methodology for this investigation as it is often applied for understanding complex social phenomena that cannot be detached from their context (Yin, 2002). A similar approach was used by Nash et al. (2001). Table 2.1 describes various elements of the case study research design.

<table>
<thead>
<tr>
<th>Purpose of investigation</th>
<th>To develop an in-depth understanding of how system and process innovation is managed in manufacturing SMEs.</th>
</tr>
</thead>
</table>
| Case selection           | A single case company was chosen for this study as it allowed for more in-depth and longitudinal study to be carried out. The case company was selected to match the definition of SME adopted from the literature review presented in Chapter 5. The company was also found suitable for this study as it provided:  
  - The opportunity to be embedded in the company and take part in various innovation projects  
  - Senior management support  
  - Trust in sharing information due to previous history of research collaboration with supervisor |
| Object of study          | A number of system and process innovation projects that the researcher directly participated in were studied (two of these are presented in Chapter 6). |
| Duration of study        | The researcher was embedded in the case company and took part in various innovation projects between year 2003 and 2006. |
| Data gathering           | Qualitative data was collected by the researcher through formal and informal interviews with staff involved in the project, noting down personal observations by the researcher, emails, reports and meeting minutes. |
| Data analysis            | The multi viewpoint model of system and process innovation developed in Phase 1 of the research (presented in Chapter 4) was used as systematic tool for analysing the findings of the case studies. By using this model it was possible to systematically analyse and understand the dynamics that govern system and process innovation in the case company. |
| Quality control          | A number of provisions were put in place to ensure appropriate conclusions were reached:  
  - A thorough literature analysis was carried out on characteristics of SMEs that influence system and process innovation (see Chapter 5)  
  - The data and interpretation of the findings were presented to the supervisor on a weekly basis  
  - The findings were regularly discussed with the sustainable innovation research group at the University of Auckland. The group consisted of a number of researchers and practitioners involved with manufacturing SMEs in New Zealand. |
2.2.3. Phase 3

This phase of the research was spent on development of a framework for successful implementation of system and process innovation in manufacturing SMEs. The previous phases of research had provided all the necessary insight and information about what organisational elements and characteristics influenced innovation in manufacturing SMEs. These characteristics were categorised with respect to their impact on various stages of the innovation process. The understanding developed in Phase 1 of the research was used to develop the framework’s structure and a list of principles which guide the implementation process at each stage of innovation (see Chapter 7 for more detail).

2.2.4 Phase 4

The final phase of the research involved the implementation of the framework with the aim of verifying its effectiveness at managing strategic system and process innovation in SMEs. There was a need for in-depth participation of the researcher in all aspects of the implementation. The method of research favoured for such circumstance is called participator observation or action research (Wadsworth, 1998). Action research has a long history in the study of social science and managerial work (Jones, 2003, Mintzberg, 1983, Lupton, 1963). A number of authors have also used this method of research for development of tools and methods for manufacturing companies in the areas of product development (Norton, 1997), performance measurement (Neely et al., 2000) and manufacturing strategy development (Mills et al., 1998).

In this approach, instead of observing from a distance and asking “What are the successful companies doing?” the researcher participates in the problem situation and asks “How can I understand this situation and how can I improve it?” This often involves a cyclic process in which the researcher participates in actions within the live organisational settings, observes, reflects and analyses the findings, draws conclusions and plans new and transformed actions. Table 2.2 describes the elements of research design in this phase.
Table 2.2 Action research study research design

<table>
<thead>
<tr>
<th>Purpose of investigation</th>
<th>To verify the effectiveness of the framework developed in Phase 3, and to identify areas of improvement for future development.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case selection</td>
<td>The same case company used in Phase 2 of the research was chosen. This was mainly due to the requirements previously outlined in section 2.1.6.</td>
</tr>
<tr>
<td>Object of study</td>
<td>The framework was implemented for two major strategic innovation initiatives at the case company (see Chapter 8)</td>
</tr>
<tr>
<td>Duration of study</td>
<td>The researcher was embedded in the case company and took part in various innovation projects between year 2006 and 2007.</td>
</tr>
<tr>
<td>Data gathering</td>
<td>Qualitative data was collected by the researcher through formal and informal interviews with staff involved in the project, noting down personal observations by the researcher, emails, reports and meeting minutes.</td>
</tr>
<tr>
<td>Data analysis</td>
<td>The structure and guiding principles of the framework were used to systematically analyse the findings.</td>
</tr>
<tr>
<td>Quality control</td>
<td>A number of provisions were put in place to ensure appropriate conclusions were reached:</td>
</tr>
<tr>
<td></td>
<td>• The data and interpretation of the findings were presented to the supervisor on a weekly basis</td>
</tr>
<tr>
<td></td>
<td>• The findings were regularly discussed with the sustainable innovation research group at the University of Auckland.</td>
</tr>
</tbody>
</table>
Chapter 3. Strategic Manufacturing System and Process Innovation

3.1. Introduction

A review of the literature on innovation reveals a substantial range of opinions and ideas on what constitutes as innovation. Zairi (1994) made reference to this when he wrote, “what makes innovation challenging is the fact that it is very difficult to agree on a common definition”. Indeed, this can be problematic as there are many misconceptions of the term innovation. For instance many perceive invention to be the same as innovation. Although both invention and innovation are associated with novelty, invention stops at the point of the creation of the new idea. Innovation, on the other hand, occurs when the new idea is implemented and commercialised (Fagerberg, 2004).

Another common misconception is that innovation is often viewed in terms of a new product or service. A study by Linder et al. (2003) conducted on forty managers revealed that these executives primarily thought about new products when considering innovation, and ignored other type of innovation such as system and process innovation. This is also reflected in the way academics view innovation. A recent review of literature by Becheikh et al. (2006) reports that a relatively insignificant portion of the studies conducted on innovation were focused on process innovation.

The research theme under investigation in this study is strategic manufacturing system and process innovation. In order to avoid the above-mentioned misconceptions and to comply with the principle of recoverability discussed in the previous chapter, it is important to clearly define this type of innovation. Thus, this chapter first describes various types of innovation based on the study of literature and arrives at a definition for strategic manufacturing system and process innovation. It then explores in more detail various aspects of this definition. Finally, a number of guiding principles are identified, to be used in the development of a framework for managing strategic manufacturing system and process innovation.
3.2. Definition of Innovation

Drucker (1985) defines innovation as “the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth”. Tushman and Nadler (1986) focus on the concept of novelty, defining innovation as the creation of any product, service or process which is new to a business unit. Cooper (1998) follows a similar definition, while asserting that the novelty factor of innovation is a matter of perception and is based on the adopting business unit and the uncertainty associated with the idea or process, rather than its originality.

Other researchers define innovation as going beyond novel products, services and processes and focusing innovation on the translation of inventive ideas into marketable propositions for customers (McAdam et al., 1998, Becheikh et al., 2006). Brown (1994) provides a broader description of innovation as “doing things differently or better across products, processes or procedures for added value and/ or performance”. This is expanded upon by a more complete definition by West and Farr (1990) defining innovation as the intentional introduction and application within a role, group or organisation of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, the organisation or wider society.

Furthermore, innovation is often classified based on the domain of its application, namely product, process or organisation. Product innovation, as the name suggests, is focused on development of new products, features or services that provide added benefits for the firm and its customers. Process innovation, on the other hand, is concerned with increasing the efficiency and effectiveness of processes that produce and deliver the company’s products or services. Organisational innovation is aimed at developing more effective and efficient systems and structures which the organisation utilises to deliver value to its customers. For instance in a furniture manufacturing company, developing a new office desk and taking it to market is regarded as product innovation. Implementation of changes in the paint line, which enables the company to offer glossy finish as an option to the customers, is regarded as process innovation. Reconfiguring the business processes in marketing, sales, design, purchasing and production to go from make-to-stock system of production to make-to-order can be regarded as organisational or system innovation. The fundamental difference between product innovation and the other types of innovation is that in product innovation the direct
implications of the changes are localised on the product, while the others affect all facets and levels of the organisation due to the interconnectedness and dynamism of business processes.

Innovation can also be classified based on the novelty or the extent of uncertainty associated with the implementation of the innovative idea in the adopting business unit. This leads to two categories of incremental and radical innovation. Mole and Elliott (1987) define radical innovation as “products and processes that result from advances in knowledge”, while contending that incremental innovation refers to the continual process of improving existing products and processes. Cooper (1998) makes similar distinction, stating that the difference between radical and incremental innovation is the degree of strategic and structural change that the firm must undergo to accommodate the innovation in question.

There is also a third categorisation of innovation, which is often neglected in the literature. Innovation can be classified as strategic or emergent based on the organisational level from which the directive for innovation is originated. If the innovation is planned by and mandated from the top of the organisational structure and supported by the firm’s strategy, it is said to be strategic. On the other hand, if the innovation arises from an individual or a group of individuals mainly for the purpose of providing a pay-off for the individual or the group, it is regarded as emergent. This type of innovation, may or may not be in line with the firm’s strategy. In fact the emergent changes might be in opposition to the strategic objectives of the organisation, since the organisational objectives might be compromised for individual benefits (Koch and Leitner, 2008).

The type of innovation under investigation in this study is strategic system and process innovation (both incremental and breakthrough) in a manufacturing environment. Based on the above discussion this type of innovation can thus be defined as the planned introduction and application of changes to various elements of a manufacturing system in a way that its overall performance is improved in line with the business strategy. According to this definition, the subject of innovation is the elements within the manufacturing enterprise, which are inventively manipulated to improve manufacturing performance, in accordance with the firm’s strategic objectives.

The following sections will explore various elements of this definition, in order to better understand the nature of strategic system and process innovation in manufacturing firms.
3.3. Manufacturing Enterprise

Suh et al. (1998) describe a manufacturing enterprise (also referred to here as manufacturing system) as a combination of people, "things", and information. People perform various functions that incrementally add value to raw materials and eventually produce and deliver products to customers. These include marketing, design, purchasing, inventory control, inspection, machining, management, safety, service, and security. "Things" range from machinery, materials, transporters, computers, warehouses and other utilities. Information is related to marketing requirements, product design, planning and control of operations, manufacturing processes and other information related to the supply chain system.

Wu and Ellis (2000) provide a model of a manufacturing system architecture comprising three layers. The physical or manufacturing layer represents the hard elements of the system, including the machines, logistics, storage and other facilities required to support the manufacturing process. This layer also describes the flow of materials throughout the system. The human and organisational layer represents the organisational structure and the interactions of the employees within the manufacturing system, including their roles, responsibilities and production tasks. Finally, the information and control layer represents the planning and control functions of the manufacturing system. It describes the processes involved in decision making and the flow of data and information throughout the system.

![Figure 3.1. Unified Manufacturing System Management (Wu and Ellis, 2000)](image-url)

As illustrated in Figure 3.2, the horizontal dimension represents various perspectives of a manufacturing system, namely Information, Resources, Organisation, Function and Decision. The vertical dimension represents the planning horizon as well as the organisational levels functioning in the manufacturing system. At the lowest level, there is a mix of people, machinery, materials and systems interacting to manufacture the products in accordance with the required order quantities and specifications. The coordination and control of the processes on the shop floor take place at the next level, which consists of factory supervisors as well as systems for managing the production activities. All the other levels are responsible for providing the production team with the required resources, systems, information, directions and specifications in a way that manufacture the right product, to the right specifications, at the right cost, in the right quantity, at the right time and without harming themselves or the environment.
Although the models presented above are separate into multiple dimensions and levels, in reality manufacturing systems are highly dynamic and all their elements are inter-related. Thus, any change introduced to the manufacturing system directly involves one or many of these elements, and impacts the others. Papinniemi (1999) has identified a number of elements within a manufacturing system, which can be improved or reengineered to significantly improve the system’s performance. These are:

- Process type: job shop, batch, repetitive, etc.
- Product structure/modularity: homogenous, assembled, etc.
- Process integration: product line, group, cell, etc.
- Operation type: fabrication, assembly, design, logistic, accounting and finance
- Man-machine-computer connections: man-machine systems
- User closeness to information: process information systems
- Management and control: decision support and information systems

Similarly, Miltenburg (2005) has identified six “manufacturing levers”, which can be adjusted to affect change in a manufacturing system. These are:

- Human resources: skills, wages, training, etc.
- Organisational structure and control: division of labour, management, monitoring
- Sourcing: vertical integration, supplier relations
- Production planning and control: flow of material, production activities, support activities such as maintenance
- Process technology: nature of the fabrication process, type of equipment, automation
- Facilities: location, size, focus and timing of changes

Based on the discussion so far, any changes made to the above elements, any change that is new to the organisation, and results in the improvement of the overall performance of the system can be regarded as system and process innovation. For instance implementation of a new and advanced manufacturing technology can be regarded as innovation. Changing the layout and flow of materials can also be regarded as innovation if it leads to improved performance. Some of the well known examples of manufacturing system and process innovation include, just-in-time production and purchasing, KANBAN, computer aided manufacturing, cellular manufacturing, single minute exchange of dies, total preventative maintenance, total quality management, enterprise resource planning, and many more.
3.4. Manufacturing Performance

A key requirement for a change in the manufacturing system to be regarded as innovation is that it results in improved performance of the system. Manufacturing performance is defined based on the notion that the primary way manufacturing adds value to the business is by enabling it to do certain things better than its competitors (Skinner, 1969). Analysis of literature in area of manufacturing performance reveals that there is general agreement on the key dimensions of performance for a manufacturing system (Brown and Blackmon, 2005, Dangayach and Deshmukh, 2006, Leachman et al., 2005, World Commission on Environment and Development, 1987, Shahbazpour and Seidel, 2006). These are:

- Cost: Production and distribution of products at low cost
- Volume: Meeting market volume requirements
- Quality conformance: Producing defect free products
- Quality capability: Manufacturing products in accordance with superior quality standards
- Delivery reliability: Meeting delivery schedules
- Delivery speed: Fast response to customer orders
- Flexibility: Proactive response to changes in production mix and volume
- Design Flexibility: Product customisation
- Sustainability: Products and processes that don’t compromise the ability of future generations to meet their own needs.

However research indicates that the above dimensions of performance do not have the same degree of impact on the firm’s overall competitiveness (Ketokivi and Schroeder, 2004). This is particularly relevant to system and process innovation, as the ultimate purpose of the innovation process is to improve the company’s competitiveness. Therefore, identifying the relative impact of each dimension of performance on the firm’s competitiveness guides the innovation activities of the company.

From this perspective, New (New, 1992) divides the manufacturing objectives into hygiene factors and competitive-edge factors. Similarly Hill (Hill, 1987) defines two categories of order-qualifying and order-winning factors. Order-qualifiers or hygiene factors are criteria that are essential for the customer to consider the product, while order-winners or competitive-edge factors are those that win the orders. To be competitive manufacturing
firms must be at least as good as their competitors on the order-qualifiers and try to outperform the competition on the order-winning criteria (New, 1992).

Shahbazpour and Seidel (2006) argue that three external elements influence this categorisation of the manufacturing objectives. These are technology, market requirement and society’s needs. The authors provide a conceptual model (see Figure 3.3) through which they analyse the evolution of production paradigms over time and the changes of manufacturing objective categorisation with respect to these three factors. They observe that new competitive-edge objectives emerge based on technological advancement and social and market requirements of the time, while previous order-winning criteria become new order-qualifiers or hygiene factors. Table 3.1 illustrates this pattern of change in manufacturing objectives.

![Figure 3.3 Model of external influences on manufacturing objectives.](image)

<table>
<thead>
<tr>
<th>Manufacturing Paradigms</th>
<th>Craft Production</th>
<th>Mass Production</th>
<th>Flexible Manufacturing</th>
<th>Mass Customisation</th>
<th>Sustainable Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Society Needs</td>
<td>Customised products</td>
<td>Low cost products</td>
<td>Variety of products</td>
<td>Customised products</td>
<td>Environmentally friendly products</td>
</tr>
<tr>
<td>Market Requirements</td>
<td>Very small volume</td>
<td>Demand-Supply Steady demand</td>
<td>Supply-Demand Smaller volume</td>
<td>Fluctuating demand</td>
<td>Declining natural resources</td>
</tr>
<tr>
<td>Technology Enablers</td>
<td>Electricity Machine tools</td>
<td>Interchangeable parts Moving assembly lines</td>
<td>Computers Flexible Manufacturing Systems</td>
<td>Information Technology Internet</td>
<td>Recycling Energy recovery</td>
</tr>
<tr>
<td>Order-winning manufacturing objectives</td>
<td>Quality conformance</td>
<td>Quality conformance Quality capability Delivery reliability Cost</td>
<td>Flexibility Quality capability Delivery speed Cost</td>
<td>Sustainability Design Flexibility Quality capability Delivery speed Cost</td>
<td>Sustainability Design Flexibility Quality capability Delivery speed Cost</td>
</tr>
<tr>
<td>Order-qualifying manufacturing objectives</td>
<td>Volume</td>
<td>Quality conformance Delivery reliability Volume</td>
<td>Flexibility Quality conformance Delivery reliability Volume</td>
<td>Sustainability Flexibility Quality conformance Delivery reliability Volume</td>
<td>Sustainability Flexibility Quality conformance Delivery reliability Volume</td>
</tr>
</tbody>
</table>

Another important aspect of manufacturing performance that affects system and process innovation is the notion of performance level. Shahbazpour and Seidel (2007) identified three
levels of performance as defined by researchers in the literature. The first is current performance, which corresponds to levels of performance resulting from current operational choices and arrangements within the manufacturing environment. The second level of performance is the performance frontier (PF), which was first introduced by Schmenner (1998) and later taken up by Vastag (2000). This level of performance corresponds to how well the system can perform without any significant structural changes in the manufacturing environment. The final level is world class manufacturing (WCM), which corresponds to the ultimate level of performance, considered “best-in-class” (Schonberger, 1996). Figure 3.4 represents a multi-dimensional view of manufacturing performance, where various dimensions and levels of performance are mapped. The tip of the arrowheads represent WCM levels of performance, while the dashed lines stand for the PF, and the centre polygon shows current levels of performance.

Mapping the current level of performance and assessing its relative position with respect to the performance frontier is critically important for the identification of appropriate areas of improvement. If the current level of performance is too far away from the firm’s performance potential for a given objective then the solutions for improving performance should be searched in the way the firm’s resources are configured and exploited to achieve that objective. However, if the current and potential levels are the same or very close then the improvement initiatives must focus on acquiring new resources and assets that push the performance frontier towards world class levels of performance.
3.5. Manufacturing Strategy

The decisions regarding what dimension of manufacturing performance should be the focus of strategic initiatives and what actions should be taken to enhance performance in those dimensions, fall in the domain of manufacturing strategy. There are many connotations of manufacturing strategy in the literature. Skinner, the pioneer of manufacturing strategy, defines it as exploiting certain properties of the manufacturing function as a competitive weapon (Skinner, 1969). Hayes and Wheelwright (1985) define manufacturing strategy as a sequence of decisions that over time, enables a business unit to achieve a desired manufacturing structure, infrastructure and set of specific capabilities. Moreover, Brown (2003) defines manufacturing strategy as the driving force for continual improvements in competitive requirements and priorities. There is a vast body of literature on the subject of manufacturing strategy, which falls outside of the scope of this chapter. Instead the discussions will be directed at areas directly related to strategic innovation and improvement of manufacturing performance. For a comprehensive literature review of the research in the area of manufacturing strategy see Dangayach and Deshmukh (2001).

Based on the notion that the primary way manufacturing adds value to the business is through enabling it to do certain things better than its competitors (Skinner, 1969), the researchers in this area have formed two distinct philosophies for manufacturing strategy formation. These are strategic choice and resource based approaches. The strategic choice approach postulates that firms gain competitive advantage through identifying external opportunities in new and existing markets or market niches and then aligning themselves with these opportunities. Under this approach, competitive strategies are devised by senior executives and translated into functional level strategies through a top-down process (Porter, 1996, Skinner, 1992). For instance, if the business strategy is to compete on cost, the key focus of the manufacturing strategy would be to reduce production costs. Alternatively, the resource based view of competitive advantage suggests that the firm should assemble and deploy appropriate resources that provide opportunities for sustainable competitive advantage in its chosen markets (Schroeder et al., 2002). Competitive advantage is thus created by distinctive, valuable firm-level resources that competitors are unable to reproduce (Gordon et al., 2005). The manufacturing strategy according to this approach will focus on accumulating resources and capabilities, which the business can then exploit to be competitive.
Recently, Brown and Blackmon (2005) argued that the dynamic and unpredictable nature of the competitive business environment requires manufacturing firms to simultaneously undertake both strategic choice and resource based approaches when building their manufacturing capabilities. This implies that manufacturing companies must engage in capability development activities that “resonate” with the market requirements, and consequently develop strategic flexibility. To achieve this, the company must reach a state of dynamic alignment between manufacturing strategy and business-level strategy where they are both aware of and responsive to one another.

A key driver of the type of strategic approach taken by companies is their attitude towards trade-offs (Sarmiento et al., 2010, Shahbazpour and Seidel, 2007). In the manufacturing context, the notion of trade-off refers to a situation where improving performance in one dimension is achieved at the expense of lowering the level of performance in another dimension. For instance, when quality is improved but at the expense of speed of delivery, there is a trade-off between quality and speed of delivery. A recent case-based study (Da Silveria and Slack, 2001) shows that trade-offs are easily recognised by practicing managers as the “operational compromises” they routinely make.

The advocates of the strategic choice approach view trade-offs as inherent and unavoidable realities of manufacturing systems that cannot be eliminated (New, 1992, Skinner, 1992). They therefore suggest that manufacturing companies must strive towards being exceptionally good at one or two of the performance dimensions (i.e. “Focused Factory”). They claim that attempting to become world class in all dimensions is practically impossible and potentially dangerous. On the other hand, supporters of the resource based approach establish that trade-offs can be avoided if the company possesses the right mix of capabilities (Flynn et al., 1999, Harrison, 1998, Hayes and Pisano, 1994, Schonberger, 1996, Flynn and Flynn, 2004). Historically, technological and managerial innovations such as Just-in-Time (JIT), Computer Integrated Manufacturing (CIM) and Advanced Manufacturing Technology (AMT) have demonstrated that certain trade-offs that were seemingly unavoidable can be eliminated. Developments in information systems have specially proven critical in enabling manufacturing firms to simultaneously perform at world class levels in multiple objectives (Qiu and Zhou, 2004).
Ferdows and Demeyer (1990) demonstrate that the order in which companies acquire manufacturing capabilities is a significant factor for elimination of trade-offs. They state that competitive objectives are not always conflicting, and can in fact be complementing if improvement programmes are implemented in a certain order. To illustrate the cumulative nature of manufacturing objectives they propose a model, where the recommended order is quality, dependability, speed, flexibility and cost efficiency (Ferdows and De Meyer, 1990).

It is therefore concluded that trade-offs are constraints or obstacles that when removed, lead the manufacturing system to reach higher levels of performance (Shahbazpour and Seidel, 2007). In fact, if a manufacturing company is able to eliminate a trade-off that is shared amongst the industry, it can gain a significant competitive advantage over its rivals. This was indeed observed in the case of Toyota Motor Company. In the mid 20th century Toyota overcame trade-offs between quality, delivery, flexibility and cost by developing and implementing a set of innovative systems and processes, now termed the Toyota Production System (TPS). TPS is regarded by many as the most significant contributor to Toyota’s boost in competitiveness in the motor industry, to the point that it revolutionised the industry and became the basis of a new manufacturing paradigm, Lean Manufacturing (Fane et al., 2003). In 2009, Toyota overtook its long time rivals, Ford and GM, and became the world’s largest motor company.

Based on the argument presented so far, it is proposed that identification, improvement and elimination of trade-offs must become the focus of the strategic manufacturing system and process innovation. Doing so provides the company with the opportunity to gain significant competitive advantage over its competitors (Shahbazpour and Seidel, 2007). As Da Silveira (2003) points out, “A focus on trade-offs may yield improvement trajectories that are more effective and sustainable”.

Currently there are two approaches to trade-off management: repositioning and enhancement. Repositioning refers to raising one manufacturing priority at the expense of the other, mainly to align operations to a new competitive strategy (Da Silveira, 2003). In other words, if one operational objective contradicts another objective which is more valuable to the customer, then the one with lesser importance will be compromised. On the other hand, enhancement aims at raising the performance level of different variables to obtain improvements on multiple competitive fronts (Da Silveira, 2003). For this purpose it has been suggested that it
is useful to view trade-offs as ‘pivot’ type models. The attributes of the manufacturing system
make up the pivot of the trade-off while the resources and capabilities of the system form the
base of the trade-off. Enhancement is achieved by either improving the system attributes or
improving operation capabilities and resources (Da Silveria and Slack, 2001).

The world class manufacturing (WCM) school of thought advocates implementation of
established “best practices” as the means for attaining improvements in manufacturing
system attributes, capabilities and resources. JIT, CIM and AMT are among these best
practices, which have been attributed to world class levels of performance. Voss et al. (1995)
conducted a study of operational practice and performance in over 600 manufacturing sites in
four European countries. They concluded that adoption of best practices is linked directly
with achieving high operational performance, which in turn results in superior business
performance (Voss et al., 1995). However, there have been a number of valid criticisms of
the best practice approach to gaining competitive manufacturing performance.

Firstly, copying is following rather than leading. Skinner (1992) notes that the strategy of
copying and adopting other companies’ practices can at best achieve “stay in the game”.
Hayes and Pisano (1994) argue that instead of adoption of specific practices, the focus must
be on attaining capabilities which are hard to duplicate by competitors. Schroeder et al.
(2002) contend that imitating WCM practices leads to “competitive parity” and not
competitive advantage. This is further supported by Porter (1996), who states that “the
essence of strategy is choosing to perform activities differently than rivals”.

Secondly, adopted solutions may conflict with one another and/or the manufacturing
environment. Skinner (1992) points out that too many companies adopt too many solutions
and practices that are in conflict. Ketokivi and Schroeder (2004) agree with Dean and Snell
(1996) that the effect of “best practices” on manufacturing performance is contingent upon
strategic manufacturing goals and limited by various characteristics of the manufacturing
environment. Furthermore a number of researchers have discussed the need for “company
specific” interpretation and implementation of world class principles and practices (Sharifi

Finally, tomorrow’s challenges cannot be all met by today’s practices. The leading
manufacturing paradigms such as agile manufacturing and mass customisation are said to
require fundamental rethinking of systems and processes and “casting off those old ways of doing things” (Gunasekaran, 1999). This is echoed by Harrison (Harrison, 1998) stating that manufacturing companies need to recognise that “today’s mindset will not work in the longer term”.

Shahbazpour and Seidel (2007) propose an alternative approach to repositioning and enhancement for elimination of trade-offs. They contend that trade-offs can be viewed as the contradicting relationship between two objectives in terms of opposing correlations they have with a system parameter. Such a contradictory relationship is the root-cause of the trade-off, and the key to improvement of the trade-off is in elimination of the root-cause. Figure 3.5 illustrates a hypothetical trade-off between sustainability and quality capability due to their contradicting relationship with a certain material property. As this involves development and implementation of innovative ideas leading to improved processes, systems and configurations in line with the firm’s strategic direction, it can be regarded as strategic manufacturing system and process innovation.

![Figure 3.5 Example of viewing trade-offs as contradicting relationship with another variable](image-url)
3.6. Conclusions

Based on the discussions presented in this chapter, the following principles must be present in a framework for strategic system and process innovation in a manufacturing organisation:

- Strategic manufacturing system and process innovation is defined as the planned introduction and application of changes to various elements of a manufacturing system in a way that its overall performance is improved in line with the business strategy.
- Strategic innovation must be introduced with the clear objective of improving manufacturing performance in one or more of the following dimensions: cost, volume, quality (conformance and capability), delivery (speed and reliability), flexibility (mix, volume, design) and sustainability.
- The decision to prioritise and focus on the performance dimension must be based on knowledge of order-qualifying and order-winning market criteria.
- The focus of the innovation activities should be on improving or eliminating manufacturing trade-offs.
Chapter 4. Multiple-View Model of System and Process Innovation

4.1. Introduction

Innovation is a complex and multi-faceted phenomenon. As discussed in the introductory chapter, this complexity has resulted in diversity of research perspectives in studying the subject (Tidd, 2001, Lam, 2004). To date, innovation has been studied from a broad range of individual and diverse perspectives and disciplines, such as engineering, psychology, economics, management, geography and sociology. This diversity of research has limited the accumulation and integration of knowledge regarding innovation and associated management practices (Becheikh et al., 2006; Tidd, 2001; Fagerberg, 2004).

With the growing importance of innovation management, a number of researchers have recently developed models identifying key drivers of innovation, and have conceptualised their relationship with the innovation process. In this chapter a review of the leading models (as found in the mainstream academic literature) is provided and their key limitations are discussed. This is followed by a comprehensive and systematic review of literature with the aim of developing a new model that overcomes these limitations. The model consists of a comprehensive set of factors that affect the success of innovation management in organisations and will form the basis of analysis of innovation management practices in SMEs. It will serve as the foundation on which the framework for strategic manufacturing system and process innovation is developed in Chapter 7.

4.2. Review of Models of Innovation

A thorough search of literature was conducted using a number of databases covering publications in areas of management, innovation, design and technology management. A number of studies were found that provided a model of the innovation process. Of these, three models were selected for further analysis as they provided alongside the core innovation process a number of critical factors that impacted innovation. These are the process-based contingency model by Boer and During (2001), the integrated innovation process model of
Bernstein and Singh (2006), and an innovation model based on the systems thinking approach by Galanakis (2006).

Boer and During (2001) developed a process-based contingency model of innovation based on three categories of activities that interact during the course of the innovation process. These are: problem solving, internal diffusion and organisational adaptation.

![Innovation Model by Boer and During (2001)](image)

Boer and During contend that innovation is essentially a learning process, thus the core of their model is a “quasi-cyclical process” of problem solving (see Figure 4.1). The process starts with the recognition of a need or an opportunity to innovate, followed by collection of information and generation of ideas. This is followed by selection of sufficiently promising ideas and the establishment of screening criteria. The next step is the development of concrete solutions. The innovative solution may then be validated before final implementation.

At each stage of the problem solving process, there is an ongoing process of communication and information processing that is referred to as “internal diffusion”. It involves two recurrent stages of knowledge awareness and attitude formation. The former encompasses the internal and external communication processes and transfer of information regarding problems, ideas and opportunities, while the latter involves the digestion of the transferred information and leads to a positive or negative attitude towards the problem, idea or opportunity.
Boer and During identify another category of activity in their model, namely organisational adaptation. This involves the organisational changes affected as a direct consequence of the implementation of the innovative solutions, as well as the organisational adaptation related to the organisation (i.e. innovation roles and organisational arrangements) of the innovation process itself.

Bernstein and Singh (2006) propose an integrated innovation process model, consisting of a multi-staged core innovation process, two contrasting drivers and a number of organisational constructs that influence the core process (Figure 4.2). Their model is based on a view of innovation that involves a complex stream of internal and external communication networks linking the structural functions of the organisation and the knowledge creation process.

The core innovation process starts with the generation of new ideas that may arise through the two contrasting mechanisms of technology push and market pull. This is followed by three consecutive stages through which ideas are analysed and supported, developed further into solutions and finally implemented. The authors identified four organisational constructs that have significant influence on the core innovation process. These are management, communication, structure and control. They found managerial behaviour and communication to be critical at the early stages of the innovation process, while organisational structure and control mechanisms were observed to be more influential at the later stages of the process.
Galanakis (2006) proposes an innovation model based on the systems thinking approach. The model has been developed from the viewpoint of product innovation. However, it can easily be adapted for process innovation at the high level. The core of the model is the innovation process, which the author describes in terms of three stages: knowledge creation, design and development, and product success, which can be interpreted as implementation (Figure 4.3).

The core innovation process is influenced by the firm’s internal factors and the national innovation environment. The firm’s internal factors influencing the innovation process, as identified in the model, are creativity, organisational climate, organisational structure, technological capability, risk-taking policy and corporate strategy. Galanakis also identifies a number of determinants in the national innovation environment, based on Porter’s (1990) “National Diamond” model. These are: regulations, financial system, infra-structure, demand conditions, physical resources and human resources. Galanakis also provides a systems dynamic model of the interrelation of the identified factors and the product innovation process, which, due to its focus on product innovation, will not be discussed further.

Upon investigation of the models described above, it can be observed that all three models follow a similar structure. They consist of a core innovation process along with a set of influencing factors encompassing innovation determinants external and internal to the firm. It is also apparent that there are many similarities between the core innovation processes in all three models, portrayed as a multi-staged innovation process starting with the creative stage of formulation of the problem and generation of ideas. This is then followed by a development phase, and concludes with the implementation of the innovative solutions.
Bernstein and Singh identify a stage between idea generation and innovation development they call innovation support. This is similar to the concept of internal diffusion highlighted by Boer and During, and is also implied by the funnel shape of the design and development process, and the arrow between idea generation and the funnel in Galanakis’ model.

Further analysis of these models indicates that, although each portrays a very similar multi-staged innovation process, they highlight different sets of determinants influencing that process (Table 4.1). These differences highlight a major limitation of the models, which is a clear evidence of the problem that is being addressed by this chapter. Closer observation of the approach employed by these researchers in arriving at their list of determinants reveals that the observed differences are because each group of researchers studied and analysed the innovation process from their distinct viewpoints. Boer and During (2001) approached innovation from a process perspective and focused on the people issues around that process. Bernstein and Singh (2006) analysed the innovation process from four organisational perspectives of management, communication, structure and control, while Galanakis (2006) developed their model based on the organisational and environmental factors that influence the flow of information and resources during the innovation process.

As a consequence of these different perspectives, the constructed models present different sets of determinants, which make each model limited by the viewpoints used in its development.

<table>
<thead>
<tr>
<th>Table 4.1 List of innovation determinants</th>
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<tbody>
<tr>
<td><strong>Innovation Model</strong></td>
</tr>
<tr>
<td>Core Processes</td>
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<td></td>
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<tr>
<td>External determinants</td>
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35
4.3. Multiple-View Model of Innovation

As has been shown in the previous section, in order to develop a more comprehensive framework for innovation management, a more systems-based and holistic analysis must be carried out. The notion of systems-based review has recently become popular in the management literature (Denyer and Neely, 2004). The key to the development of a comprehensive model of innovation determinants is to carry out a holistic analysis based on multiple-views. A model is merely an abstract representation of a reality (Yu et al., 2000) and is thus inherently limited by the perspectives used in its construction. Morgan (1986) likens such limitation to that experienced by the subjects of the old Indian tale of “the blind men and the elephant”. He concludes that, much like the men in this story, those trying to understand organisational realities are limited by their perspectives (Figure 4.4). It is only through the synthesis of these multiple-views that a more complete model of reality can be constructed. Multiple-view analysis is a powerful technique used to handle the ambiguity and complexity of organisations, their systems and processes. Innovation, too, is a complex (Bernstein and Singh, 2006), ambiguous (Boer and During, 2001), paradoxical (Riis et al., 2001) and diverse organisational phenomenon. Applying multiple-view analysis to the study of innovation would ensure a more comprehensive understanding is reached.

![Figure 4.4. Artistic illustration of “the blind men and the elephant”](image)

Given that innovation is a phenomenon arising from the organisational context (Fagerberg, 2004), it is argued that in order to understand innovation, one can apply the same viewpoints which are used to analyse organisations. Multiple-view analysis has been widely used to analyse organisations in enterprise modelling (Doumeingts and Ducq, 2001, Scheer, 1992, Yu et al., 2000, Vernadat, 2002), system and process improvement (Doumeingts and Ducq, 2001, Flood 1996, Mertins and Jochem, 2001) and organisational research literature (Morgan, 1986, Bolman and Deal, 1991). Table 4.2 presents a list of viewpoints used in these studies.
In order to develop a comprehensive model of innovation, it is therefore necessary to create a set of viewpoints or perspectives through which innovation is to be viewed and analysed. This set of viewpoints must encompass all the viewpoints listed above. After reviewing the studies cited in Table 4.2, it was observed that there were commonalities amongst the different views used in these studies. It was therefore decided to consolidate the viewpoints to a smaller set of six perspectives, as follows:

- **Process** (also includes Function, Transformation, Performance),
- **Structure** (also includes Organisation, Roles, Environment)
- **Control** (also includes Decision, Politics, Influences)
- **Knowledge** (also includes Information, Data)
- **Culture** (also includes Norms and Values, Rituals and Symbols, Ideologies)
- **Resources** (also includes Human, Physical)

In order to develop a multiple-view model of system and process innovation, first the available literature on innovation was analysed from each view separately. The findings were then used to construct a relational model for that view, which showed the key influential “factors” identified in the literature, their direct “effect” on the organisation and the “impact” of that effect on success or failure of innovation. The factors and effects were directly extracted from the literature, however the impact on innovation was determined through inductive reasoning. For this purpose successful innovation was defined as completed successfully and leading to performance improvement and competitive advantage.
This systematic analysis of literature was completed for all the six views, and at the end the six relational models were synthesised into a consolidated model that can be used to better understand system and process innovation (Figure 4.5).

![Figure 4.5 Multiple-viewpoint modelling process](image)

**A note about multi-level analysis**

Study of the innovation literature indicates that innovation is multi-level in nature, manifesting itself at multiple levels of detail: the organisation, team and individual levels (Anderson and Vastag, 2004). Indeed, innovativeness as a characteristic can be ascribed to organisations, teams as well as individuals. However, since the model is being constructed for the development of a framework for strategic innovation, it must address those determinants that can be manipulated at the organisational level to ensure the success of the innovation process. This is not to say that matters related to teams and individuals will be ignored. Organisation is the context within which the teams and individuals carry out innovation. It plays a role of creating the motive for initiating innovation, as well as directing and enabling its further development and implementation. Those aspects of teams and individual innovation which can be influenced at the organisational level are addressed by this study.
However, other important aspects of innovation such as cognitive abilities of the individuals are not included.

4.3.1. Process View

The process view of innovation is concerned about the sequence of activities through which inventive ideas are materialised into benefits for the innovators and the recipients of the innovation. It is generally agreed that the innovation process is carried out in the three stages of initiation, development and implementation. The initiation stage starts with the realisation that the status quo is not the desired state (Rogers, 2003, Nightingale, 1998) and ends with the formulation of the innovation problem, which is in fact a mandate to change the system, process or organisation towards the desired state (Boer and During, 2001). This is followed by the development stage, through which the organisation, team or individual design and develop solutions for the innovation problem (Bernstein and Singh, 2006, Boer and During, 2001). In the final stage, these solutions are validated and implemented and the benefits of the innovation are actualised. Analysis of literature reveals a number of processes that occur throughout these stages of the innovation process. These were grouped into the categories of creative problem solving, internal diffusion and project management, and are discussed in the following sections.

4.3.1.1. Creative Problem solving

Innovation is at its core a problem solving process. Creative problem solving involves an iterative and recursive process of divergent creative thinking and convergent critical thinking (Treffinger et al., 2006). The literature contains numerous tools and methods that have been developed to guide this process. While a comprehensive review of these tools is beyond the scope of this thesis, a selection of problem solving methods were analysed in order to identify important characteristics of an appropriate problem solving approach for system and process innovation. These methods included Six Sigma, Soft Systems Methodology, Theory of Constraints (also known as TOC) and theory of inventive problem solving (also known as TRIZ). Analysis of these problem solving methods highlights the following shared characteristics:

- Systems approach to problem definition,
- Structured approach to analysis,
- Focus on elimination of root-causes.
The first characteristic that these methods have in common is the systems approach. As discussed in the previous chapter, a manufacturing system is made up of numerous elements that are dynamic and interconnected. Any change made to any of these elements will cause compensatory changes in the others (Flood 1996). Furthermore, systems thinking argues that “systems have emergent properties that are not found in their parts” (O'Connor and McDermott, 1997). The implication of this is that redesigning certain parts of the system without giving due consideration to its remaining parts would result in unexpected “emergent” effects. These effects may be harmful and as a result diminish the overall system performance. The literature on change management clearly indicates that successful change requires a systematic and holistic approach in which all stakeholder viewpoints and various aspects of the organisation are considered (Yu et al., 2000, Cao et al., 2000).

Furthermore, analysis of the change management literature reveals that overlooking soft aspects of the system is a major contributing factor to failure of improvement efforts (Al-Mashari and Zairi, 1999, Cao et al., 2001, Harrington, 1998, Nwabueze, 2001). A manufacturing system is largely a social system of human activities carried out by people whose rationality is limited, who have their own goals and preferences, and who react differently to change. This type of system generally has permeable boundaries, is dynamic as a result of human action, is affected by human intent and is self regulating (Pidd, 2009). Consequently, the definition of the innovative problem to be solved is not straightforward, and is itself problematic. Special attention must therefore be paid to structuring the problem definition so that due consideration is given to both hard and soft aspects of the system.

Another common characteristic of these problem solving methods is their structured approach to problem analysis. Dietrich and Lehtonen (2005), in their empirical study of factors affecting successful implementation of strategic intentions in 288 companies, report that successful organisations employ a formal structured decision-making and analysis approach. Moreover, development of appropriate innovative solutions requires a thorough understanding of the system’s current situation and its desired future state. Developing such understanding requires collection, structuring and analysis of a complex set of information. As stated by Lane and Oliva (1998), the human brain has limited memory, cognitive skills and information processing capabilities, and as such is unable to create a complete mental model of a complex and dynamic system. It is therefore necessary to employ a structured approach for identifying the root-causes of the problem.
The focus on identification and elimination of root-causes is another common characteristic of the mentioned problem solving methods. This is the key for developing novel and long lasting solutions. In this context the root-cause of the problem can be defined as “anything that limits a system’s higher performance relative to its purpose” (Scheinkopf, 1999). This is very much in line with the discussions presented in Chapter 3 with regards to trade-offs.

4.3.1.2. Internal Diffusion
The diffusion process involves two recurrent stages of knowledge awareness and attitude formation (Rogers, 2003, Boer and During, 2001). Knowledge awareness encompasses the internal and external communication processes and transfer of information regarding problems, ideas and opportunities. Attitude formation involves the digestion of the transferred information that leads to a positive or negative attitude towards the problem, idea or opportunity. McAdam (2005) further divides the attitude formation process into two recursive stages of normative evaluation and legitimisation. He states that normative evaluation is based on comparing the incoming innovation against existing norms, while legitimisation is said to involve a sense-making process of integrating or rejecting the intended innovation. Rogers (2003) finds five variables that influence the diffusion process. These are:

- Perceived attributes of the potential innovation: relative advantage, compatibility, complexity, trialability and observability.
- Type of innovation decision: is the decision to innovate optional, part of a collective voluntary decision made with other entities, or forced upon the organisation by the market or an authoritative entity such as government?
- Communication channels: has the organisation become aware of the innovation through trusted channels of communication?
- Nature of the social system: the organisational culture, norms, values that determine the organisation’s willingness to accept changes to the already established norms, routines and practices.
- Persuasive power of the change agent: the ability of the change agent to gain support for the innovation.
Analysis of literature highlights a number of process groups that influence these key variables. These have been grouped into the following categories: communication processes, collaboration processes and political processes.

*Communication Processes*

These processes aim to spread ideas, knowledge and information amongst the stakeholders of innovation. Cox and Moode (2008) report that management use communication tactics to establish conditions conducive to innovation and to establish the constraints around the innovation activities. Kivimäki et al. (2000) have found communication encourages collaboration and participation, which results in improved innovation performance. Fidler and Johnson (1984) contend that effective communication reduces uncertainty by overcoming perceptions of risk and complexity. Linton (2002) identifies a dual role for communication in innovation implementation. These are reducing resistance to change and facilitating resource acquisition. Moenaert et al. (2000) identify a number of factors influencing the efficiency and effectiveness of communication. They state that effectiveness of communication is dependent on information transparency, codification and credibility, while its efficiency depends on distance, frequency and secrecy.

Furthermore, Fidler and Johnson (1984) provide a thorough analysis of various aspects of the communication process and their effect on internal diffusion of innovation. They contend the manner in which information regarding innovation and the influencing power behind it are communicated determine its ultimate success. The authors find “influence” rather than “dictation” or “sanctioning” is the best approach for inducing adoption of innovation. They identify three types of influence: referent, expert and persuasion. In the case of referent influence, the adopting unit chooses to adopt the innovation simply because the decision unit has done so. The expert influence is based on the adopting unit’s perception that the decision unit has greater knowledge in the area of innovation. Persuasion, on the other hand, is concerned with communication of evidence and the rationale advocating the implementation of innovation. If carried out effectively, persuasion results in high levels of participation and diminished resistance attributed to lack of understanding and to fear of change.

*Collaboration Processes*

These processes are boundary-spanning processes that aim to foster the integration of diverse interests, values, ideas and bodies of information. Bernstein and Singh (2006) state that
bringing people from different disciplines and backgrounds into the team encourages viewing
the situation from multiple perspectives and fosters creativity. Rogers (2003) also contends
that nature of diffusion demands that at least some degree of heterophily (the degree to which
two or more individuals who interact are different in attributes) be present. Linton (2002)
argues that successful innovation requires the involvement of people from different
functional areas as they bring with them a diverse set of skills and knowledge. They also find
cooperation as key element of collaboration, which leads to better co-ordination of activities
required for successful implementation. Similarly, Teece (1989) states that collaboration
processes reduce and at times eliminate the wasteful duplication of efforts in an organisation.
Singh (2005) reports that collaboration fosters lasting interpersonal linkages that significantly
improve diffusion of knowledge in an organisation.

In terms of structure, collaboration processes can be divided into two categories (Swink,
2006). Structured processes focus on creating opportunities and incentives for interaction and
sharing of information. Technology and organisational structure are key drivers of the
effectiveness and efficiency of these processes. Unstructured processes, on the other hand,
concern interpersonal relationships and participative decision making (Drach-Zahavy and
Somech, 2001).

Political processes
These processes aim at establishing the support of the decision makers and people in power
positions. Jones and Stevens (1999) demonstrate the critical role organisational politics play
in the innovation process. Frost and Egri (1990) suggest innovation is a political process,
where the establishment of a new system or process is the outcome of a power game, and not
of its value in terms of utility or profitability. Knights and Murray (1994) contend that the
driving force of the political process is the apparent constant struggle of individuals and
collectives to acquire and use resources in pursuit of their own objectives. Similarly,
Asimakou (2009) states that political processes are manifested through the attempts of
individuals and groups to exploit the rules and take control of the current order, for their own
benefit and at the expenses of others.

Senior executives play a critical role in this political process. They are the main providers of
vision, credibility, protection and access to resources (Wu, 2008). Tactics such as bargaining,
manoeuvring, blocking, subverting and manipulating are used to build coalitions and gain the
support of senior executives in order to assist or derail the innovation (Barnes, 2002, Koch and Leitner, 2008). Dawson and Buchanan (2005) identify another set of political processes, which they refer to as social interpretive processes. They contend that technological change is often accompanied by social processes that shape the collective interpretation of the change that is taking place. They observe that power is exercised through establishing a version of reality by scripting compelling narratives, which thereby discredit, delegitimise and weaken the accounts of reality set by rival narratives.

4.3.1.3. Project Management
Developing an idea into economic success typically takes the simplest institutional form of a project, and is managed and implemented by a project team (Gebhardt, 2005, Taatila et al., 2006). Project management processes concern the management of allocation, mobilisation, and deployment of resources to deliver the desired innovation, while minimising risks at every stage. These have been categorised as planning, scanning, organising and controlling.

Planning Processes
Planning is concerned with the mental simulation of future activity, which provides the basis for other project-management processes. A number of studies have reported that planning is more likely to occur and is more effective if the organisation is in a turbulent environment, resources are scarce, interdependence is high and external demands do not dictate a certain course of action (Bluedorn et al., 1994, Dean and Sharfman, 1996). Mumford et al. (2008) provide a comprehensive analysis of planning processes in the context of innovation. They argue that plans are constructed through the analysis and reconfiguration of experiential knowledge. The first stage is the development of a cognitive planning template based on the understanding of “critical cause operatives” derived from past experiences. This template is then used to construct the initial plan by identifying the causes, resources, restrictions, contingencies, actions and outcomes applicable to specific project. The initial plan is subsequently refined through a process of forecasting the outcomes of the project. This is followed by the identification of markers for monitoring progress.

Based on this process, the effectiveness of the plan relies mainly on the cognitive template constructed based on prior experience. However, this poses a challenge for the early stages of the more novel innovations. Due to high levels of uncertainty associated with novelty, there will potentially be limited or no prior experience to be used as the basis for the planning
process. One approach to remedy this issue is to pursue multiple projects (Kamoche and Cunha, 2001). However, this approach has the inevitable problem of resource allocation and prioritisation (Engwall and Jerbrant, 2003). Mumford et al. (2008) argue that this problem can be minimised if multiple projects are pursued early on in the innovation process, when costs and commitment are relatively low. They also contend that the multiple projects are best developed around a number of fundamental and integrative themes. Furthermore, to overcome the uncertainty associated with planning for innovation, plans can be made flexible and regularly updated based on newly acquired information.

Scanning Processes
The process of seeking and acquiring new and potentially useful information for the strategic planning is called scanning. This may include processes that seek to identify external opportunities such as scanning the marketplace, market research, benchmarking, evaluating the usefulness of new methods, foresighting and predicting future scenarios. It may also include processes aimed at identifying internal opportunities in terms of reducing cost, improving throughput, quality, delivery, flexibility, etc. Alternatively, it may include knowledge acquisition processes seeking technical knowledge from internal and external sources. Day and Schoemaker (2004) contend that there are two main attributes of the scanning processes, which affect the firm’s innovation process. These are the breadth and activeness of the scan.

The breadth defines how far the scope of the scan covers the things that are in the peripheral area of a firm’s vision and are typically ignored. The authors illustrate that many of the first signs of shift in the business environment can be noticed by scanning the periphery. They find that having narrow and deep focus is dangerous in a rapidly changing and increasingly interconnected environment. The key is said to be the development of capabilities for “rapid information processing, quick sense-making and fast refocusing, all with an open mind and high vigilance”. The activeness attribute refers to whether the scan is carried out through passive sensing or active seeking. In a passive mode, management keeps their antennae up and wait to receive signals. The limitation here is the antenna and its bias towards familiar information. Active scanning, on the other hand, is hypothesis-driven. By hypothesising about possible threats and opportunities companies who conduct active scanning, deploy resources internal and external to the firm to seek information.
Organising Processes

Organising is concerned with preparation of conditions (environment, mechanisms) as well as coordination of tasks and allocation and mobilisation of resources required for innovation (White and Bruton, 2007). Issues concerning the supportive environment, enabling mechanisms and resources required for innovation are discussed in the sections related to culture, structure and resource perspectives. The primary activity involved in coordination is managing dependencies between actors, tasks and resources. Actors include members of the project team as well as other stakeholders affected by the project (Gebhardt, 2005, Taatila et al., 2006). Actors take on various roles in the innovation projects. These include gatekeeper, scout, idea generator, developer, problem owner, champion, project leader, integrator, coach, ambassador, reorganiser and worker (Boer and During, 2001, Tomala and Sénéchal, 2004). Tasks and resources are allocated to the actors based on the roles they assume.

However, coordination becomes more complex when multiple projects are involved, and it appears that they are very common. Payne (1995) suggests that up to 90% of all projects occur in a multiple project context. Most of these projects take place in environments with limited resources, so effective sharing of project resource becomes critical. Traditionally the resource allocation issue was seen as a scheduling problem, which can be resolved with better scheduling, more progress reporting and more time spent reviewing projects (Engwall and Jerbrant, 2003). Platje et al. (1994) observe that the key to effective allocation of resources in a multiple project environment is to balance the interests of multiple participants. Engwall and Jerbrant (2003) report that this mix of competing for resources and personal and group interests, is a major cause of conflict in organisations, especially if there is no clear guideline with regards to project priorities. They report that some of the mechanisms causing the “resource allocation syndrome” are related to the company’s systems of costing and rewarding, as well as the opportunistic behaviour of some project managers.

Controlling Processes

These processes are concerned with defining and enforcing the criteria for making decisions with regards to selection and adoption of innovative solutions, as well as decisions regarding allocation of resources. The key drivers of innovation from a control perspective are discussed in the control section (see section 4.3.4).
4.3.1.4. Relational Model from the Process Perspective

Figure 4.6 shows the model which summarises the discussions provided so far about the main factors affecting innovation from the process perspective and their impact on success of innovation. Table 4.3 illustrates the details behind the effect of these factors on innovation.

![Figure 4.6 Innovation determinants from a process perspective](image)

### Table 4.3 Innovation determinants from a process perspective

<table>
<thead>
<tr>
<th>Process Dimension</th>
<th>Factor</th>
<th>Effect</th>
<th>Impact on Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solving</td>
<td>Problem definition</td>
<td>Systematic Soft and Hard</td>
<td>+ Appropriateness</td>
</tr>
<tr>
<td></td>
<td>Analysis</td>
<td>Fact based Root-cause analysis</td>
<td>+ Appropriateness</td>
</tr>
<tr>
<td></td>
<td>Find solutions</td>
<td>Focus on system constraints</td>
<td>= Creativity/Novelty</td>
</tr>
<tr>
<td>Internal diffusion</td>
<td>Communication</td>
<td>Persuasion</td>
<td>+ Appropriateness</td>
</tr>
<tr>
<td></td>
<td>Transparency</td>
<td>– Resistance to change</td>
<td>= Support for innovation</td>
</tr>
<tr>
<td></td>
<td>Appropriate Codification</td>
<td>– Resistance to change</td>
<td>= Support for innovation</td>
</tr>
<tr>
<td></td>
<td>Credibility</td>
<td>– Resistance to change</td>
<td>= Successful completion</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Diversity</td>
<td>+ Creativity/Novelty</td>
<td>= Support for innovation</td>
</tr>
<tr>
<td></td>
<td>Appropriateness</td>
<td>= Support for innovation</td>
<td>= Improved performance</td>
</tr>
<tr>
<td></td>
<td>Cooperation</td>
<td>+ Resource availability</td>
<td>= Support for innovation</td>
</tr>
<tr>
<td></td>
<td>Personal interaction</td>
<td>– Resistance to change</td>
<td>= Support for innovation</td>
</tr>
<tr>
<td></td>
<td>Politics</td>
<td>Political tactics</td>
<td>+ Support for innovation</td>
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<td></td>
<td>Project management</td>
<td>Planning</td>
<td>– Risk</td>
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<td></td>
<td>Flexibility</td>
<td>+ Risk</td>
<td>= Creativity/Novelty</td>
</tr>
<tr>
<td></td>
<td>Scanning</td>
<td>Breadth of search</td>
<td>+ Appropriateness</td>
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<td></td>
<td>Depth of search</td>
<td>+ Appropriateness</td>
<td>= Improved performance</td>
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<td></td>
<td>Active scanning</td>
<td>– Risk</td>
<td>= Support for innovation</td>
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<td></td>
<td>Organising</td>
<td>Task allocation</td>
<td>+ Resource availability</td>
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<td></td>
<td>Resource allocation</td>
<td>+ Resource availability</td>
<td>= Successful completion</td>
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<tr>
<td></td>
<td>Competition for resources</td>
<td>+ Conflict</td>
<td>= Successful completion</td>
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<tr>
<td></td>
<td>Opportunistic behaviour</td>
<td>– Conflict</td>
<td>= Successful completion</td>
</tr>
<tr>
<td></td>
<td>Clarity of priorities</td>
<td>= Conflict</td>
<td>= Successful completion</td>
</tr>
<tr>
<td></td>
<td>Appropriate reward system</td>
<td>– Conflict</td>
<td>= Successful completion</td>
</tr>
</tbody>
</table>

Note: (+) indicates a reinforcing effect and (–) represents a diminishing effect.
4.3.2. Structure view

The structure view of innovation is concerned with the arrangement of entities internal and external to the organisation and their relationship to one another with respect to flow of information and resources. The major entities which are discussed in the following sections are:

- Networks: structural relations with external entities,
- Organisation: structural relations with internal entities.

4.3.2.1. Networks

Networks and alliances of customers, suppliers, competitors and other non-market participants, such as financial institutes and universities are key enablers of innovation (Baum et al., 2000). These networks widen the firm’s opportunity and access to key resources such as funds, materials, labour, knowledge, information and other capabilities beyond its own (Gulati et al., 2000). They are also instrumental in creation of new knowledge and inimitable combination of resources that lead to more innovation (Swan et al., 2003, Gulati et al., 2000). Network structure plays a crucial role in how effective a firm can use the opportunities provided by its alliances (Zaheer and Bell, 2005). Research in this area indicates that three structural variables directly affect the innovation capability of firms (Ahuja et al., 2000, Brass et al., 2004, Capaldo, 2007). These are boundary openness, network ties and cohesiveness.

Boundary openness

Chesbrough (2004) reports that organisations are increasingly embracing the open innovation paradigm, by using internal resources to develop and implement external ideas as well as using external capabilities to take internally developed ideas to market. Research indicates that firms who are more open to external sources or search channels are more likely to have a higher level of innovative performance (Laursen and Salter, 2005, Maula et al., 2006). In fact, openness is becoming a prerequisite for firms that want to successfully innovate, in light of fierce competition and growing complexity in the business environment (Knudsen, 2007). However, Chesbrough (2004) argues that openness requires the firm to also share ideas, knowledge and resources with other entities. Lauresen and Slater (2006) point out that this creates a paradox between Appropriability and openness. Using a large-scale database of UK manufacturing firms, they examined the effect of Appropriability strategies on innovative performance. They reported that there is a curvilinear (taking an inverted U-shape)
relationship between extent of appropriability and innovative performance, indicating that some firms may suffer from a “myopia of protectiveness”, relying too heavily on appropriation to the detriment of other activities.

**Network ties**

Ahuja et al.’s (2000) longitudinal study of 97 firms in the global chemical industry revealed a direct correlation between the number of alliances a firm develops within a network and its innovation output. They argued that this correlation is mainly due to three main benefits that the increase in number of ties provides for a firm: knowledge sharing, complementarity and scale (Ahuja et al., 2000). While number of ties determine the size of the opportunity provided by the collaborative networks, the strength of the ties influence how effective a firm can use these opportunities. Researchers in this area classify inter-organisational relationships as being either strong or weak, based on three characteristics of the alliance: duration, frequency and intensity (Capaldo, 2007). The literature contains contradictory accounts of the effect of tie strength on business performance, with a number of studies promoting strong ties, while others endorsing firms to engage in more diverse yet weak inter-organisational relationships. Strong ties are said to be characterised by relational trust and mutual gain and reciprocity that grow through a history of interactions, thus providing organisations with access to high quality information and tacit knowledge as well as the ability to control the risks associated with the collaboration (Capaldo, 2007). On the other hand, weak ties are found to act as conduits for firms to access novel and diverse resources and information (Capaldo, 2007).

This has led a number of recent studies to reconcile these opposing viewpoints and search for the conditions under which various tie strengths may be beneficial to firms. Rowley et al.’s (2000) multi-industry study of collaborative networks finds the strong tie argument is credible when dealing with lower environmental uncertainty and a competitive environment demanding a high degree of exploitation, while the weak tie argument is valid especially within an uncertain environment, which demands more exploration into new innovations and alternative strategic directions. Capaldo (2007) proposes a dual network structure through which the firm is engaged in a large periphery of heterogeneous weak ties and a core of strong ties, thereby increasing both network size and diversity.
Cohesiveness

Another structural characteristic of networks that has been shown to influence the innovation capability of organisations is cohesiveness. Also known as network closure, cohesiveness is an indication of how much a firm’s alliance partners are interconnected amongst each other (Brass et al., 2004, Padula, 2008). Such interconnectedness is said to aid trust building and cooperation amongst the firms, thus creating a normative environment for knowledge sharing and recombination that leads to more innovation (Ahuja et al., 2000). However, as with the strength of network ties, there is an opposing view, which argues that cohesive contacts are likely to have similar information and therefore provide redundant information benefits (Burt, 2000).

The researchers supporting this viewpoint promote firms to position themselves in sparse alliance networks. They assert that the structural holes created due to the absence of strong ties amongst members of the network provide an opportunity to broker the flow of information and control the projects that bring together people from opposite sides of the hole (Burt, 2000). Sparse alliances are also found to break the tendency of cohesive alliances to produce redundancy, by exposing firms to novel and varied knowledge flows. In a recent study Padula (2008) reconciles these viewpoints by demonstrating that a dual alliance portfolio, made up of both sparse and cohesive structures, provides higher rates of innovation than those from either structure alone. She argues that a dual alliance portfolio assists the flow of new and diverse insights across the web of trusted and well-connected partners, making it possible for the knowledge recombination process that takes place across cohesive relationships to bear the fruits of innovation (Padula, 2008).

4.3.2.2. Organisation

Organisational structure in general determines the allocation of tasks, methods of reporting and information sharing, coordination, control and interaction. It affects innovation as it determines the link between individuals and their activities, as well as influencing the exchange of information and knowledge transfer amongst collaborative. Research in this area has identified a number of structural characteristics, such as centralisation, formalization and complexity, as determinants of innovation (Bernstein and Singh, 2006).

Structural centralisation refers to the spread of organisational decision-making. In a highly centralised organisation decisions are made within a small group of authoritative individuals,
whereas in a decentralised structure decision-making occurs across a range of levels within an organisation. Studies have shown that low levels of centralisation are more likely to encourage creativity (Leenders et al., 2003) as individuals feel more empowered and are exposed to more opinions and information. It is also found to assist adaptation to market needs, acquiring innovative input from stakeholders and avoiding long chains of command (Gebhardt, 2005). In contrast, high levels of centralisation have been associated with increased levels of control and decreasing levels of employee discretion and flexibility, thus hindering the creative process (Fiol, 1994). However, Gebhardt (2005) reports that centralisation helps achieve integration, stops redundancies, imposes control and sets standards. This makes centralised structures suitable for the latter stages of development and implementation, where more control and decisiveness are beneficial (Bernstein and Singh, 2006, Damanpour and Wischnevsky, 2006).

Formalization refers to a mechanistic orientation in organisations and is characterized by rigid guidelines that instil conformity among members, policies and methods. Similar to centralisation, formalisation has been found to affect innovation differently at various stages of the innovation process. By imposing procedures and boundaries forcing individuals to adopt mechanistic approaches to their work interactions, formalisation limits interaction opportunities and reduces flexibility, and hence hinders creativity alliances (Bonner et al., 2002). This makes formal structures unsuitable in the early stages of innovation (Bernstein and Singh, 2006). However, it has been reported that formalisation is necessary for effective and efficient processes at later stages of development and throughout the implementation stages of innovation (Bernstein and Singh, 2006, Damanpour and Wischnevsky, 2006).

Organisational complexity is defined as the amount of professionalism and differentiation in the organisation’s core processes and technologies, customers and markets, product lines, distribution networks, suppliers, or geographical locations (Dooley, 2002). It has been reported that organisational complexity positively influences the innovation potential of the firm. Damanpour (1996) associates this positive link to the depth and diversity of the knowledge base that exists in organisations with higher levels of functional differentiation and role specialisation. He asserts that such a rich and diverse knowledge base stimulates creativity and increases awareness and cross-fertilization of ideas, thus helping initiation of innovation. In a recent study Damanpour and Wischnevsky (2006) observe that complexity has a positive influence on initiation but not on implementation. They argue that the potential
conflict and diversity of values arising from complexity may lead to resistance in accepting the innovation, thus hindering the implementation process.

4.3.2.3 Relational Model from the Structure Perspective

Figure 4.7 shows the model that summarises the discussions provided so far about the main factors affecting innovation from the structure perspective and their impact on success of innovation. Table 4.4 illustrates the details behind the effect of these factors on the success of innovation.

Table 4.4 Innovation determinants from a structure perspective

<table>
<thead>
<tr>
<th>Structure dimension</th>
<th>Factor</th>
<th>Effect</th>
<th>Impact on Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
<td>Boundary openness</td>
<td>+ Risk, + Resource Availability, + Creativity/Novelty</td>
<td>– Successful completion, + Successful completion, + Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Number of ties</td>
<td>+ Resource Availability</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Strong ties</td>
<td>+ Resource Availability, – Risk</td>
<td>+ Successful completion, + Successful completion</td>
</tr>
<tr>
<td></td>
<td>Weak ties</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Cohesiveness</td>
<td>– Risk, – Creativity/Novelty</td>
<td>+ Successful completion, – Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Structural Holes</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td>Internal Structure</td>
<td>Centralisation</td>
<td>– Conflict, – Creativity/Novelty, – Motivation, + Efficiency</td>
<td>+ Successful completion, – Competitive advantage, – Successful completion, + Improved performance</td>
</tr>
<tr>
<td></td>
<td>Formalisation</td>
<td>+ Efficiency, – Motivation, – Creativity/Novelty</td>
<td>+ Improved performance, – Successful completion, – Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Complexity</td>
<td>+ Appropriateness, + Creativity/Novelty, + Resistance to change</td>
<td>+ Improved performance, + Competitive advantage, – Successful completion</td>
</tr>
</tbody>
</table>

Note: (+) indicates a reinforcing effect and (–) represents a diminishing effect.
4.3.3. Knowledge view

From the knowledge viewpoint, innovation is a process of knowledge creation (Swan et al., 2003). It involves exploitation of knowledge already known to the firm as well as the exploration of knowledge that is new to the firm. The role of the organisation in this context is to develop the conditions that would enable the knowledge creation process (Popadiuk and Choo, 2006). Management of knowledge thus becomes critical for successful innovation. Darroch (2003) has identified three components of knowledge management. These are knowledge acquisition, knowledge dissemination and responsiveness to knowledge. Firms that are capable in all three have been found to be more innovative (Darroch, 2005).

4.3.3.1. Knowledge acquisition

Acquiring knowledge involves seeking and discovering new knowledge. Researchers have identified three organisational aspects of knowledge acquisition as key determinants of innovation. These are source of knowledge, type of knowledge and absorptive capacity.

Source of Knowledge

The first of these determinants is the source of knowledge. Using organisational structures and processes, firms can influence and manage the sources of knowledge and information both internally and external to the firm. Amara and Landry’s (2005) survey study shows the source of knowledge used for the development of innovation is a determinant of the novelty of that innovation. They report that firms that have introduced innovation with higher degrees of novelty are more likely than other innovative firms to rely on a larger variety of internal sources of information to develop their innovative products or processes. They also find that increasing the number of different market sources of information used for innovation, decreases the likelihood of firms developing truly novel innovations. Similarly Frishammar and Hörte’s (2005) study of 206 manufacturing firms, reveals a negative relationship between innovation performance and relying too much on information from customers, suppliers and competitors. However, they report a significant positive association between scanning the technological sector of the external environment and the innovation performance of the firm.

Knowledge Type

The second innovation determinant is reported to be the type of knowledge that is acquired. By recognizing various forms of knowledge and the learning processes associated with them,
organisations can put in place structures and processes that help the acquisition of the appropriate type of knowledge for the type of innovation the firm seeks. Knowledge is generally classified as either tacit or explicit. Tacit knowledge is based on experience, thinking and feelings, is contextual and is composed of both cognitive and technical components. The cognitive components refer to mental models, maps, beliefs, paradigms, and viewpoints, while the technical components refer to specific contextual know-how and skills. The explicit dimension of knowledge is codified, articulated and communicated using symbols. Explicit knowledge is object-based when codified in words, numbers, formulas, or made tangible as equipment, documents or models. It is regarded as rule-based when it is encoded as rules, routines, or standards (Popadiuk and Choo, 2006).

Jensen et al. (2007) identify two types of innovation based on the forms of knowledge and learning processes used to develop the innovation. First is scientific innovation that is based on the production and usage of explicit scientific and technical knowledge. The learning process that uses this form of knowledge is through studying or observation. The second type is innovation through doing-using-interchanging. This is a more practical type of innovation, which relies on tacit knowledge acquired through informal processes of learning and experiential observation. The authors report that firms who combine the two types of innovation outperform those who rely on only one.

**Absorptive capacity**

The third determinant of innovation and knowledge acquisition is the firm’s absorptive capacity which can be defined as the existing organisational knowledge base. It has been found critical in determining the firm’s ability to be receptive to external signals (Cohen and Levinthal, 1990). Jantunen (2005) reports that accumulated prior knowledge enhances the acquisition of new knowledge, so long as it is related to the existing knowledge base. However, the existing knowledge base may act as a filter dissuading the firm from pursuing and acquiring new knowledge if it cannot be linked with the existing cognitive frameworks. He argues that this can potentially be problematic as some organisations fall into a competency trap, making them resistant to recognising the need to renew their capabilities in order to match the requirements of changing markets.
4.3.3.2. Knowledge dissemination

Dissemination of knowledge in the organisation is concerned with flow and absorption of knowledge, which occurs when knowledge that exists internal or external to the firm, is learned by individuals within the organisation (Peri, 2005). Three factors have been found to affect knowledge dissemination: knowledge type, integration and technology.

Knowledge Type

In their influential book Nonaka and Takeushi (1995) assert that knowledge flows in the organisation and absorbed through the conversion and interaction between its tacit and explicit components. They identify four modes of knowledge conversion:

- socialization – from tacit to tacit,
- externalization – from tacit to explicit,
- combination – from explicit to explicit, and
- internalization – from explicit to tacit.

Furthermore, Popadiuk and Choo (2006) observe that organisations innovate through exploration of new knowledge or exploitation of existing knowledge. Exploration occurs when organisations acquire knowledge that differs fundamentally from the existing insights (Liao et al., 2008), and is predominantly concerned with the creation and use of tacit knowledge through the processes of socialization and externalization (Popadiuk and Choo, 2006). On the other hand, exploitation is found to be concerned with acquisition of new knowledge framed within existing insights (Liao et al., 2008) and involves conversion of explicit knowledge through the processes of combination and internalization (Popadiuk and Choo, 2006).

Integration

A key organisational characteristic that aids the knowledge conversion processes, is organisational integration. It has been suggested that integration is a two-dimensional construct representing a structural and a cultural dimension (Lemon and Sahota, 2004). The structural dimension is referred to as interaction, representing the formally coordinated activities between functional departments and includes meetings, memoranda and flow of standard documentation. The cultural dimension is described as collaboration, representing the more unstructured affective nature of interdepartmental relationships and emphasises continuity of relationship between departments rather than just transactions.
Another organisational determinant of knowledge dissemination, and thus innovation, is technology. Du Plessis (2007) argues that knowledge management technology, and specifically IT, helps innovation by

- assisting in creating tools, platforms and processes for tacit knowledge creation, sharing and leveraging in the organisation,
- providing the platform for conversion of tacit to explicit knowledge,
- aiding collaboration across inter and intra-organisational boundaries,
- ensuring availability and accessibility of both tacit and explicit knowledge,
- ensuring integration of the organisation’s knowledge base,
- assisting in identifying gaps in the knowledge base,
- assisting in building skills and competencies required for the innovation,
- structuring knowledge in a way that provides context to the knowledge base,
- enabling steady growth of the knowledge base through gathering and capturing tacit and explicit forms of knowledge,
- providing a knowledge driven culture.

### 4.3.3.3. Knowledge Responsiveness

Responsiveness to knowledge means that the organisation responds to the various types of knowledge it has acquired by taking new actions or making changes to existing practices according to the new information. The main organisational characteristic that determines knowledge responsiveness is agility. Bullinger (1999) defines agility as mobility in an organisation’s behaviour towards the environment. Bessant et al. (2001) asserts that there are for dimensions to agility: strategy, process, linkages and people. Dove (1999) identifies change proficiency as a key capability for agile organisations. He presents a change proficiency maturity model, which defines multiple stages of change proficiency in an organisation. The accidental stage includes companies in which change does not occur as an intentional result of response to newly-acquired knowledge, but rather as an accident. Slightly more change-proficient companies fall under the repeatable stage, in which change occurs based on conceptual knowledge and past experiences of change initiatives. The defined stage, on the other hand, is characterized by set procedures that are employed to use the newly acquired knowledge. The next stage is referred to as managed, and describes organisations
who have gone beyond defining procedures and have set up structures, responsibilities and processes to manage the response to the new knowledge. Finally, the mastered stage of change proficiency consists of firms that have developed a culture of knowledge and learning, backed by capabilities that enable them to incorporate acquisition and use of new knowledge as a way of managing their businesses.

4.3.3.4 Relational Model from the Knowledge Perspective

Figure 4.8 shows the model which summarises the discussions provided so far about the main factors affecting innovation from the knowledge perspective and their impact on success of innovation. Table 4.5 illustrates the details behind the effect of these factors on the success of innovation.

Table 4.5 Innovation determinants from a knowledge perspective

<table>
<thead>
<tr>
<th>Knowledge dimensions</th>
<th>Factor</th>
<th>Effect</th>
<th>Impact on Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition</td>
<td>Source</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Market</td>
<td>– Creativity/Novelty</td>
<td>– Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Internal</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Technology providers</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Tacit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Explicit</td>
<td>+ Exploitation</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td>Tacit</td>
<td>+ Exploration</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td>Absorptive capacity</td>
<td>Absorptive capacity</td>
<td>– Creativity/Novelty</td>
<td>– Competitive advantage</td>
</tr>
<tr>
<td>Dissemination</td>
<td>Integration</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interaction</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Collaboration</td>
<td>– Resistance to change</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Pressure</td>
<td>+ Creativity/Novelty</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td>Knowledge management</td>
<td>Technology</td>
<td>+ Resource availability</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>– Risk</td>
<td></td>
<td>+ Successful completion</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Responsiveness</td>
<td></td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Agility</td>
<td>+ Responsiveness</td>
<td>+ Competitive advantage</td>
</tr>
</tbody>
</table>

Note: (+) indicates a reinforcing effect and (–) represents a diminishing effect.
4.3.4. Control view

Control view of innovation is concerned with innovation decisions, the factors influencing them and the mechanisms employed to make them. Innovation, by nature, brings about change in the organisation. It also introduces some level of novelty to the firm, and is often complex in itself or its application. This combination of change, complexity and novelty leads to uncertainty about the probability of success of the innovation. Given that the innovation process - from idea generation to development and implementation - requires significant investment in resources, the inherent uncertainty about the outcomes of the innovation creates risk. Thus, throughout the innovation process, decisions have to be made about whether the project should continue (i.e. commit more resources), permanently stop (i.e. divert resources to other projects), be placed on hold (i.e. commit more resources when the conditions are right), or be modified (i.e. commit more resources to re-iterate parts of the process) (Schmidt, 2005). Decisions also have to be made throughout the innovation process, with regards to selection of appropriate solutions.

To impose control on the innovation process is, therefore, to define and enforce the criteria for making the required decisions. Simons (1995) contends that these criteria are set by influencing three levers of control. These are:

- Core values – the belief system,
- Risk – the boundary system,
- Critical variables and outcomes – the feedback and measurement system.

The mechanism to control core values is through culture. Core values embedded in culture narrow the range of possible actions thought about and, ultimately, undertaken by groups and individuals within the organisation (Herzog, 2008). Given that these values are the least accessible aspect of culture, control is exercised on these values indirectly by managing the organisational norms and practices (see Figure 4.9). Since shared values are generated and re-enforced through repetition of certain norms and practices, standardisation is used to control the consistency of these norms and practices. For instance, introducing routines such as 5S generates shared values about quality, or implementing policies on recycling waste creates core values in the area of sustainability.
The main mechanism for controlling the boundary system of innovation is planning. Plans map out an agreed and acceptable path of reducing uncertainty through development and acquiring new knowledge. They also set boundaries for acceptable use of resources. Mumford et al. (2008) state that planning is a viable response to uncertainty and resource scarcity.

Finally, critical variables and outcomes can be controlled by employing process control mechanisms, such as controlling the input, activities and the outputs of the process. Cardinal (2001) states that input control can be about resource allocation and regulating the antecedent conditions of performance. This, for example, could take the form of budgets and staff allocation. Cardinal (2001) also reports that activities are controlled by standard procedures and routines. For instance, many companies have developed standard problem solving procedures and innovation roadmaps. By controlling the activities the company reduces variation and consequently improve the predictability of behaviour and outcome.

On the other hand, Scozzi and Garavelli (2005) have found that outputs along the innovation process are controlled by defining multiple criteria (feasibility, cost, time, etc) and setting appropriate targets. They report the innovation task is made more difficult because these criteria are often uncertain (not all the information necessary to rate options is available) and ambiguous (information can be misunderstood; priorities and criteria to rate options are not clear or well defined). A very common innovation output control mechanism is the implementation of Stage Gates (Schmidt, 2005). In this approach, the innovation process is divided into a number of stages that are separated by gates. Each gate is a review or decision point where managers determine whether or not to proceed to the next stage.
Analysis of literature in the areas of management control systems and innovation management has resulted in identification of a number of key characteristics of control mechanisms that influence the success or failure of innovation. These are style, flexibility and autonomy.

4.3.4.1. Style of control

Style refers to how the management of the organisation use the control mechanisms. Simons (1995) was first to point out that how management control systems were used was as important as whether they were used. He identified two main styles of use, namely diagnostic and interactive. Diagnostic systems are mechanistic, traditional control approaches of monitoring, assessing and rewarding/punishing. They are typically concerned with critical variables and can be represented by negative feedback loop, where the difference between the desired and actual output is used to adjust the inputs and activities of a process. The diagnostic approach is based on the following underlying assumptions:

- the right set of variables have been selected,
- the relationships between variables are well understood,
- the variables can be accurately and objectively measured,
- accurate data is available in a timely fashion,
- appropriate targets have been set,
- the variables have been correctly prioritised.

Given that innovation is by definition accompanied with some degree of novelty and uncertainty, especially at its earlier stages, the validity of these assumptions can be questioned in the context of the innovation process. This results in potentially incorrect decisions as well as encouraging undesirable behaviours to influence the decision, such as building slacks in targets, playing the system to increase reward, smoothing and adjusting the data, biased reporting towards favourable information and breaking of legal and moral rules to influence the measure (Simons, 1995). Furthermore, it has been found that applying the diagnostic approach to the uncertain stages of the innovation process may constrain cross-functional interaction, limit communication to established patterns, penalise deviation and diffuse leadership (Davilla, 2009).
On the other hand, interactive style of control is organic, constructive and learning oriented, encouraging development of new ideas and strategies (Simons, 1995). This approach focuses on strategic uncertainties and allows top management to guide the search stage of the innovation process. It emphasises the constantly changing nature of information that top level managers consider to be of strategic importance. Interactive systems are found to be best suited for the front end of the innovation process, as they address uncertainty (Davilla, 2009).

In a recent study, Bisbe & Otley (2004) found that the interactive approach enhances innovation by providing guidance for search, triggering and stimulus of initiatives, and giving legitimacy to autonomous initiatives. They also report that interactive style of control moderates the effect of innovation on business performance by providing direction, integration and fine-tuning. However, they warn that in complex and dynamic settings, such as those of highly innovative firms, this style of control may result in filtering out of initiatives by sharing and exposure of ideas at an early stage.

4.3.4.2. Flexibility of control

Another characteristic of control mechanisms that affects innovation is flexibility. Georgsdottir and Getz (2004) define flexibility as the capacity to change and to adapt to a challenging environment. Davila et al. (2009) states that control systems should be flexible and dynamic to be adapting and evolving to the unpredictability of innovation. However, Benner and Tushman (2002) find that many organisations, in their desire to improve efficiency and speed of the innovation process, sacrifice flexibility. This is based on the notion that evaluation criteria that are not formally applied or strictly enforced lead to confusion, ambiguity and poor evaluation (Schmidt, 2005). Consequently, in their desire to impose control, managers increase rigour and rigidity of the control system. Sethi and Iqbal (2008) define rigour as strict enforcement, objectivity and frequency of application of the decision criteria. They report that making the evaluation process and enforcement of decision criteria overly rigorous may force the innovation team to commit too early to specific criteria without being certain about meeting those criteria. This forced commitment directly influences ideas generated and choices made by the team and significantly reduces the team’s flexibility to acquire and process new information and integrate it into the project and make changes to the project plan. As a result, the authors contend that emphasis on rigour increases learning failure in the innovation team.
Rigidity, too, can negatively influence innovation. Grandori (2006) defines rigidity of control as the degree of detail in the specification of the control mechanism. Based on this definition, rigidity reduces the number of choices and paths that can be explored during the innovation process. This is in direct contrast to the divergent nature of the creative processes at the early stages of innovation. In fact, research indicates that the “fuzzy front end” of innovation requires disorder, emergence and improvisations (Koch and Leitner, 2008). Thus applying rigid controls early on in the innovation process is not desirable. Instead, control can be imposed flexibly by setting integrative strategic themes, which guide the creative process in line with strategic objectives and promote emergence of cross-project synergies (Mumford et al., 2008). However, as innovation progresses towards development and implementation, divergence is no longer desirable. In such circumstances rigidity of control has been found beneficial (Bernstein and Singh, 2006).

4.3.4.3. Autonomy

Another characteristic of control mechanisms that affects innovation is centralisation. Centralisation refers to the spread of organisational decision-making. In a highly centralised control system, decisions are made within a small group of authoritative individuals, whereas in a decentralised structure, decision-making occurs across a range of levels within an organisation. Centralisation has been associated with increased levels of control and decreasing levels of employee discretion and flexibility, thus hindering the creative process (Fiol, 1994). However, Gebhardt (2005) reports that centralisation helps achieve integration, stops redundancies, imposes control and sets standards. This makes centralised control mechanisms suitable for the latter stages of development and implementation, where more control and decisiveness are beneficial (Bernstein and Singh, 2006). On the other hand, studies have shown that low levels of centralisation are more likely to encourage creativity (Leenders et al., 2003) as individuals feel more empowered and are exposed to more opinions and information.

Furthermore, a recent study indicates that even in organisations where centralised controls are in place, in the early stages of the innovation process, decisions are made outside the organisationally defined teams and formal processes (Koch and Leitner, 2008). Using complex systems analysis, the authors demonstrate that a high degree of self-organisation is prevalent during the “fuzzy front end” of the innovation process. Self-organisation is defined as the emergence of new structures, patterns and properties from within the system (Koch and
Leitner, 2008). It has been found to aid the success of innovation by resulting in the formation of strong self-managing teams with the ability to overcome internal organisational barriers (Koch and Leitner, 2008).

**4.3.4.4. Relational Model from the Control Perspective**

Figure 4.10 shows the model which summarises the discussions provided so far about the main factors affecting innovation from the control perspective and their impact on success of innovation. Table 4.6 illustrates the details behind the effect of these factors on the success of innovation.

![Figure 4.10 Innovation determinants from a control perspective](image)

**Table 4.6 Innovation determinants from a control perspective**

<table>
<thead>
<tr>
<th>Control dimension</th>
<th>Factor</th>
<th>Effect</th>
<th>Impact on Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Style</strong></td>
<td>Diagnostic</td>
<td>- Risk</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>- Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Efficiency</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td>Interactive</td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
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<tr>
<td></td>
<td></td>
<td>- Risk</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>Lack of Rigour</td>
<td>- Efficiency</td>
<td>- Improved performance</td>
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<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>- Competitive advantage</td>
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<tr>
<td></td>
<td></td>
<td>+ Risk</td>
<td>- Successful completion</td>
</tr>
<tr>
<td></td>
<td>Lack of Rigidity</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Risk</td>
<td>- Successful completion</td>
</tr>
<tr>
<td><strong>Autonomy</strong></td>
<td>Centralisation</td>
<td>+ Efficiency</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Creativity/Novelty</td>
<td>- Competitive advantage</td>
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<tr>
<td></td>
<td></td>
<td>- Motivation</td>
<td>- Successful completion</td>
</tr>
<tr>
<td></td>
<td>Self-organisation</td>
<td>- Efficiency</td>
<td>+ Improved performance</td>
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<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
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<tr>
<td></td>
<td></td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
</tr>
</tbody>
</table>

Note: (+) indicates a reinforcing effect and (−) represents a diminishing effect.
4.3.5. Culture view

The innovation literature identifies organisational culture as a critical determinant of successful innovation (Hult et al., 2004). Culture is concerned with norms, values, meaning, symbols and rituals shared by members of the organisation, describing “how things are done” (Martins and Terblanche, 2003). A commonly-used definition of culture has been provided by Schein (1985) who defines culture as a "pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems". The literature in the area of culture and innovation can be categorised into three groups: typologies, characteristics and climate.

4.3.5.1. Culture typologies

The first group is a body of research that has focused on typologies of corporate culture. Literature in this area often refers to the typologies described by Quinn and Rohrbaugh (1983) in their competing values framework. As illustrated in Figure 4.11 it consists of two competing cultural dimensions. The horizontal dimension maps the degree to which the organisation focuses inwards or outwards, and the vertical dimension determines whether the organisational culture is organic or mechanistic.

![Figure 4.11 Typologies of organisational culture (Cameron et al., 2006)]
The framework outlines four cultural typologies depending on the position relative to these two dimensions. These are called Clan, Adhocracy, Market and Hierarchy. Herzog (2008) contends that the adhocracy typology indicates the characteristics of an "innovation-supportive culture". Dasanayaka (2006) provides empirical support for this claim, and demonstrates that the market typology is also supportive of innovative behaviour.

Cameron et al. (2006), however, state that all the culture typologies can be supportive of innovation so long as it is the right type of innovation. The authors introduce two secondary diagonal axes to the competing values framework, one of speed and the other of magnitude. They observe that companies operating under the clan typology take part in more long-term collaborative innovation projects while the hierarchy-oriented companies conduct controlled incremental innovation projects. They also find that those firms classified with adhocracy culture undertake more transformational styles of innovation. Finally, the market culture type is found to support innovative projects that bring about fast change.

4.3.5.2. Characteristics of Innovative Culture
The second group of studies conducted on the subject of culture and innovation, have focused on specific characteristics of cultures supportive of innovation. A number of studies have identified a firm’s external orientation as a cultural dimension which influences innovation (Hult et al., 2004). This refers to the extent to which the firm is aware of and acts upon the changes and opportunities in its external environment and entities such as customers, competitors and suppliers. Narver et al. (2004) contend that having a proactive market orientation leads to "deeper insight into customer needs and thus to the development of innovative products and services". Baker and Sinkula (2007) find that a strong market orientation helps create a balance between incremental and radical innovation by shifting the firm’s innovation priority more towards radical innovation activities.

Culture is also found to be a critical influence on creativity in organisations. A culture supportive of innovation encourages innovative ways of representing problems, and finding solutions (Martins and Terblanche, 2003). It encourages risk taking and views creativity as both desirable and normal (Woodman et al., 1993). This, however, requires an organisational culture that encourages experimentation, tolerates mistakes and fosters learning from failure (Herzog, 2008). Furthermore, organisational culture influences the way change is viewed and reacted to within the firm. This is particularly important for innovation, as innovation by
nature brings about change. Every change not only disturbs the stability gained through previous rationalisations, but also is a disturbance for the social settings of the organisation (Pohlmann, 2005). Therefore, a culture supportive of innovation must manifest shared values, norms and routines that embrace change and support the disseminiation of change across the organisation.

4.3.5.3 Climate
The third group of studies have focused on the concept of organisational climate. Climate may be most accurately understood as a manifestation of culture (Reichers and Schneider, 1990). While culture represents the basic values and assumptions that underlie the firm’s policies, practices and procedures, climate refers to organisation members’ perceptions of those policies, practices and procedures. Schneider et al. (1996) identify four dimensions for innovative organisational climate. These are the nature of interpersonal relationships, the nature of the hierarchy, the nature of work and the focus of support and rewards.

Isakson and Ekvall (2006) present a more detailed framework referred to as SOQ (Situational Outlook Questionnaire). SOQ is a climate assessment tool based on nine key factors, which the authors have demonstrated in a number of studies to successfully distinguish between innovative and non-innovative organisations (Ekvall, 1996, Isaksen and Lauer, 2001). These key factors are:

- Challenge/Involvement: the degree to which people find meaning in their work and are involved in setting long-term goals and visions.
- Freedom: the level of independence in behaviour demonstrated by the people.
- Trust/Openness: the degree of emotional safety in interpersonal relationships.
- Idea-time: the amount of time people have for working on new ideas.
- Conflict: the presence of personal and emotional tension in the organisation.
- Idea-support: the manner in which new ideas are treated and the extent to which new initiatives are encouraged.
- Debate: the manner in which opposing views and disagreements are handled.
- Risk-taking: the degree of tolerance for uncertainty and ambiguity.
West and Richter (2008), also present a number of factors they refer to as “group climate factors for innovation”. Based on a comprehensive synthesis of theory in the area of innovation implementation in work groups (De Dreu, 2002, West, 2002), these factors are:

- Commitment to group vision
- Participation in decision-making
- Minority dissent
- Supporting innovation
- Intra-group safety and trust
- Reflexivity

A number of studies have identified leadership as the most influential factor affecting the organisational climate (Amabile et al., 2004, Isaksen, 2007). Research in the area of leadership and innovation can be categorised into three groups: traits, styles and behaviour. Studies have shown that successful implementation of strategic innovation is largely dependent on personal qualities and skills of the project leader (Minarro-Viseras et al., 2005, Peterson et al., 2003). Zaccaro (2007) argues that effective leaders possess an integrated set of cognitive capacities (e.g. general intelligence, cognitive complexity, creativity, problem solving), social capabilities (e.g. social and emotional intelligence, persuasiveness, negotiation skills) and dispositional qualities (e.g. adaptability, extroversion, risk propensity, openness). Sternberg and Vroom (2002) argue that the attributes and skills that leaders must demonstrate vary widely across different situations. In the context of innovation this means that at various stages of the innovation process different sets of skills and attributes are desirable.

Deschamps (2005) argues along similar lines, stating that leadership traits vary depending on the situations at the “front-end” and “back-end” of the innovation process. He also contends that different approaches to innovation management (top-down or bottom-up) require varying cognitive and social capabilities from the leader. A large body of literature also covers leadership styles and their effect on innovation. Participative or empowerment style of leadership has been found to positively influence employee’s innovative behaviour (Somech, 2006). Oke et al. (2009) studied the suitability of transformational and transactional styles of leadership on the innovation process. They concluded that transformational leadership (charisma, idealised influence, inspirational motivation, intellectual stimulation,
individualised consideration) fosters creativity and is more suited to exploratory innovation activities. This is supported by Kahai et al. (2003) and Shin and Zhou (2003). Oke et al. (2009) also find that transactional leadership (coordinating activities, clarifying expectations, establishing rewards, managing by exception) are more appropriate for exploitative activities and the implementation stage of the innovation process.

However, the research in the area of leadership behaviours and their effects on innovation seem to be scarce. One recent study conducted by de Jong and Hartog (2007) identifies a number of leader behaviours critical to successful innovation. These are role-modelling, intellectual stimulation, providing vision, knowledge diffusion, consulting, delegating, supporting, acquiring feedback, recognising, rewarding, providing resources, monitoring and assigning tasks.

4.3.5.4. Relational Model from the Culture Perspective
Figure 4.12 shows the model which summarises the discussions provided so far about the main factors affecting innovation from the culture perspective and their impact on success of innovation. Table 4.7 illustrates the details behind the effect of these factors on the success of innovation.

![Figure 4.12 Innovation determinants from a culture perspective](image-url)
<table>
<thead>
<tr>
<th>Culture dimension</th>
<th>Factor</th>
<th>Effect</th>
<th>Impact on Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orientation</strong></td>
<td>Organic</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Mechanistic</td>
<td>- Creativity/Novelty</td>
<td>- Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Internal</td>
<td>- Responsiveness</td>
<td>- Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>+ Responsiveness</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td><strong>Norms and Values</strong></td>
<td>Experimentation</td>
<td>+ Risk</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
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<tr>
<td></td>
<td></td>
<td>- Efficiency</td>
<td>- Improved performance</td>
</tr>
<tr>
<td></td>
<td>Tolerance for mistakes</td>
<td>+ Risk</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
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<tr>
<td></td>
<td></td>
<td>- Efficiency</td>
<td>- Improved performance</td>
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<tr>
<td></td>
<td>Embracing change</td>
<td>- Resistance to change</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td>Challenge/Involvement</td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Freedom/Independence</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Trust/Openness</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>+ Collaboration</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Idea–time</td>
<td>- Efficiency</td>
<td>- Improved performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Conflict</td>
<td>- Motivation</td>
<td>- Successful completion</td>
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<tr>
<td></td>
<td></td>
<td>- Collaboration</td>
<td>- Successful completion</td>
</tr>
<tr>
<td></td>
<td>Idea–support</td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
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<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
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<tr>
<td></td>
<td>Debate</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
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<td></td>
<td></td>
<td>+ Collaboration</td>
<td>+ Improved performance</td>
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<td></td>
<td>Risk taking</td>
<td>+ Risk</td>
<td>+ Successful completion</td>
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<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
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<td></td>
<td></td>
<td>- Efficiency</td>
<td>- Improved performance</td>
</tr>
<tr>
<td></td>
<td>Commitment to vision</td>
<td>- Resistance to change</td>
<td>+ Successful completion</td>
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<td></td>
<td></td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td><strong>Leadership traits</strong></td>
<td>Cognitive capacity</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Social capability</td>
<td>Resistance to change</td>
<td>+ Successful completion</td>
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<td></td>
<td></td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
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<td></td>
<td></td>
<td>+ Collaboration</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Dispositional qualities</td>
<td>+ Risk</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td><strong>Leadership styles</strong></td>
<td>Participative</td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
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<tr>
<td></td>
<td>Transformational</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
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<td></td>
<td></td>
<td>+ Exploration</td>
<td>+ Competitive advantage</td>
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<td></td>
<td>Transactional</td>
<td>+ Exploitation</td>
<td>+ Improved performance</td>
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<tr>
<td></td>
<td></td>
<td>+ Efficiency</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td><strong>Leadership behaviour</strong></td>
<td>Innovation role modelling</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Intellectual stimulation</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Providing vision</td>
<td>+ Responsiveness</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Knowledge diffusion</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Risk</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Consulting</td>
<td>+ Collaboration</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Delegating</td>
<td>+ Collaboration</td>
<td>+ Successful completion</td>
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<tr>
<td></td>
<td>Supporting</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
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<td></td>
<td></td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
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<tr>
<td></td>
<td>Acquiring feedback</td>
<td>+ Appropriateness</td>
<td>+ Improved performance</td>
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<tr>
<td></td>
<td>Recognising</td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
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<td></td>
<td>Rewarding</td>
<td>+ Motivation</td>
<td>+ Successful completion</td>
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<tr>
<td></td>
<td>Providing resources</td>
<td>+ Resource availability</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>+ Efficiency</td>
<td>+ Improved performance</td>
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<td></td>
<td></td>
<td>+ Planning</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Assigning tasks</td>
<td>+ Resource availability</td>
<td>+ Successful completion</td>
</tr>
</tbody>
</table>

Note: (+) indicates a reinforcing effect and (–) represents a diminishing effect.
4.3.6. Resources view

Resources are essential for successful innovation. They are used by firms to develop and deliver innovative products and processes. Resources include tangible and intangible assets controlled by the firm. There are also organisational resources, which are referred to as capabilities. They define the firm’s capacity to deploy and co-ordinate other resources (Kostopoulos et al., 2002). Based on this understanding of resources, system and process innovation can be viewed as a newly acquired capability or resource in itself. Analysis of relevant literature in the area of resources and innovation leads to three groups of factors that impact successful innovation. These are,

- resource attributes,
- resource availability, and
- dynamic capabilities.

4.3.6.1. Resource attributes

In an influential study, Barney (1991) identifies four key characteristics of an innovative resource that results in competitive advantage. He states that, for a firm’s resource to lead to competitive advantage, it must be

- Valuable: it must exploit opportunities and/or neutralise threats,
- Rare: it must be rare with respect to current and potential competitors,
- Imperfectly imitable: it must be either path dependent, or causally ambiguous.
- Un-substitutable: it must be without equivalent substitutes in or out of the firm.

A number of recent studies have confirmed these characteristics and have added the need for complementarity of the innovative resource with other capabilities of the firm (Herzog, 2008, Liao et al., 2009).

4.3.6.2. Resource availability

A sizeable body of literature has explored the resource requirements of innovation. Studies have shown that the availability of tangible resources such as time, labour, coded knowledge, skills, patents, brands, technology and money are required for successful innovation (Anderson and Vastag, 2004, Kostopoulos et al., 2002, Pohlmann, 2005). While these studies focus on what resources are required for innovation, a number of researchers have analysed the effect of the amount of resources on innovation (Chiu and Liaw, 2009, Greiger and
Cashen, 2002, Nohria and Gulati, 1996). They demonstrate that excessive level of available and recoverable resources, known as slack, has an inverse U-shaped relationship with innovation. In other words, both too much and too little slack may be detrimental to innovation. These studies report that, while slack fosters greater experimentation and risk-taking, it also diminishes discipline and creates a relaxed environment encouraging managers to neglect innovation efforts.

However, literature also points to situations where scarcity of resources has led to innovative developments. Baker and Nelson’s (2005) study of 29 resource-constrained firms showed that they often “created something out of nothing” by engaging in entrepreneurial bricolage and exploiting physical, social and institutional resources that other firms rejected or ignored. Katila and Shane (2005) argue that whether scarcity of resources enables or disables innovation depends on the environmental context within which the firm operates. They find that resource-constrained firms that operate in competitive and small markets, and in environments that do not demand extensive production assets, outperform the more established firms with slack resources. Furthermore, Hoegl et al. (2008) report that scarcity of resources enables rather than inhibits innovation, when the project objective is engaging and the innovation team possesses characteristics such as bounded creativity, leveraging domain-relevant skills, team potency and cohesion.

4.3.6.3. Dynamic capabilities
A number of studies point out that of resource availability is necessary but not sufficient conditions for successful innovation (Herzog, 2008, Darroch, 2005, Tarafdar and Gordon, 2007, Liao et al., 2009). What is essential and of critical importance for firms to engage in innovation is their ability to use and transform such resources into innovation. Teece and Pisano (1994) argued that, given the rapidly changing environments within which firms operate, in order to successfully use and transform resources into competitive advantage, organisations must develop dynamic capabilities.

Dynamic capability is defined as the ability to integrate, build and reconfigure internal and external competencies to exploit environmental opportunities and maintain a dynamic fit between its internal working and its external environment (Teece and Pisano, 1994). These include capabilities such as new product/process development, brokering, co-evolving, patching, knowledge creation and learning, networking, sensing and responding and

4.3.6.4. Relational Model from the Resource Perspective

Figure 4.13 shows the model which summarises the discussions provided so far about the main factors affecting innovation from the resource perspective and their impact on success of innovation. Table 4.8 illustrates the details behind the effect of these factors on the success of innovation.

![Figure 4.13 Innovation determinants from a resource perspective](image-url)
### Table 4.8 Innovation determinants from a resource perspective

<table>
<thead>
<tr>
<th>Resource dimension</th>
<th>Factor</th>
<th>Effect</th>
<th>Impact on Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
<td>Complementary Value</td>
<td>+ Exploitation</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td>Rare</td>
<td>+ Exploitation</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td>Imperfectly Imitable</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Un-substitutable</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Resource availability</td>
<td>+ Improved performance</td>
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<tr>
<td></td>
<td></td>
<td>+ Resource availability</td>
<td>+ Improved performance</td>
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<td></td>
<td></td>
<td>+ Resource availability</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td>Availability</td>
<td>Knowledge/Skills/Expertise</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Finance</td>
<td>+ Resource availability</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Human resources</td>
<td>+ Resource availability</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td>+ Creativity/Novelty</td>
<td>+ Improved performance</td>
</tr>
<tr>
<td></td>
<td>Slack</td>
<td>+ Creativity/Novelty</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Resource availability</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Resource availability</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Scarcity</td>
<td>− Resource availability</td>
<td>− Successful completion</td>
</tr>
<tr>
<td>Dynamic Capability</td>
<td>Resource Acquisition</td>
<td>+ Resource Availability</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Resource Reconfiguration</td>
<td>+ Resource Availability</td>
<td>+ Successful completion</td>
</tr>
<tr>
<td></td>
<td>Learning and Sense-making</td>
<td>+ Responsiveness</td>
<td>+ Competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Strategic aligning</td>
<td>+ Responsiveness</td>
<td>+ Competitive advantage</td>
</tr>
</tbody>
</table>

Note: (+) indicates a reinforcing effect and (−) represents a diminishing effect

### 4.4. Consolidated Model

So far, the large body of literature related to management of innovation has been analysed from six viewpoints of process, structure, knowledge, control, culture and resources. The analysis was carried out with the aim identifying key factors affecting innovation from each specific viewpoint and the nature of their impact on successful innovation. This was then followed by a synthesis process, which resulted in construction of models for each perspective, illustrating the relationship between these factors and various aspects of successful innovation. Each model was also accompanied with a table providing a higher degree of detail about the factors and their impact on innovation.

In order to consolidate these models, the purpose of the modelling exercise must first be ascertained. Creating a much larger relational diagram containing all the factors identified so far, is not beneficial as it does not provide any new information or insight. In fact, it makes the model much less useful by significantly increasing its complexity. The main purpose behind creation of this model was to use it to better understand the dynamics that govern innovation in SMEs. Innovation is a complex and ambiguous organisational phenomenon. For the model to be useful it must therefore help reduce the level of complexity when analysing innovation.
The multiple-view approach provides the appropriate framework for reducing complexity. Analysing innovation from the single perspective of a specific viewpoint, allows for a structured and simple approach to understanding innovation from that viewpoint. The relational model constructed for each viewpoint can be used as a structured innovation assessment tool used to identify the key drivers of innovation from a single viewpoint at a time. A comprehensive understanding of innovation as it takes place in the organisational context is therefore achieved by mentally combining the understanding gained from each single-view analysis. In this way, the consolidated model acts as a six-sided prism, with each side of the prism representing one viewpoint (see Figure 4.14). It is through the use of this six-sided prism which innovation is holistically and comprehensively analysed and understood. Figure 4.15 shows a flattened version of the prism.

In chapter 6, this model will be used to systematically analyse two case studies of system and process innovation in a manufacturing SME. It will also be used in the development of the framework for successful system and process innovation in Chapter 7.
Figure 4.15 Multiple-View Model of Successful Innovation Determinants
Chapter 5. Characteristics of SMEs Affecting Innovation

5.1. Introduction

While many researchers, practitioners and law-makers understand the significant contribution SMEs make to the local and indeed the global economy, their efforts to assist the SME sector to innovate are often hindered by their incomplete understanding of the characteristics of smaller firms. This is reflected in the fact that most definitions of an SME are based on size-related measures.

SMEs are generally considered to be non-subsidiary, independent firms which employ fewer than a given number of employees. This number varies across countries. The most frequent upper limit designating an SME is 250 employees, as in the European Union. However, some countries set the limit at 200, while the United States considers SMEs to include firms with fewer than 500 employees. Small firms are mostly considered to be firms with fewer than 50 employees while micro-enterprises have at most ten, or in some cases, five employees (OECD, 2005). Other measures such as financial assets, sales turnover and profitability are also used to define SMEs.

However, Storey (Storey, 1994) argues that there is a problem with definitions relating to ‘objective’ measures of size as this encourages viewing small firms as the ‘scaled-down’ version of larger firms. Wynarczyk et al. (1993) argue a similar point, emphasising the need to identify the characteristics of the small firms, other than scale, which distinguishes them from larger companies. As Welsh and White (1981) succinctly point out, “a small business is not a ‘little’ large business; differences exist in structure, policy making procedures, utilisations of resources to the extent that application of large business concepts directly to small businesses may border on the ridiculous”. Penrose (1959) likens these differences to those between a caterpillar and a butterfly.

On that notion, the innovation process in SMEs is expected to have different characteristics when compared to larger organisations. Understanding these characteristics is an essential key requirement for development of a practical framework for enhancing strategic system and
process innovation in SMEs. In this phase of the research, presented over two chapters, an in-depth analysis of SMEs and their innovation characteristics was carried out. Firstly a thorough literature review was conducted to explore the existing knowledge about SME characteristics. The results of the review were categorised and presented in this chapter based on the following groups of characteristics:

- organisational flexibility
- planning and strategic approach
- the influence of owner/manager
- resource deficiencies
- knowledge management

Secondly, given the dominance of survey-based research in the studied literature, a number of longitudinal case-studies were conducted (as described in Chapter 2), in order to develop a more in-depth understanding of these characteristics. These are presented in the following chapter.

5.2. Organisational Flexibility

Flexibility may be one of the main characteristics that distinguish SMEs from large firms. It is also reported to be the source of many of their key advantages, such as speed of response, ability to innovate, and capacity to adapt (Feigenbaum and Karnani 1991). Flexibility is also found as a tool for mitigation of the effects of hostile environments for SMEs (Pett and Wolff, 2009). In fact it can be argued that under difficult business environments, flexibility of SMEs can compensate for their limited access to resources (Qian and Li, 2003).

Bhamra et al. (2011) find that the infrastructure within SMEs allows for open and effective communication channels across all aspects of the business. This means that during sudden changes in the business environment, SMEs are able to effectively exchange information across the organisation. The authors also observe that SMEs are closely integrated with their customers, and are thus able to be more responsive to market demand and meet customer needs. Singh et al. (2008) state that the management structure of SMEs tends to be flat, resulting in fewer departmental interfaces and a more flexible work environment. This is also noted by Nicholas et al. (2011) stating that the fewer layers of management result in greater functional integration, less resistance to change and consequently shorter decision making.
process. Aragón-Sánchez and Sánchez-Marín (2005) also observe that compared with large firms, SMEs implement a greater number of human resource management practices that promote flexibility.

It is however, important to note that although SMEs are organisationally and structurally flexible, in terms of their planning and strategic orientation their flexibility is only in response to sudden environmental changes. It is not proactive and based on systematic analysis of the changes in their business environment (Levy and Powell, 1998).

5.3. Planning and strategy at SMEs

From the perspective of strategic innovation, planning refers to a rational systematic process involving assessment and forecasting of initiatives with clear outcomes that serve the objectives of the firm’s business strategy. It encompasses a dimension of strategic innovation that is both deliberate and long-term.

Previous studies have shown the importance of planning to the success of innovation in SMEs (Laforet and Tann, 2006, Panizzolo, 1998). However, research indicates that innovation within small firms is not part of long-term proactive strategies (Freel, 2000, Lagace and Bourgault, 2003). Barnes (2002) has observed that in SMEs, managerial intentions are not always expressed in formal plans, and as such change and innovation in manufacturing SMEs follows a semi-formal thought process linking business and market requirements to improvement initiatives. Similarly Andersen and Gavin (2001) have found that co-ordination of initiatives in SMEs happens through direct instructions and supervising, thus minimising the need for formal planning and control. Other studies have also reported the informal and unstructured nature of planning in SMEs (Freel, 2000, Hudson et al., 2001, O'Regan and Ghobadian, 2002).

Research also indicates that the management at most SMEs spend most of their time on “fire-fighting” and responding to short-term operational issues (Ates and Bititci, 2009, Temtime, 2004). Boyle and Desai (1991) provide a framework for analysing the activities that management of SMEs engage in order to respond to changes in their environment. Illustrated (with some customisation to account for the manufacturing systems scenario) in Figure 5.1, the environment/response matrix classifies SME management activities into four categories.
Boyle and Desai report that management in most SMEs is mainly concerned with short-term operational issues resulting from internal and external influences (quadrants 1 and 3 in the matrix).

<table>
<thead>
<tr>
<th>Internal</th>
<th>Operational</th>
<th>Strategic</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;b&gt;1&lt;/b&gt;</td>
<td>Short-term operational problems within management’s control</td>
<td>Long-term strategic issues within management’s control</td>
</tr>
<tr>
<td>e.g. machine breakdown, staff issues, quality issues, delayed delivery, cash flow, wages, bills etc.</td>
<td>e.g., need for dynamic capabilities, production capabilities, human resource management etc.</td>
<td></td>
</tr>
<tr>
<td>&lt;b&gt;3&lt;/b&gt;</td>
<td>Short-term operational problems beyond management’s control</td>
<td>Long-term strategic issues beyond management’s control</td>
</tr>
<tr>
<td>e.g. new regulations, unavailability of raw material, unreliable supplies etc.</td>
<td>e.g. changing socio-economic trends, new technologies, global market trends, etc.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.1 SME environment/response matrix - adopted from (Boyle and Desai, 1991)

Temtime (2004) identifies the inability of SMEs to analyse the long-term strategic issues in their external environment as a major factor affecting their competitiveness and eventual survival. He finds that, despite the uncertain and unstable environment in which SMEs are operating, their scanning behaviour is characterised by informal and unorganised ways of gathering and processing information from wrong sources with irregular scanning frequency (Temtime, 2004). He concludes that SMEs must be assisted to understand the implication of operational and short-term problems in their long-term survival and competitiveness.

Moreover, McAdam et al. (2000) report that even most of those SMEs that appear to be quite good at producing business plans, development plans and following structured decision-making approaches, fail to implement the required changes in practice. Chu (2003) associates such failure to the overemphasis of “hard” aspects of change during planning, at the cost of neglecting the “soft” ingredients in the process of planning and implementing change. O’Regan and Ghobadian (2002) have also found “soft” issues such as inadequate communication, ineffective co-ordination as well as lack of understanding of overall strategic
objectives by employees, as some of the main barriers to strategic deployment in SMEs.

Other critical issues related to planning in SMEs have been identified to be lack of prioritisation of strategic objectives (Fernandes et al., 2006) as well as the inability of owner/managers of SMEs to deal with the internal and external complexities of their organisations (Vos, 2005). A number of recent studies have associated this apparent lack of appropriate strategic planning to the SME owner/managers’ limited awareness of the tools associated with the practice of strategic management (Woods and Joyce, 2003, Richbell et al., 2006). Others have pointed out that management in most manufacturing SMEs lacks sufficient experience and know-how in system thinking, strategic planning and practical change management (Holman et al., 2000).

Furthermore, previous studies have found that, in the absence of a formal well-articulated plan in SMEs, often a pattern of incremental decisions may reveal an innovation strategy over time (Barnes, 2000, Mintzberg, 1978). This is referred to as an emergent strategy and encompasses an element of strategic innovation that is responsive and incremental. This is particularly relevant to SMEs as research has shown that, when owner/managers of SMEs plan for innovation, it is often as a reaction to rapid unpredictable changes in the market place as well as other short-term influences and circumstances (Freel, 2000, Harvey et al., 1992, O'Regan and Ghobadian, 2004). Therefore, strategies of many SMEs are constantly in the course of modification, revision and refinement in response to changes in their dynamic environments (O'Regan and Ghobadian, 2002).

There appears to be a paucity of empirical research in this area, with the most notable recent contributions coming from two studies by Barnes (Barnes, 2000, Barnes, 2002). He has found the strategy formation in SMEs, to be a complex process, involving a combination of deliberate and emergent actions and decisions. He observed that organisational culture and politics strongly influence the balance between the incremental and the deliberate elements of strategy in small firms. He further found the educational level and the interpretative process of managers and powerful individuals in SMEs, to be important determinants of the incrementalism of the strategy.
5.4. Owner/Manager

Study of literature suggests that a key driving force for change and innovation in SMEs is the personal preference of the CEOs or owner/managers of SMEs (Barnes, 2002, Chu, 2003, Miller and Toulouse, 1986, O’Gorman, 2001, O'Regan and Ghobadian, 2004, O'Regan et al., 2006). The centrality of the CEO or the owner/manager in a SME means that they occupy a position of unique influence, serving as the locus of control and decision-making, thus directly determining the growth and direction of the business (O'Gorman, 2001, O'Regan and Ghobadian, 2004). In fact, previous studies (Chu, 2003, Miller and Toulouse, 1986) have found that change in small organisations takes place as a result of inexplicit, intuitively-derived strategies that reside mainly in the mind of the CEO, and are only communicated to the subordinate in the form of instructions to implement the change. Therefore, the CEO or owner/manager’s background, intuition, vision, personal judgement as well as personal motivation play important roles in the change and innovation process in SMEs.

For instance, Barnes (2002) finds that, amongst the firms that participated in his study, the SME owners’ attitude towards manufacturing directly affects manufacturing decisions and actions. Similarly, Jones (2003) observes that a manufacturing SME’s bias towards investments in new technology stemmed from the favourable attitude of the managing director of the company towards technology along with his unfavourable attitude towards personal development of his employees. In the words of the author, “His vision of the company was one in which unreliable workers were replaced by machines” (Jones, 2003). McGovern and Hicks (2004) find that the introduction of any new technology that may have structural, operational and strategic ramifications for the small firm is only successful if it has the full support of its owner/manager. Panizzolo (1998) has also reported that, in most companies that took part in his survey study, the special attention paid to new technology by “charismatic” figures within the firms, resulted in little attention paid to development of in-house technical expertise and organisational competencies. McAdam et al. (2000) have found this a common trait of SMEs that score low on the innovation scale. They state that in such firms, innovation is viewed in terms of new products and new machines (McAdam et al., 2000).

Furthermore, small size coupled with flat and flexible organisational structure associated with SMEs, result in an environment where the personalities, backgrounds and individual
objectives of owner/managers play a significant role in how effectively the resources are used (Neumann and Finaly-Neumann, 1994, Heunks, 1998). Miller and Toulouse (1986) report from their study of managerial behaviour in 97 SMEs, that “smaller firms are often closely held and frequently the CEO is in a position to decide everything. His/her personality can, therefore, take on great importance specially where there are few strong managers to challenge his/her views”.

A number of studies have found characteristics of the owner/manager such as higher levels of education, his/her future orientation, leadership and self-confidence as important factors positively influencing the prevalence of strategic innovation in SMEs (Richbell et al., 2006, Heunks, 1998). On the other hand, personal traits such as extreme conservatism or purely reactive orientation have been found to be harmful to small firms as they result in strategic stagnation (Miller and Toulouse, 1986). CEOs with much seniority can also show politically and emotionally motivated resistance to the new initiatives if they are deemed to be conflicting with long-standing policies that are so closely tied up with their self-esteem (Miller and Toulouse, 1986). Gray (2004) states that the desire for personal independence is consistently the most commonly cited career-choice motive reported by small firm owners. He argues that this desire for independence inhibits effective delegation of responsibilities to subordinates. Hudson et al. (2001) state that such personalised and centralised style of management is one of the key defining characteristic of SMEs. Jones (2003) observed that a higher degree of autocratic management is usually found where product markets demand staff with low skills who were easily replaceable.

Research also indicates that SME owner/managers play a significant role in the formation and nature of their firms’ relationships with external experts and resource providers (Kingsley and Malecki, 2004, Ramsden and Bennett, 2005, Bennett and Robson, 1999, Clarke et al., 2006, Fuller-Love and Thomas, 2004). The owners and managers of SMEs do not just receive resources and advice: they also play a crucial role as seekers and assimilators of resources and advice. The perception of the SME’s top management with regards to the value of the relationship with an external entity is therefore a crucial factor in their decision to further engage with that entity.

Ramsden and Bennet (2005) argue that this perceived value is attained through realisation of hard objectives such as cost reduction, or increase in profits or turnover, as well as soft
objectives that are subjective and cognitive in nature involving change in the SME owner’s outlook, or in the approach of its other managers and staff. In fact, the results of their extensive survey study demonstrated that from the viewpoint of the SME owner/managers, soft impacts considerably outweigh hard ones, thus implying that advice has mainly personal development outcomes for the owner/manager (Ramsden and Bennett, 2005).

Similarly, Clarke et al. (2006) find that SME owner/managers favour engaging their firms in external relationships that provide them with opportunities to learn and create contextual knowledge in an informal manner. Kingsley and Malecki (2004) identify a number of factors that seem to be important to a small firm’s willingness to use such informal relationships for information. These include trust in the information source, proximity, and whether or not the firm has multiple relationships engaged in the information exchange. They report that SMEs are far more likely to seek information from traditional, familiar or “tried and true” sources that have been used previously, rather than from a new or non-traditional source such as universities or government programmes (Kingsley and Malecki, 2004). In fact the most frequently used sources of advice by SMEs are those from private sector, particularly accountants, solicitors, banks, consultants and the supply chain (Bennett and Robson, 1999, Ramsden and Bennett, 2005). This is in spite of the fact that collaborating with universities and government services have obvious advantages such as being low cost, well regulated and fairly impartial, (Bennett and Robson, 1999, Ramsden and Bennett, 2005).

This is in line with Bessant’s observation (1999) that, for many SMEs, there appears to be a ‘perception gap’ where they view the activities of research and technology organisations as being too advanced, specialised, expensive and not applicable to their problems. Scott et al. (1994) on the other hand, highlight perceived “loss of control” as one of the main factors resulting in the unwillingness of SME owner/managers to explore external sources. Nevertheless, those SMEs who demonstrate greater willingness to use government grants and collaborate with universities have reported greater levels of innovation (Freel, 2000, Laforet and Tann, 2006).

SME owner/managers also have a major influence on the firm’s culture and climate. The localisation of power in the position of the owner/manager, flat and flexible structures and scarcity of resources associated with SMEs, results in a political climate (Knights and Murray, 1994). Levy and Powel (2005) state that the organisational climate at SMEs is
substantially influenced by their owner/managers’ personality and style of leadership. This is also reflected in the findings of Haugh and McKee (2004), who have identified survival, independence, control, pragmatism and financial prudence as shared cultural values amongst SMEs.

5.5. Resource deficiencies

SMEs are often characterised by the limitations of their resource. In fact, as discussed earlier, the most commonly adopted definition of SMEs are based on quantifiable measures related to resources, such as number of employees, financial assets and sales turnover.

Finance

Many researchers have listed limited availability of financial resources as one of the main differentiators of SMEs from their larger counterparts (O'Regan and Ghobadian, 2004, Wong, 2005, Hudson et al., 2001, Bessant et al., 2001, Tucker and Lean, 2003). The financial dimension of performance is critical for both large and small companies, but given the lack of a monetary safety net to absorb the impact of short-term fluctuations resulting from change, this dimension is paramount in SMEs (Hudson et al., 2001). Tucker and Lean (2003) make a similar observation, stating that SMEs generally have smaller financial reserves to draw on in times of crisis and are also relatively highly geared compared to larger companies due to the difficulty and expense of attracting new equity finance. A number of studies report that the prevalence of close participative relationships between finance providers and managers of SMEs is critical for raising capital (Binks and Ennew, 1997, Madill et al., 2005, Uzzi and Lancaster, 2003). Van Auken (2001) also finds that the owner/manager’s awareness of the various types of funds available to the SME is also an important factor for acquiring financial resources. His survey study indicates that SME managers are mainly aware of traditional sources of capital and least familiar with government funding initiatives.

Barad and Gien (2001) identify such limitations of financial resources as one of the main barriers to competitive advantage for SMEs. This is reflected in a number of studies reporting the effect of insufficient funds on long-term strategic initiatives such as training and learning (Coetzer, 2006), knowledge management (Wong, 2005), integrated performance measurement (Hudson et al., 2001), and adoption of new manufacturing changes (Lagace and Bourgault, 2003).
Advanced manufacturing technology (AMT) includes a group of integrated hardware-based and software-based technologies which, when properly implemented, monitored and evaluated, can improve the operating efficiency and effectiveness of SMEs, creating vital business opportunities for the adopting firm. A survey study of 248 manufacturing SMEs in Canada (Raymond and St-Pierre, 2005) showed that the most prevalent cases of AMT assimilation in the participating companies were related to CAD/CAM, automation and computer controlled production machinery. The more advanced applications of technology that connect the majority of the SME’s value chain, such as MRP, MRP II or ERP, were significantly less prevalent. Sohal et al. (2001) reported similar tendencies of South African SMEs to invest in technology that involves less financial and organisation risk. Gupta and Cawthon (1996) also pointed to the prevalence of flexible manufacturing technologies such as CAD/CAM and CNC production, in small American firms.

While these studies indicate a positive investment trends in AMT uptake by SMEs, as Raymond (2005) points out, it is perhaps more important to look at how well these technologies are assimilated within the strategic and operational context of the organisation. Bessant (1999) contends many SMEs lack the capability to understand and articulate their needs, and rarely scan for source of new technological opportunity. As a result more manufacturing SMEs seem to tend towards adaptive hands-on approach to new technology adoption than macro strategic analysis (Panizzolo, 1998).

Moreover, recent studies have highlighted the fit between adapted operational management practices and AMT implementation as a critical factor for successful assimilation of the new technology in small firms. Bajaj (2005) conducted a participatory research study of AMT uptake in a manufacturing SME. He demonstrated that adoption of world class manufacturing practices in conjunction with AMT implementation yields better business performance improvement compared to simply replacing old machinery with new ones. Raymond (2005) also demonstrated the links between SME performance and the fit between AMT and the firm’s critical success factors, through a survey study of 118 manufacturing SMEs. His findings were echoed by Zhang et al. (2006), stating that companies who employ operations improvement practices alongside implementation of AMT achieve higher levels of flexible manufacturing competence compared to those who just focus on technology uptake.
Furthermore, when implementing new technology, SMEs appear to have difficulties with the more “soft” aspects of AMT uptake (Raymond, 2005). Fink (1998) associates this to the significant challenges faced by SME managers in bringing about necessary organisational changes that must be present for successful technology implementation.

Knowledge/Skills/Expertise

A shortage of human resources is a well established and reported characteristic of SMEs (O'Regan and Ghobadian, 2004, Wong, 2005, Hudson et al., 2001, Bretherton and Chaston, 2005, Barad and Gien, 2001, Storey, 1994). A number of authors have identified inadequate in-house human resources as one of the main barriers to SMEs’ competitive advantage (Barad and Gien, 2001, Hudson et al., 2001). In fact, lack of human resources has been found to be a bigger barrier to implementation of strategic initiatives in SMEs than their financial limitations (Fernandes et al., 2006). The significance of the limitations imposed on SMEs by the lack of human resources is further amplified by the prevalence of staff turnover and subsequent loss of knowledge observed in SMEs (Wong, 2005). Scott et al. (1994) make an interesting observation that where actual skill shortfalls are recognised by small firms, they often do not employ the appropriate resources.

Barad and Gien’s (2001) empirical study of 21 SMEs identified human-oriented concerns such as low skill/versatility of employees and low motivation as major contributors to some of the most urgent operating needs of SMEs. A number of recent studies have highlighted employee qualities such as creativity (O'Regan et al., 2006) and flexibility (McAdam et al., 2000) as critical ingredients of successful innovation in SMEs. However, as reported by Laforet and Tann (2006), many SMEs face major obstacles to innovation such as lack of expert knowledge, inadequate training, and restrictive attitude to learning and employees’ contribution to new ideas. McAdam et al. (2000) find that in SMEs demonstrating inadequate levels of innovation, employees were generally not expected to contribute beyond their job skills. Panizzolo (1998) attributes this shortage of quality employees in SMEs, to absence of formal selection, training, compensation and human resource management practices generally found in larger firms. Recent studies have highlighted the importance of empowerment and human resources leadership as critical factors for successful innovation strategy in SMEs (O'Regan et al., 2006, Laforet and Tann, 2006, Chu, 2003). In a survey study of 464 employees in 31 small manufacturing companies, Coetzer (2006) finds that
employees of small organisations perceive they have limited autonomy in their jobs and have limited or no access to training.

Although many characteristics of human resources in SMEs are not favourable to strategic innovation, the organisational flexibility associated with SMEs (Hudson et al., 2001, O'Regan and Ghobadian, 2002, Andersen and Gavin, 2001) is found to enhance the small firms’ capacity for innovation and entrepreneurship (Entrialgo et al., 2000, Laforet and Tann, 2006). However, the combination of flatter structures and limited human resources in SMEs means that employees often have a greater number of job roles and more responsibility (Hudson et al., 2001, Coetzer, 2006). This has a detrimental impact on implementation of innovation strategies in SMEs, as many small firms fail to allocate dedicated resources to research and development (Freel, 2000).

Similar to other human resources, shortage of management resources is a major obstacle in the way of strategic innovation in SMEs (O'Regan and Ghobadian, 2004, Wong, 2005, Hudson et al., 2001, Bretherton and Chaston, 2005, Barad and Gien, 2001, Storey, 1994, Coetzer, 2006). Managers in small firms are often found to be multi-skilled, as small firms rely on fewer personnel resources for multiple activities (Coetzer, 2006). Trau (2003) argues that in the face of rising environmental complexity, small firms must devote more resources than before to evaluating the information that is required for simply running their business activities. Consequently, little time is left for innovative developments.

**Dynamic Capabilities**

As stated in Chapter 4, dynamic capabilities can be classified under four categories of resource acquisition, resource reconfiguration, learning/sense-making and strategic aligning. Matters related to strategy in SMEs were discussed in section 5.2, and will therefore not be covered here again. Acquiring new valuable and unique resources is a challenge for SMEs (Brush et al., 2001). Apart from the issue of finances and raising capital covered earlier, the risk of getting the wrong resource causes hesitation on behalf of the small firm’s management. That is why most SMEs rely on trusted person-to-person relationships developed over time to gain access to complementary resources and reduce risk and transaction costs (Borch and Madsen, 2007). Thus, strong network ties characterised by reciprocity, collaboration and trust significantly enhance the resource acquisition capability of SMEs.
Given the limited access to new resources, SMEs often have to find new ways to patch, recombine or realign their resources to respond to changing market requirements. Miller and Toulouse (1986) have found SMEs to be particularly efficient at reconfiguring their resources due to low levels of formalisation, absence of significant organisational boundaries, and centrality of decision making. Borch and Madsen (2007) also highlight the involvement of the top executives of SMEs in all operational facets of the organisation as an advantage in terms of resource reconfiguration. They contend that this close involvement gives the main decision makers in the company a complete overview of the firm’s existing capabilities.

Scott et al. (1994) observe an informal, intuitive and incremental learning process in SMEs. Coetzer (2006) finds that conditions in the work environments of the small firms are more conducive to an adaptive mode of learning (the learner has to evaluate the outcomes and make minor corrections in the way the methods were used to solve the problem at hand) than a developmental mode of learning (learning through experimentation, search, risk taking, discovery and creativity). Borch and Madsen (2007) state that in SMEs, the managers play a significant role in the training of the employees. Similarly, Coetzer (2006) observes that effective learning is not prevalent in those SMEs in which managers do not adopt a proactive stance in fostering their subordinates’ learning. Jones (2003) attributes this to the absence of personnel specialists in the management recourses of majority of SMEs.

5.6. Knowledge management (KM)

Study of knowledge management in SMEs is a new and emerging discipline. This is in spite of the fact that knowledge is perhaps the most significant resource at the disposal of SMEs in terms of availability and impact. Desouza and Awazu (2006) report that, in their sample of Australian SMEs, those were successful who could leverage their knowledge in an effective and efficient manner so as to make up for deficiencies in traditional resources (Desouza and Awazu, 2006). Similarly, in their study of 108 Finnish SMEs, Salojärvi et al. (2005) reveal that firms that approach KM systematically grow faster than those that do not have a KM strategy.

However, recent research indicates that KM is not a recognised practice in SMEs. Edvardsson (2009) argues that most SMEs have no explicit policy targeted at strategic KM,
and they tend to treat KM on an operational level. McAdam and Reid (2001) compare the KM practices at SMEs with their larger counterparts. They conclude that KM in SMEs is far less advanced, as most SMEs view KM as a resource-intensive additional initiative than a critical driver of competitive advantage. Nunes et al. (2006) attribute this to the fact that owner/managers in SMEs do not perceive KM as a business-critical function and are consequently unwilling to invest in the KM systems.

This is, however, not to say that SMEs do not manage or transfer knowledge in their organisations. As uit Beijerse (uit Beijerse, 2000) finds, in SMEs there are all sorts of instruments used to evaluate knowledge and to determine the knowledge gap, to develop or acquire knowledge and to share knowledge. However, SMEs use these instruments without seeing them as knowledge management. Similarly, Kraaijenbrink et al. (2006) find that SMEs intentionally search for knowledge, acquire it, and apply it only for the goal they acquired it for. They use a number of general methods and software, like email, search engines and brainstorming for knowledge integration. However, they report that KM is not part of their daily language and it is not a specific process separate from the day to day operations. The authors observe that SMEs that participated in their study were not very aware of the knowledge management issues that they had and the solutions that might exist for those problems.

Furthermore, a number of studies have focused on revealing specific characteristics of KM in SMEs. Desouza and Awazu (2006) find that in SMEs socialisation methods are the predominant way through which knowledge transfer occurs from owner to employees and between employees. Supyuenyong et al. (2009) report that knowledge sharing occurs through informal means and only among those who work closely together in the organisation. They attribute this to the dominance of the tacit type of knowledge available in SMEs, and the absence of structures and processes to retain explicit forms of knowledge. Similarly, Edvardsson (2009) contends that SMEs place much emphasis on management of tacit knowledge. This view is shared by Desouza and Awazu (2006), reporting a lack of explicit knowledge repositories in SMEs for sharing and storing knowledge. They observe that, instead of technological means, key individuals in the company act as knowledge repositories. Therefore, in SMEs knowledge is created, shared, transferred, and applied via people based mechanisms.
A number of studies have attempted to reveal the dynamics that result in the above-mentioned characteristics. Wong (2005) carried out a comprehensive study of critical success factors for systematic adoption of KM in SMEs. He found 11 factors impacting KM in SMEs, with the top five factors being management leadership/support, culture, strategy/purpose, resources and processes/activities (see Table 5.1 for the complete list). A recent exploratory study conducted by Supyuenyong et al. (2009) confirms the finding of Wong (2005), that management and culture have the most impact on KM practices in SMEs. They report that system, process and procedure, and customer and market characteristics have a more moderate effect, while human capital management practices in SMEs seem to hinder the KM processes. Figure 5.2 illustrates their findings.

| Table 5.1 Critical success factors for knowledge management in SMEs (Wong, 2005) |
|---------------------------------|---------------------------------|
| 1. management leadership and support | 6. training and education |
| 2. culture | 7. human resource management |
| 3. strategy and purpose | 8. information technology |
| 4. resources | 9. motivational aids |
| 5. processes and activities | 10. organisational infrastructure |
| 11. measurement |

Figure 5.2 Impact of SME characteristics on KM processes (Supyuenyong et al., 2009)
5.7. Summary of SME Characteristics

The following are some of the key insights gained from the body of literature regarding these SME characteristics:

- The infrastructure within SMEs allows for open and effective communication channels across all aspects of the business.
- The fewer layers of management in SMEs result in greater functional integration, less resistance to change and consequently shorter decision making process.
- Planning in SMEs is characterised as informal and unstructured.
- Management in SMEs is mainly concerned with short-term operational problems, rather than long-term strategic issues.
- “Soft” issues are often ignored in during planning at SMEs.
- Management in SMEs is largely unaware of tools and methods related to systematic analysis, strategic planning and practical change management.
- Strategy in SMEs is emergent, responsive and incremental.
- The owner/manager is the key driving force for change and innovation in SMEs.
- The owner/manager’s background, intuition, vision, area of interest as well as personal objectives play a critical role in the innovation process in SMEs.
- Owner/managers play a significant role in the formation and nature of their firm’s relationships with external entities, as they are more likely to engage in relationships that contribute towards their personal developments.
- Owner/managers seek information from traditional, familiar, trusted external sources that have been used previously, rather than from new or untraditional sources such as universities.
- Owner/managers’ personality and leadership style are manifested in the culture and climate of their firms in the form of cultural values such survival, independence, control, pragmatism and financial prudence.
- Lack of financial resources is one of the main barriers to innovation in SMEs.
- Use of advanced manufacturing technology is prevalent in SMEs, but it is often not assimilated with the strategic context of the organisation.
- Shortage of quality human resources is one of the main barriers to innovation in SMEs.
• Flat organisational structures and limited human resources means that the few internal experts in SMEs are often occupied with many roles and various responsibilities.
• Strong network ties characterised by reciprocity, collaboration and trust enhance the resource acquisition capabilities of SMEs.
• SMEs are particularly efficient at reconfiguring their resources due to low levels of formalisation and centrality of decision making.
• SMEs do not approach knowledge management in a structured and strategic manner.
• Most SMEs are unaware of their existing knowledge management activities, the issues related to the way they manage knowledge and the potential solutions to these problems.
• Socialisation is the most dominant mode of knowledge transfer, and tacit knowledge is the most common type of knowledge retained and used in SMEs.
• Supportive management and organisation cultures have the most impact on knowledge management practices in SMEs.
Chapter 6. Case Studies of System and Process Innovation in a Manufacturing SME

6.1. Introduction

The literature review presented in the previous chapter highlighted some of the characteristics of SMEs that impact system and process innovation. As discussed in the methodology (see Chapter 2) there is a need to carry out further in-depth case-study research in this area to better understand the dynamics of system and process innovation in SMEs. Table 2.1 presents a summary of the case-study research design. In this chapter two case-studies will be presented, based on two system and process innovation projects that were undertaken by a manufacturing SME in New Zealand. For privacy reasons, the case company is referred to in this thesis as ‘CM Ltd’. As mentioned in the introductory chapter, the principal researcher in this study was employed at CM Ltd for the duration of these case studies. He was employed as a manufacturing analyst and was heavily involved in all of the project activities. Thus, the researcher is able to bring detailed and firsthand account of how the projects took place.

The projects under investigation in this chapter are

- Implementation of advanced manufacturing technology
- Design and implementation of manufacturing performance management system

The multiple-view model of system and process innovation developed in Chapter 4 provides a holistic and systematic approach for analysis of characteristics of SMEs that affect successful management of innovation. The model is figured as a hexagonal prism, with each side providing a filtered view of the innovation process from a specific perspective. It is through the synthesis of the analysis carried out in each perspective that a more comprehensive understanding of the dynamics that governs the innovation process is revealed. The following sections first provide a brief background to the case company, followed by the descriptive analysis of the two projects. This analysis is structured according to the multiple-view model of innovation.
6.2. CM Ltd - History and Background

CM Ltd is a privately owned panel furniture manufacturer that traces its history back to 1964, starting in a family garage by two young entrepreneurial brothers. Since then the company has grown to a medium sized manufacturer and exporter of panel products such as office desks, storage cabinets, home furniture, tables, wall units, entertainment centres, kitchen cabinets, etc. At the time of this study, the company employed around 200 people. It is structured as a group of companies consisting of a manufacturing division, sales and marketing division, design and development team, IT department and a finance department. The manufacturing side consists of a sophisticated production facility, a production planning department, a procurement department as well as quality assurance and engineering teams. The sales and marketing division consisted of sales staff, a marketing team and a number of warehousing facilities.

The ownership and directorship of the company is shared by two brothers, referred to here with their initials as WS and BS. At the time of the study, the company was run by a newly appointed CEO and each department was managed by a departmental manager. With the exception of the manufacturing manager, the remainder of the managers been with the company for over five years. The company had experienced significant growth over the years, achieved through a strategy of accumulating design and production capabilities, purchasing and implementing advanced technology, and making strategic acquisition of companies with the desired capabilities.

In the early years of CM Ltd’s history, the stimulus for this capability building strategy came from opportunities in the external environment of the company. For instance, from 1975 to 1979, CM Ltd recognised and took advantage of export incentives to develop markets in Australia, and through that justified the move to bigger premises and major investment in cost-effective flow line processes. Furthermore, 1979 through to 1987 saw CM Ltd replicate its Australian marketing initiatives in the USA, selling cabinets in high volume to United States electronics distributors. As a result more investment followed to increase both production efficiency and capacity, the most notable being a complete roll-laminating line. In 1984 CM Ltd was an early adopter of computerisation, implementing both CAD and a full MRP system. In 1985, CM Ltd was one of the first panel furniture manufacturers in the world to purchase a point to point CNC machining centre.
From 1988, increased competition in the US market forced CM Ltd to turn its focus to the local furniture market of functional ready-to-assemble furniture for the home and office. Between 1988 and 1995, many infrastructure and production developments were undertaken. These included investing in a MRP2 system, developments of a factory planning system, distribution systems in Australia, as well as automated forecasting and master scheduling systems. A group technology approach to design and a manufacturing cell structure in production were also implemented. During this period CM Ltd first obtained ISO9000 certification. The period 1995 to 1998 saw the implementation of an integrated training system, as well as accounting reporting systems. Since 1998 a number of company acquisitions were made, which provided CM Ltd with additional panel finishing and processing capabilities, notably painting and kitchen cabinet manufacturing. In 2000 the company expanded its factory and completely revamped its production layout, and added a warehousing facility to supply the NZ market.

6.3. Case 1– Implementation of Advanced Manufacturing Technology

The case study presented here concerns pre and post implementation of a state-of-the-art flexible drilling line at CM Ltd in 2004. It replaced an old drilling line purchased in the late 1970s. The new line was a multi-million dollar investment in advanced manufacturing technology, which introduced significant changes in the factory in terms of computer integrated production and flexible manufacturing practices.

Figure 6.1 Automated CNC Multi-boring line
6.3.1. Process

The following is a descriptive analysis of the project from the process viewpoint. It is based on the factors outlined in Table 4.3 presented previously in Chapter 4.

*Problem Definition*

No systematic approach was used to describe the problems associated with the aging drilling machines (referred to as B-Lines). This is evident in the fact that there was no clear statement describing the requirements of the new drilling machinery. The problem was simply framed as the replacement of the old machinery with a new one. As a result, many of the requirements of the processes before and after the drilling processes were not taken into account. This lack of systematic analysis at the problem definition stage was the cause of many problems that became apparent once the new machine (referred to as B900) was installed and in operation. For instance, one major problem was the specific in-feed requirements of B900, which meant that the panels fed in to the machine had to be oriented in a certain direction. This orientation was the exact opposite orientation of the panels at the out-feed of the preceding machine (referred to as A-Lines). To remedy this problem, the A-Lines operators were asked to manually flip the panels that came from their machines. This manual process added significant load and cost to the A-Lines team.

Furthermore, the lack of a systematic approach meant that the soft issues related to the problem were inadvertently ignored. For instance, staff training and skill requirement for effectively running the new machine were considered only after the new machine was installed. Another example was the disregard for the requirements of the operational staff in the design of the new layout of the factory. The B900 line had a much larger footprint than the machine it was replacing. Consequently, in the reshuffle of the adjacent machinery to make room for the new line, much of the storage area and work flow of these processes were altered without consulting the operators.

*Problem Analysis*

Factual information was used to justify the replacement of the B-Lines. A detailed pack of information regarding the components that were to be machined on the replacement machine was sent to a number of shortlisted machinery manufacturers. This pack included an itemised list of all relevant components, production volumes, average batch sizes, technical drawings
and external dimensions of the components. The technology providers were asked to estimate the machining time for drilling the required holes for each component. This information was subsequently used to quantify the potential operational cost savings for each of the shortlisted machineries. Other information used in the decision-making, were cost, warranty, service and availability of spare-parts.

Search for the solutions

The decision regarding the type of machinery to be purchased to replace the B-Lines was primarily based on the knowledge of WS – the founder and director of the company. He was regarded internally as the main expert and authority on matters related to advanced manufacturing technology. Given the lack of systematic approach at the problem definition stage, the task of searching for the appropriate solution was simply left to WS to select a machine that he felt was appropriate. There was no evidence to suggest that WS considered system constraints or contradictions in selecting the B900. However, choosing a state-of-the-art computer-controlled drilling line meant a major contradiction between batch size and cost was eliminated. This could have had a major effect on the overall production system performance. However, it went unnoticed and no intentional changes to the production batch sizes or product offering were considered to take advantage of this newly gained capability. Furthermore, since the B900 replaced a number of drilling machines, it can be argued that it created a potential bottleneck (or a new constraint) in the factory. This was because with the implementation of the B900, near 80% of the production volume would flow through one drilling line, whereas in the past it would go through three different machines.

Communication

The information regarding the new machine was communicated only to the management team, once the decision was made by the board of directors to replace the old machinery. A number of videos were made available to the management team to see examples of some of the shortlisted machinery in action. More technical information regarding the machines was communicated only to a handful of people on a need-to-know basis. This caused some difficulties after the installation of the new machine, as there were very few people in the company who had sufficient knowledge about the machine. The absence of documentation about machine capabilities also meant product costing and production scheduling systems could not be modified to reflect the change in the processing machinery. Once the decision was made to purchase the B900, a project team was put together to coordinate the installation
process. There were no apparent objections to the purchase of B900 amongst the project team and all the team members cooperated well to successfully install the new machine. Throughout the project, meeting minutes would be distributed to all the attendees and the team members would frequently communicate via email and in meetings. However, no formal communication was carried out to inform the shop floor staff of the intended changes, and no formal mechanism was created to gather ideas and feedback from the staff.

**Collaboration**

As mentioned earlier, the approach to this project was not very collaborative at the start. As the project moved towards the implementation stage, it became more collaborative. A team was constructed of internal technical experts, some of whom travelled to Italy to be trained by the machinery manufacturers on installation and operation of B900. The project team included people from engineering, manufacturing, design and IT departments. It also included the team leader of the drilling processes. The team members formally met and discussed the project and the progress towards the set milestones on a regular basis. Other meetings outside of the project schedule were also frequently organised by the team members to collaborate on the tasks that were assigned to them. Overall there was a high level of cooperation amongst the team that could be due to a number of factors. Firstly, the decision to replace the B-Lines was very popular as the aging machines were the subject of much complaint from those involved with their operations and maintenance. Secondly, WS was regarded internally as an expert on the latest developments in panel manufacturing technology because of his extensive travels to Europe. Thirdly, over the years, it had become an accepted and somewhat expected norm for decisions regarding manufacturing machinery to be made by WS. Finally, WS as the founder, director and major shareholder of the company held a powerful position in the company, and it was regarded as natural to follow his decisions.

**Politics**

The main champion for this project was WS. Due to his standing in the company as the founder/director/shareholder he had a lot of power and authority to initiate and carry out such a project. However, given that this was a major capital expenditure, WS needed the approval of the Board of Directors in order to seek finance from the bank. In order to secure the support of the Board, WS relied heavily on his power position and internal reputation as the expert on panel manufacturing technology. He also provided supportive evidence from his
trips to Europe and put together a spreadsheet outlining the financial benefits and calculated a rate of return on investment. His estimates and assumptions, however, were never verified once the machine was purchased and installed. WS also used narratives quite effectively in his favour. On many occasions in formal meetings, via email or even informal conversations at the company’s social area he would narrate stories of his trips to world class manufacturing companies and machinery manufacturers. He would talk enthusiastically about the latest technologies developed and implemented. He would also regularly vocalise his criticism of how the factory was being run and would blame much of the problem on the manual processes and the involvement of the operators in setting the machines. In his view, automation and computer controlled machinery were the answer. Given his position and standing in the company, his views were rarely challenged and as a result his narrations reinforced the idea that the company needed to equip itself with more automated manufacturing technology in order to stay competitive and survive in the volatile market. In the absence of competing narratives, this became the main driver of strategic actions in the company.

Planning

This project was not part of a documented and communicated strategic plan. In fact it was not even reflected in the budgeting process for the financial year that it was carried out. However, it is very likely that it was a reflection of an implicit strategy developed by WS. A look back at the historic development at CM Ltd reveals an emergent strategy of acquiring state-of-the-art manufacturing capabilities, specifically in the area of automation and computer-controlled machinery. Planning activities were more evident as the project moved towards the implementation stage. Prior experience played a major part in this process. As mentioned earlier, CM Ltd had previously installed advanced manufacturing technology on a number of occasions. As a result there was a sense of familiarity and confidence with the process amongst those involved in the planning stage. A project plan was constructed with work breakdown based on this experience. However, this was only used to set and manage milestones, and the project tasks were not carried out in exact accordance with the plan. The plan was also light on analysis of resources required for the project and it was assumed there would be enough manpower, knowledge and expertise for the team to carry out the project. This lack of rigour and rigidity in the planning process had the advantage that the plan was very flexible.
Scanning
The company does not allocate much resource to the scanning process. At the management level very few people have the time to look for information regarding the environmental changes and trends in their domains of expertise. IT and manufacturing departments subscribe to some trade magazines and the marketing and design department occasionally travel to Europe to attend trade shows. In the area of manufacturing technology, WS actively searches for new advances in production technology. However, the scope of his search is limited to a number of well-known machinery manufacturers in Europe, with whom he has formed a long-lasting relationship. Consequently he is well informed of their latest developments and has in-depth knowledge of their offerings.

Organising
Each department at CM Ltd has a list of key projects which they work on alongside their day-to-day operations. Although the B900 project was not strategically planned, due to its importance the project and its associated tasks were given high priority and moved up to the top of the list for each department. This meant that each departmental manager had to allocate resources and ensure completion of tasks in accordance with the planned deadlines. Given the involvement of WS as the project champion, all managers were fully committed to the successful completion of the project and cooperated accordingly.

6.3.2. Structure
The following is a descriptive analysis of the project from the structure viewpoint. It is based on the factors outlined in Table 4.4 presented previously in Chapter 4.

Market Competition
CM Ltd is a major player in the local panel furniture market. At the time of this project the company was experiencing stable organic growth. The market concentration therefore did not contribute to the decision to purchase new manufacturing machinery. However, it can be argued that the relatively sound financial performance of the company was influential in the top executives’ willingness to invest in long-term capability building initiatives such as B900.
Network

In terms of openness, the external boundary of CM Ltd can be regarded as open but unidirectional. This means that external entities are used as the need for resources arise. For instance in the B900 project, the funds were borrowed from the bank and the main technology was provided by a European panel processing machinery manufacturer. The company also used the expertise of a CAD company to develop an automated system for conversion and upload of 3D component drawings suitable for B900’s proprietary operating system. Furthermore, CM Ltd used its relationship with Department of Mechanical Engineering at University of Auckland to employ a number of students in order to carry out an optimisation project on the B900 drilling line.

These affiliations that were used to acquire resources for the project can all be classified as strong ties. Over the years WS had formed close professional relationship with key technology providers in the panel furniture industry in Germany and Italy. The strength of this relationship has been reinforced through numerous technology purchases, personal visits made by WS to the technology providers and keeping in touch regularly via email. The company had also developed a strong collaborative relationship with a senior lecturer at the University of Auckland by hosting numerous student projects over the years. The relationship with the CAD company was also maintained over numerous years and a number of collaborative projects had been carried out. CM Ltd has also formed a long lasting, transparent and professional relationship with a local bank, through its chief financial officer.

A key observation to be made with regards to these affiliations is the critical role WS has played in brokering and strengthening these relationships.

Internal structure

CM Ltd is a highly centralised organisation. A look back at the history of developments in the organisation indicates that almost all major initiatives in the company were started and lead by the two brothers, WS and BS (both have equal shares in the company). This has become a norm in the organisation to the point that very few people in the company propose new ideas especially at the strategic level. This is not to say, however, that people do not have opinions about how things should be done. In fact, in conversations with employees at all levels of the organisation, they vocalise their ideas and opinions about what they feel the answer to certain problems are. But this is almost immediately followed by expressed
cynicism about their ideas being heard. The company has put in mechanisms for staff and managers in each department to come up with improvement projects. However, since the list of projects, their prioritisation and progress are monitored by the CEO, WS and BS, the projects that are proposed by the directors are always given top priority and other ideas are either given low priority or are dismissed altogether. This has created a perception of disempowerment amongst the management team. This is reflected in the answer given by the staff and management when asked why they are working on certain projects. The answer is “WWW”, which stands for “this is What WS Wants!” In spite of the negative effect on empowerment, this level of centralisation proved helpful at the implementation stage of the project. As explained earlier, project tasks associated with B900 were moved up the project list of each department as a coordinated effort to successfully install and operationalise the new machinery.

In terms of formalisation, the project was fairly informally organised and managed. This created a flexible and interactive environment where those responsible for carrying out tasks related to the project could self-organise in order to meet the planned deadlines. This is in line with how most projects would be carried out in CM Ltd. Interestingly, this is in spite of the fact that the company had a comprehensive set of procedures developed as part of its ISO9001 manual. Each department had a folder of detailed (step-by-step) procedures related to the day-to-day operations of the department. However, in practice, most people did not refer to the procedures for their activities and only administrative tasks were carried out using standard forms and in accordance with procedure.

With respect to complexity, CM Ltd has high levels of role specialisation and functional differentiation. This was reflected in the composition of the project team, which consisted of specialised people in the area of production technology, engineering, maintenance, CAD systems, IT infrastructure, software programming and system analysis. In fact this level of specialisation enabled CM Ltd to carry out most of the tasks related to installation and operationalisation of B900 internally. This was very beneficial in terms of removing potential complications associated with coordination, keeping costs to a minimum and preserving the knowledge generated as part of this project inside the company.
6.3.3. Knowledge

The following is a descriptive analysis of the project from the knowledge viewpoint. It is based on the factors outlined in Table 4.3 presented previously in Chapter 5.

Sources of Knowledge

The knowledge used in selection of the appropriate manufacturing technology came mainly from two sources. Firstly it came from knowing the gaps in CM Ltd’s existing capabilities, which was built on internal awareness of current capabilities shared amongst key individuals in the company. These included the Manufacturing manager and the Engineering manager as well as WS. The second critical source of knowledge was WS’s awareness of the developments in the area of panel manufacturing technology gained through his extensive network of European machinery manufacturers and panel producers. Little or no attention was paid to the market, and whether there were certain finishes or features that the market required which should guide the selection of the appropriate technology.

Type of Knowledge

The type of knowledge that led to the selection of B900 was predominantly tacit knowledge, acquired through a learning process that can be described as hands-on. Firstly, the internal awareness of CM Ltd’s manufacturing capabilities was mainly developed through a hands-on approach adopted by the company’s technical managers and the founding director, WS. Over the years, they had all run and experimented with the main production machinery in the factory and had thus developed a “feel” for how the system of machines should be run and processes synchronised to achieve optimum levels of productivity. Furthermore, WS travelled annually to Europe and visited trade-shows, machinery manufacturers as well as world class panel manufacturers. He was therefore in a position to see the latest machinery in action at some very large and successful European panel processing factories. Through observation of what he regarded as “best practice” and socialising with the key technology providers, WS had developed a mental model of how he envisaged CM Ltd should operate and what capabilities it should have.

Finally the know-how for selection, purchasing, transportation, installation and operationalisation of advance manufacturing technology existed in tacit form, and learned through numerous technology uptake projects, as outlined in the company’s background
information. Indeed it was surprising to find that after so many projects, the company had not developed a set of documentations, procedures, policies, rules or guidelines for selection and implementation of manufacturing technology.

**Absorptive capacity**

As illustrated by the historic account of the growth of CM Ltd, the company has acquired over the years considerable know-how in implementation of advanced production technology. Success that has come about through exploitation of capabilities gained through each technology implementation project has also created and reinforced the mind-set of a number of key decision makers in the company, that in order to improve the performance of the company and grow it you must invest in manufacturing capability. In fact, WS would go as far as saying that “The panel furniture industry is not led by designers and fashion trends, instead it is the panel processing machinery manufacturers in Europe who set the trend for the market by providing companies with the ability to manufacture new features and apply new finishes”. The implication of this mindset is clearly observable in the significant bias in the company’s major expenditures and development projects towards manufacturing. Other investments in staff training, marketing and branding as well as design capabilities are seen as much less important.

It was therefore natural for the company to once again look at further investment in panel processing capability. One important note to make here is that this mindset and bias towards manufacturing was not shared amongst all managers of the company. The finance and marketing managers believed strongly in the need for CM Ltd to invest in their brand and marketing capabilities and look into designing world leading and trend setting products, using existing capabilities. However, being the founder and major shareholder, WS played a critical role in decisions regarding major expenditure. It was therefore his knowledge-based assets in the area of production technology implementation that influenced the entire organisation’s bias towards manufacturing technology.

**Knowledge Conversion Processes**

The most dominant processes in dissemination of knowledge about the B900 machine were socialisation and internalisation. A number of instruction and training manuals were provided by the machinery manufacturer, as well as temporary access to a number of experts who aided in the installation and operation of the machine. CM Ltd’s engineering manager and
CAD manager, as well as the founding director, WS, also travelled to Italy to spend time at the manufacturing plant to see how the B900 machine was put together and how it was connected to, and integrated with the wider manufacturing information system. Through socialisation with external experts, these managers were to become the internal experts on the machine. However, the time spent with the external experts was limited and given that the documentation and training manuals provided by the manufacturer were also limited, the main process of acquiring knowledge became ‘learning by doing’, i.e. internalisation. This became more prevalent and critical as, post-implementation, the operators and internal experts realised the machine did not necessarily behave in the manner described by the manufacturer in their manuals. This was attributed to a number of customisation requests by CM Ltd, which meant the overall line was a unique installation, and thus knowledge from previous installations could not predict all the observed behaviours. New insights were, therefore, gained by the operators and engineering team as problems were overcome and the machine was fully operational. These insights, however, remained with the people in close interaction with the machine and were rarely externalised into amendments to the existing manuals or new operation/maintenance instructions. It was only when the need for documentation of certain information was established through repetition (e.g. machine breakdown), that the local experts developed some instructions or procedures to overcome the problem.

_Exploration vs Exploitation_

This localisation of knowledge in the mind of certain operational staff also meant that very few people in the organisation had access to information about the capabilities of the B900 machine. This was a major obstacle for further innovation and exploration of new possibilities in the utilisation of B900’s capabilities. As a result B900 was simply treated as a mere replacement of the thirty year old machine, even though its capabilities were far more advanced than its predecessors. For instance B900 was fully automated, CN controlled, and it had a one-minute setup time, as opposed to the old machine that required a lot of operator intervention, was not computer controlled and would take 2-3 hours to set up. With more than 80% of produced panels going through this line, the much enhanced flexibility of the drilling process provided many opportunities for significant improvements in the overall manufacturing system performance. However, due to inaccessibility of information, many of these opportunities were not explored. Instead, more attention was given to achieving incremental improvements in the performance of B900 itself, by combining externalised
knowledge to the wider team. For instance a project was carried out to optimise the drilling head configuration of the machine, through combination of documented information about the required drilling patterns (as found in component drawings) and documented information about B900’s drilling heads and their operational capabilities. The result was a report highlighting the analysis with recommendations on how the drilling heads should be configured.

Interaction
No formal structure was set up to disseminate the knowledge gained by WS and other staff visiting the machinery manufacturers in Europe. The processes leading up to the decision to purchase the machinery were highly centralised and mainly involved the directors of the company. However, the implementation of this new technology required coordinated activities between manufacturing, engineering and design departments. As a result a number of project meetings were organised to help manage the project. However, these meetings were mainly used to report on progress and very little information was shared among the various stakeholders. Post-implementation, issues regarding improved performance of the machine were discussed separately within each department, and thus very little cross-departmental integration was achieved.

Collaboration
While absence of formal structures limited the opportunities to share knowledge to the wider organisation, there were also cultural obstacles for dissemination of knowledge. Firstly, the fact that most of the knowledge about the machine was held with few internal experts, meant that they could exert some power over others in need of the information. This was further amplified by the fact that B900 was a major capital expenditure for the company and the return on this investment relied heavily on using the specialised knowledge gained by the internal experts. For the operators of the B900 this meant higher wages and more job security. It also meant less willingness to share their knowledge. At the management level, knowing about B900 meant becoming an “insider” in the informal community of technical experts who were trusted, informed and, on occasions, consulted by WS about future technology implementation plans.

From an organisational perspective, while teamwork and cross-functional collaboration were never discouraged, there was no effort to promote sharing of knowledge and information. In
fact, while individual achievements were at times celebrated at CM Ltd, team work and knowledge sharing were not given much attention. Consequently, many individuals within the company did not see the need to document and share their expertise with the others unless it had an immediate effect on their job. This absence of a supportive culture was further reinforced by the scarcity of time available to the internal experts for knowledge activities. These experts were, in fact, some of the busiest people in the company as they were responsible for most of its technical operations (from design and CAD systems to machinery and site maintenance). This meant that they had very little time to spend on documentation or even training and thus would often opt for the following response: “In the time that it takes to explain this, I might as well do it myself”. It was only when the repeated enquiries for information regarding the day to day running of the machine would get to sufficient levels of annoyance, that the internal experts would document their knowledge and share it with others.

**Technology**

The use of information technology for knowledge management at CM Ltd was limited to use of Microsoft server technology, shared folders, Microsoft office documents (PowerPoint, Word, Excel, Project, Access) and CAD software. These were mainly used to create and store information, while the email system was the main method of sharing information regarding the B900 project.

**Knowledge Responsiveness**

From an agility and change proficiency point of view, CM Ltd qualifies for the repeatable level. As the history of the company’s development and capability acquisition illustrates, knowledge about new technology has led to change in the organisation. However, this change has not come about based on set procedures or structures designed to explore or exploit newly acquired knowledge. Instead, the new knowledge about the latest panel processing technology led to implementation of new machinery, through informal and loosely structured routines. These routines have been developed by key individuals (e.g. WS) based on their experiences with previous technology implementation projects. They are known implicitly to those who have been involved in similar projects; however, they are not shared explicitly in the form of guidelines or procedures.
6.3.4. Control

The following is a descriptive analysis of the project from the control viewpoint. It is based on the factors outlined in Table 4.6 presented previously in Chapter 4.

*Style*

The management at CM Ltd predominantly use critical variables as the main lever of control. They employ mechanisms such as budgeting and staff allocation to control the resources, systems and procedures to control the activities, as well as measures and milestones to control the outcomes. The style of control at CM Ltd is very much in line with the definition of diagnostic control provided in the previous chapter. This style can be characterised as mechanistic and traditional, focused on monitoring, assessing and rewarding/punishing. The performance of each department is measured and reported on a monthly basis with respect to set budget, as well as key performance targets and set project outcomes. Almost all the departmental managers had parts of their remuneration packaged tied to some of the measures for their own department. The effect of this style of control has been significant on the type of activities the management engage in. This makes it difficult for new initiatives to originate from people other than the top executives and gain support from other departments. However, if the project is initiated or strongly supported by the CEO or directors of the company, it will immediately receive attention from the management team. This was evident in the all-round support given to the B900 project by all departments involved. The style of control can also be attributed to the incremental style of change that CM Ltd has been engaging in. For instance, the need for an improved drilling process was recognised after monitoring and assessing the deteriorating performance of the B-Lines. It was not identified as the means for achieving a strategic objective, responding to a market opportunity or a potential threat.

*Flexibility*

The enforcement of control mechanisms at CM Ltd is relatively flexible. Although mechanisms exist for controlling the resources, activities and the outcomes, only those involving the outcomes were rigorously enforced. However, if the teams failed to deliver the required outcomes the attention would turn towards the controls around the activities and resources. In terms of rigidity, none of the control mechanisms were applied in a rigid manner. It was common for deadlines and milestones to be changed, project priorities altered,
systems and procedures modified and staff relocated, when the benefits of the change would justify costs associated with it.

Autonomy

Issues related to centralisation were discussed in the structure section. The CEO along with the founding directors, WS and BS, would exercise their authority on strategic projects. They would ultimately decide on what had to be done. At times they would specify in great detail the requirements of what they thought had to be carried out. However, the task of figuring out how the project was to be carried out was mostly delegated to the departmental managers. In the case of the B900 project this proved to affect creativity at the initiation stage of the project. The search space for a solution to the drilling problem was limited to the knowledge and the network that WS had built up in this area. Involving experienced operators and departmental managers in the selection process may have resulted in a completely different solution. However, the control process at the implementation stage resulted in an efficient yet flexible implementation process. The centralised decision making on what needed to be done reduced uncertainty and conflict. On the other hand, self-organisation of how project milestones were to be achieved provided the right amount of flexibility to overcome problems due to unforeseen changes. It also created an opportunity for interaction and collaboration amongst the team, which was critical for successful implementation.

6.3.5. Culture

The following is a descriptive analysis of the project from the culture viewpoint. It is based on the factors outlined in Table 4.7 presented previously in Chapter 4.

Typology

The culture at CM Ltd can be categorised as hierarchical. It is mechanistic, as it is mainly focused on control, order and stability. It is also internally oriented as the company is mainly concerned with developing internal capabilities and overcoming internal weaknesses, than market positioning and external threats and opportunities. As mentioned in the previous chapter, such cultural typology is mainly suited to incremental and exploitative innovation. The B900 project is very much in line with this culture type. It came about as a solution to an internally identified weakness without a clear connection to a market need or threat. The choice of the new machinery was decided at the top of the organisation, and, for the main part
of the project, the management focused on orderly installation and operation of the new machine.

Norms and Values
On technical matters, especially related to the factory, learning by doing is valued at CM Ltd. Practical and hands-on experience is regarded much more highly than academic knowledge. Both WS and BS had started out in the factory and were quite familiar with the operations of most of the machinery. In the eyes of the directors, especially WS, those who could demonstrate practical knowledge about the factory had credibility and their opinions were valued and trusted. They were also given some freedom to experiment. However, the number of people in this category was fairly limited. Furthermore, those who showed limited interest in the factory were regarded as too theoretical or academic and their opinions were easily dismissed. For instance, the managers of the marketing and finance departments were regularly criticised for not going to the factory and not knowing about the status of the factory and its capabilities. Consequently, very few people would tinker, experiment or propose new ways of doing things. Even those with some freedom to experiment, were limited by lack of tolerance for mistakes. The combination of this lack of freedom for experimentation and lack of tolerance for mistakes can explain high levels of centralisation and control discussed earlier. It also explains why most managers and employees would not challenge the opinions and decisions of the top executives (CEO and directors). Thus, it had become a norm for the top executives to dictate what needed to be done and for the departmental managers and other employees to follow orders without questioning. However, following orders does not mean that employees embrace the change. If they do not resist it, they are mainly indifferent towards it. On the surface the B900 project seems to have benefited from such culture, as the implementation and operation of the new machine was carried out successfully and on time. However, what can not be seen is what potential new ideas and new initiatives the company missed out on, due to a culture that does not encourage employee creativity.

Climate
The following is the climate analysis based on the SOQ model:

- Challenge/Involvement: The tasks associated with the B900 project were technically challenging and interesting. This was a contributing factor in engaging the project
team members. However, due to a low tolerance for mistakes, this also created a tense climate.

- Freedom: As mentioned earlier, the objectives and milestones were decided upon by the top executives and the individuals were given the freedom to self-organise in order to achieve the objectives.

- Trust/Openness: There was trust and openness amongst the project team members. This was reflected in the collaboration amongst the team during the planning and implementation stages of the project. However, the level of trust and openness between the project champion, WS, and the team was quite low. From the perspective of WS, the key to the trust was demonstrated technical competence. On a number of occasions WS had verbalised this by saying “people have to earn my trust”. This trust was key to open communication with WS and being able to voice ideas and concerns. On the other hand, the main obstacle for trust and openness from the team members’ perspective was WS’s low tolerance for mistakes and his position as the founder and director of the company.

- Idea-time: In general at CM Ltd, the amount of time people have for working on new ideas is very low. The company does not have any slack human resources. Most of staff are immersed in the day to day operations. Departmental managers work on a number of set projects, however their time is predominantly occupied by operational issues and problem solving in a “fire-fighting” mode.

- Conflict: There exists a sense of personal and emotional tension in the organisation amongst some of the managers and top executives. This at times overshadows rational decision making, which can have detrimental effect on new initiatives. However, in the case of the B900, this factor did not play a significant part.

- Idea-support: As mentioned earlier, the support of top executives of the company for new ideas depended very much on whose idea it was. There were a handful of individuals whose ideas and opinions were taken as valuable. Furthermore, the company employees were cynical of the success of any idea that had not originated from the top of the organisation. They were however, cooperative when a new idea came from the authority figures such as the top executives or the departmental managers.

- Debate: There is a tendency at CM Ltd to rapidly conform to the dominant view, which is often the view of the top executives. Vocalising minority dissent or
challenging the accepted status quo is discouraged to avoid confrontation. Therefore, instead of embracing minority dissent, which increases divergent thinking and creativity, most people would resort to political tactics, in order to gain the support of one of the directors and subdue the opposite viewpoint. Consequently, it was frequently observed during the B900 project that many people would hold back their ideas and only express them to trusted colleagues outside of the project meetings.

- Risk-taking: On the surface, there is a high tolerance for uncertainty and ambiguity at CM Ltd. The dominant view in the organisation is that too much planning and analysis can lead to “paralysis by analysis”. There was therefore a bias for action. However, the company still imposed some restraint on risky activity by only undertaking familiar projects, and limiting freedom to take initiatives to only those who were trusted.

- Commitment to group vision: During the B900 project there was a common understanding and full commitment to the project’s vision and objectives amongst the project team members. This is probably due to the fact that the key decisions for the project had been made prior to the formation of the team. The objective was therefore well-defined and simple to understand. However, the connection between the project to the overall organisational vision and objectives was not understood by all. In fact this had been the case for majority of the projects at CM Ltd (if not all of them). Although there is a written statement of the company’s vision and mission statement, the company’s strategic direction is ambiguous and uncertain to most employees. Only by looking back at the history of initiatives and decisions made by the top executives, one is able to deduce an emergent strategy. However, due to lack of time and at times limited cognitive skills, most departmental managers and employees at CM Ltd, are not able to reflect the company’s track record. Consequently, the overall vision and strategic direction of the company remains implicit in the minds of the top executives.

Leadership

The style of leadership demonstrated throughout the project matched the characteristics of transactional leadership. The focus was on coordination of activities, setting milestones, establishing rewards for the managers and managing by exception. As discussed previously this proved to be successful in terms of establishing control and managing the implementation stage of the project. This was also evident in the leadership behaviours
observed in the project. Out of those activities that led to an innovative climate, only those behaviours were observed that fitted the implementation stage of innovation. These were: monitoring, assigning tasks, providing resources, rewarding and recognising.

6.3.6. Resources

The following is a descriptive analysis of the project from the resource viewpoint. It is based on the factors outlined in Table 4.8 presented previously in Chapter 4.

Resource attributes

Analysis of the B900 machine as a resource reveals that it has three out of the five attributes of a resource that leads to competitive advantage:

- It is a valuable resource as it significantly boosts the flexibility of the drilling process, reduces its cost and improves its finish quality and consistency. Although, as discussed earlier, the full value and potential of the resource is not commonly known in the organisation.
- It is a rare resource as many of CM Ltd’s local and international competitors lack such state-of-the-art drilling machinery. In fact, the overall B900 line was the first of its kind in terms of configuration of a number of drilling and material handling equipments.
- It is complementary to the existing technology and resources within the company.
- It is not path-dependent, causally ambiguous or socially complex. It can thus be easily imitated by competitors with sufficient funds.
- It is not difficult to substitute it with equivalent technology. For instance, similar levels of flexibility and quality of drilling can be achieved by using a combination of CNC machines. In fact on a number of occasions that the B900 machine was down for maintenance, other CNC machinery in the factory was used for drilling.

Resource Availability

The project required external financing, and without it the project would not have gone ahead. CM Ltd had come out a number of years of good trading and as a result was in good standing with the bank. Furthermore, the company and its finance team had developed a good and transparent relationship with the bank over the years and, as a result, there was no major problem with securing the funds for the project. In terms of the knowledge, skills and
expertise required for the project, the company predominantly relied on its internal know- how for selection, purchasing, installation and operation of the new machinery. External knowledge providers were the experts from the technology vendor and the CAD company. This combination of internal and external knowledge resources was enough to successfully implement the new line. The company also had adequate workforce to carry out the changes required in the factory systems and layout. The staff on the shop floor were dissatisfied with some of the changes, but overall very were cooperative and showed a lot of flexibility to accommodate the changes. In terms of technology, the company had the appropriate IT infrastructure and CAD/CAM systems to use the capabilities of the machine. There was great awareness of the internal technological capabilities, which aided in the selection of the appropriate machinery. This was instrumental in success of the installation stage of the project. However, one major risk to the project was the fact that most of the knowledge and expertise necessary for the project existed in tacit form in the minds of a handful of internal experts. This shortage of internal experts meant that they were in high demand throughout the project. As a result many of the administrative tasks, such as writing up instructions, updating operating procedures, and comprehensive training of staff were put on hold.

Slack/Scarcity
Like most SMEs, CM Ltd does not have slack resources. It also was not severely constrained in terms of resources. This factor therefore did not play an important role in the B900 project.

Dynamic Capabilities
Resource acquisition is perhaps one of CM Ltd’s main strengths. As mentioned in the introduction to this case study, ever since its early years of inception, CM Ltd has followed a strategy of acquiring technological capabilities. They have also been successful at securing the external funding necessary for the resource acquisition. Both of these capabilities were evident in the B900 project and played a major part in its successful completion. However, it has to be noted that the main factor in these capabilities has been key individuals in the company and their relationships with people in the organisations that provided the required resources. For instance, it was because of the close relationship WS had developed over the years with individuals working for the technology providers that he was kept informed about the latest developments in panel processing machinery. It was also because of a personal contact and close relationship that the CAD manager had with certain employees of the CAD company that provided additional expertise for the project. Also, it was the professional and
transparent relationship between the company’s chief financial officer and the account manager at the bank that eased the acquisition of the necessary funds. Another notable characteristic of resource acquisition at CM Ltd, was that acquiring new capabilities was not led by a commonly agreed strategic plan or in response to an anticipated market requirement. In fact the process of seeking and acquiring new technical capabilities, like the B900, seemed to be carried out independently of new business development activities.

Indeed, it can be argued that business development activities at CM Ltd were led by the outcomes of the technical capability development. This is reflected in the fact that CM Ltd regards itself as a “Panel Producing Company”, which manifests a company-wide mindset that the company can turn its resources to any business opportunity as long as it involves wooden panels. In fact, a study of the historic development of the company reveals that CM Ltd has much experience in integration of new resources and reconfiguration of their existing resources to take advantage of new opportunities. For instance in the late 1980s, the company shifted its focus from the previously profitable US market to the local furniture market in New Zealand. This resulted in major changes in order quantities and product varieties, which significantly affected the configuration of the company’s resources. In a relatively short time the company managed to recombine its design and manufacturing capabilities to suit the new market requirements.

Another example is the flourishing of painted components in the company’s product families after the factory acquired a state-of-the-art paint line. Prior to this resource acquisition the marketing department had dismissed the need for high quality painted finish. But after WS convinced the top executives of the company to add high quality painted finish to their repertoire of production capabilities, CM Ltd acquired a sophisticated paint line. Soon after the implementation of the paint line, the marketing department increased their demand for painted components, to the point that it overtook the demand for other more traditional finishes. However, in the case of B900, although the new line was well integrated with the existing technology, systems and processes it did not lead to any major business development opportunities. This highlights a number of characteristics of the CM Ltd’s ability to integrate and reconfigure resources to create new business opportunities. Firstly, it is a clear indication that there is an absence of a planned strategic approach to resource acquisition and reconfiguration. Secondly, it shows that the resource reconfiguration process at CM Ltd, is very reactive and driven by clear signals indicating crisis or opportunity in the market.
Finally, it is evident that, on the business development side of the organisation (i.e. sales, marketing, design, etc), there is a lack of understanding of the new capabilities gained by acquiring the new technology.

The last point mentioned above is an indication of a critical dynamic capability which is underdeveloped at CM Ltd, that is: collective learning and sense-making. All across the organisation the management and employees come across or generate new pieces of information. However, the company lacks mechanisms, systems or even a culture for assimilating newly acquired information into the collective knowledge of the company. As a result only those with direct interaction with the new technology become familiar with its capabilities and consequently the remainder of the organisation is unable to make sense of what it means to have this new capability. Consequently, cognitive connections between opportunities and capabilities are not made outside the circle of the technical experts of the company, who do not have the same degree of insight into the requirements of the market and potentially new customers. For instance, if the marketers and designers who select the appropriate hardware for a given product are unaware of the new capabilities of the new drilling line, they may disregard certain types of hardware based on their historic knowledge of the old machinery. In the furniture industry hardware pieces such as handles, hinges, or drawer runners make a significant difference in the customers’ decision to purchase. Furthermore, even within the technical departments of the company there is a lack of comprehensive collective understanding about the machine’s capabilities. This makes it difficult for new projects to be initiated to take advantage of these capabilities.

Such limitation in collective learning and sense-making hinders another critical dynamic capability that innovative companies possess: strategic aligning. This is a major shortcoming for CM Ltd. As discussed in the previous sections there are clear indications of a lack of an explicit and communicated strategy that informs and influences key decisions, such as major capital expenditure in new technology. This is not to say that the company does not have a strategy. It is only claimed that the strategy is implicit in the minds of the top executives, and as such is not communicated to and learned by the rest of the organisation. The task of strategic aligning therefore can only be carried out by those with access to this implicit strategy. In other words, only the top executives of the company (CEO, WS and BS) can ensure the actions of the rest of the organisation are aligned with their vision and strategy. This has a number of negative effects. Firstly, the employees and departmental managers of
the company are disempowered to start major new initiatives. Secondly, the nature and type of major initiatives started by the company will be biased towards the areas of expertise and interest of the top executives. Both of these effects are observed in the case of the B900 project.

6.4. Case 2– Design and Implementation of a Manufacturing Performance Measurement System

This project was initiated with the aim of giving structure, accessibility and prominence to the company’s manufacturing performance measures. The principal researcher (referred to as MSH) in this study was the project leader. With the help of the manufacturing manager (referred to as MN), a simple framework was developed based on the balanced score card concept. Four categories of performance measures were proposed: Financial, Customer, Internal and Growth. An intranet-based portal was developed, referred to internally as the Criternet, and graphs associated with the proposed measures were displayed on Criternet (see Figure 6.2). A system was set up with the help of the IT department, through which relevant base data for the measures would be automatically collected, collated and used to calculate the final metrics that were graphically displayed on the intranet site.

Figure 6.2 Snapshots of “Criternet” - intranet based performance management system
6.4.1. Process

The following is a descriptive analysis of the project from the process viewpoint.

Problem Definition
The original idea for the project came from the company directors, WS and BS. Their request for a new approach to measuring and reporting manufacturing performance was mainly motivated by the fact that there were too many reports generated by various departments in the company. This had resulted in inefficient and unreliable reporting of information to the management and directors of the company. Since both directors believed very strongly in the importance of performance measures this lack of reliability and inefficiency was regarded as unacceptable. There was also frustration due to the fact that, although the directors wanted to introduce new measures, they were reluctant to do so until a more reliable approach was found. So the directive from WS and BS with regards to this project was to find a reliable and accessible way to consolidate and display the measures monitored by the directors.

However, because of the background of the two main leaders of the project, MSH and MN, they decided to take a more systematic approach. After discussing the decision making and monitoring needs of the production managers they added a number of additional requirements to reliability, efficiency and accessibility. These were:

- Balance: there was a general feeling amongst the production team that the existing measures were mainly cost oriented.
- Customisation: the system had to cope with specific and changing requirements of the directors, in terms of metrics as well as the style of representation.
- Simplicity and visual representation: existing measures were often reported in the numerical form and in multi-page printed documents, which was very difficult to follow by the production managers.

Problem Analysis
Before searching for a solution the project leader created a list of all the measures in the company. A thorough analysis of the inventory of measures was conducted in terms of methods of collection, collation and reporting of data as well as the purpose for creation and continued monitoring of the measures. It was observed that many individuals around the
company were responsible for running certain custom-made database queries to extract the required information. This was then manually entered in certain spreadsheets, which were printed and handed to the company secretary who was responsible for collation and distribution of these measures to the directors and the management team. This combination of manual processes and diversity of data sources were found to be the root-cause of the reliability and efficiency issues with the existing systems.

It was also found that there was a proliferation of measures, some of which were still produced and reported but rarely looked at. The analysis revealed that most of these measures had been set up to gauge the performance of processes that were at some point of special interest to the directors. Once their interest was shifted to other matters, previously set up measures continue to get reported, however new ones were created to cover the new areas of interest. As a result a considerable amount of resource was used to maintain the large inventory of measures, many of which had lost their importance or even relevance to the current situation of the company.

Furthermore, analysis of the nature of the measures revealed that most of them were historic in nature. This was evident from and strongly influenced by the fascination of the directors with comparing current performance with historic data, at times going back a decade. (This tendency to compare performance against history could be as a result of the personal involvement of the founders in the day to day activities of the business in the periods of growth and success and their attribution of this success to their own involvement). This often created frustration amongst staff as they felt the dramatic environmental and contextual changes that occurred over the years were not represented in one-dimensional trends so closely monitored by the founders. For instance, when studying historic measures of process efficiency, one must also take into account the increasing age and the resultant deterioration of the machine, as well as changes in the run sizes, number of set-ups and changing component parameters such as size or quality.

Search for the solutions

The responsibility to search for the appropriate solution was assigned to MSH and MN. Right from the beginning the idea of buying an off-the-shelf system was dismissed due to lack of financial resources as well as the likelihood of high levels of customisation required. Given the academic background of both project leaders, they started their search for an appropriate
framework in the academic literature. Using MSH’s access to academic databases a number of searches were conducted to identify some of the most popular performance measurement systems. Balanced Score Card (BSC) was selected as the framework of choice. The following factors influenced this decision:

- The directors as well as MN were familiar with the concept of BSC through articles in business journals.
- Most of the existing measures at the time were for the manufacturing operations and heavily biased towards measures of cost and efficiency. Other aspects of performance such as quality, throughput and delivery were not effectively measured.
- BSC was the simplest framework to communicate to others.
- BSC was the simplest framework to customise to the company’s specific requirements.

**Communication**

There was very little evidence of formal and planned communication of the project proposals, developments and outcomes to the wider organisation. At the start of the project, the manufacturing manager presented the plans for the use of BSC to the CEO and directors of the company, who approved of the concept. Once the system was up and running, WS dictated the use of the system, by asking the IT department to put a short-cut link to Criternet on every manager’s computer desktop. The manufacturing manager also enforced the use of Critenet by introducing it to the daily production meeting. This, along with the visible support the directors were giving to the project, was critical for persuading managers to regularly check the displayed measures. It is also important to note that giving the system a name proved very useful in terms of ease of communication about the project and the system. Credibility and transparency proved to be very important in order to get more buy-in from the production team. At the beginning there was some element of mistrust in the manner the metrics were calculated. It was therefore very important to explain how the data was collected and calculated. This became especially important when financial incentives were offered to selected production managers for reaching and maintaining certain performance targets.
Collaboration

This project was run by a very small project team of two engineers (MSH and MN). Expertise of others would be used on occasions, but mainly on a temporary basis. For instance, the IT department would be involved purely for programming and bug-fixing purposes. As a result the project was heavily biased towards the engineering world view.

In terms of cooperation, there appeared to be very little resistance to the new performance measurement system. Given the importance of the project, it also meant that tasks associated with the project (e.g. programming by IT for a given metric) would be given high priorities, which ensured on-time completion. The level and manner of interaction between the IT and project team was also a key factor in successfully collaborating to complete the assigned tasks.

Politics

As mentioned before this project was fully supported by the directors of the company, who hold powerful positions and are involved in many of the company’s decisions. Their direct involvement made the diffusion of the new system much quicker. However, it also resulted in the directors influencing a lot of the decisions with regards to what measures should be included in the system. The BSC framework along with the high regard both directors had for MN, helped in avoiding significant bias towards measures requested by the directors. As a manufacturing manager, MN had a good overview of the requirements of the production team in terms of performance management. He would therefore use his credibility to persuade the directors to take a more balanced approach.

Planning

There was very little formal planning done by the project team. This is due to a number of factors. Firstly, there was no real deadline ever defined for the completion of the project. There was never a demand for a project plan and thus the project was mainly treated as an ongoing activity. Secondly, there was little prior experience with setting up a system like this, and as such it could not be used as a template for planning.

Scanning

Throughout the project MSH kept himself informed about latest developments in MS Excel (the main tool used for calculation of metrics and creation of charts). This proved very useful
as new features in the new version of the software were used to increase the quality of the graphs and the information presented. MSH also kept in touch with new developments in area of business performance management software and data mining software. A number of presentations were organised for various companies to come and present their software packages. In spite of better functionality and reliability, these packages were not considered by the directors due to loss of their ability to customise measures as well as high costs associated with purchasing the software.

Organising
The organising of tasks associated with this project was done in a similar fashion to the B900 project.

6.4.2. Structure
The following is a descriptive analysis of the project from the structure viewpoint.

Market Competition
This project was not directly led by market forces. However, it can be argued that due to competition, the company needed to have better control over the performance of the factory.

Network
This project was carried out using internal expertise. Therefore external networks had little or no influence on this project.

Internal structure
The centralised structure of decision-making at CM Ltd, was quite evident in this project. It once again proved helpful at the implementation stage. However, it was very limiting in terms of the design and development stages of the project. Both WS and BS were deeply involved in deciding what measures should be included in the system. They even imposed control over the method of data collection, calculation and the structure and details of graphs.

In terms of formalisation, there was little evidence of formal routines. In fact there were a number of attempts to formalise the process for requesting new measures. However, since the requests would normally come from the directors, attempts to formalise the process failed.
The lack of formality however proved very inefficient, as on many occasions there were instances of miscommunication in terms of exact requirements of a measure.

6.4.3. Knowledge

The following is a descriptive analysis of the project from the knowledge viewpoint.

Sources of Knowledge
The main source of knowledge for this project was the awareness of the internal requirements of the means for effective management of factory performance. MN and WS were instrumental in identifying those metrics that were critical to the performance of the factory. Also, as mentioned previously, MSH and MN searched through academic literature for an overall framework which gave the system structure and purpose.

Type of Knowledge
A mix of tacit and explicit knowledge was available and used for this project. Most of the knowledge regarding the best ways to manage the performance of the factory, and overall performance targets for the manufacturing system were in tacit form. The reasons behind the creation and reporting methods of the existing measures were also in tacit form. At the start of the project, MSH and MN made the above knowledge explicit. Doing so enabled the project team to systematically analyse the existing measures as well as the existing requirements of directors and production managers. This proved to be critical in identifying the root-causes of the problem.

The main explicit forms of knowledge used in this project were the existing performance reports, emails from the directors expressing their frustrations with the existing system, as well as academic articles and books in the area of performance measurement and business process management. Internalising this explicit knowledge allowed MSH and MN to adapt the BSC framework to the requirements of CM Ltd and to become aware of potential issues that had occurred during implementation of BSC in the case study companies mentioned in the literature.
Absorptive capacity
There was a tendency from the directors of the company to measure performance in two dimensions: cost and delivery. Although the BSC framework assisted in promoting a balanced approach to measuring and managing performance, the eventual set of the measures compiled in the project still shows the bias towards internal measures of cost and customer measures of delivery (see Figure 6.3). This bias made it very difficult to introduce new measures addressing other dimensions of performance. For instance, MSH had found a comprehensive list of manufacturing measures promoted in Neely et al’s (Neely et al., 2002) concept of “Performance Prism”, but was unable to gather support for implementing those measures.

Knowledge Conversion Processes
The most dominant process in dissemination of knowledge in development and implementation of Criternet were socialisation. Transfer of knowledge about how the system was put together and maintained, mainly happened between the project team and the IT department. This occurred predominantly during collaborative work between MSH and programmers in the IT department. By looking over each other’s shoulders when fixing a problem or working on a program to extract and manipulate data, the parties became quite familiar with how they each developed their parts of the system. This proved to be a critical factor in the success of the project as the requested metrics became more complex. The knowledge gained through these interactions enabled MSH to better translate the commonly ambiguous and complex requests for new metrics into easy-to-understand instructions for the
programming team. It also allowed MSH to respond to the requests with an informed estimate of time of delivery and resources required.

*Exploration vs Exploitation*

Similar to the B900 project, the bulk of knowledge about Criternet was localised in the minds of the project team as well as some of the IT staff. Furthermore, very few people in the company were aware of the significance of the structure provided by the BSC framework. BSC is a strategic performance management approach, which links the measures to strategic objectives. Although, as illustrated in Figure 4.3, MSH and MN displayed the strategic objective associated with each set of measures (on the left hand side of each quadrant), these were hardly noticed. As a result, Criternet was mainly treated as an electronic display board rather than a tool for strategic performance management. This was evident in the fact that soon after its implementation, due to the request of some of the managers, other types of information such as meeting minutes, phone list, etc were posted on the site.

*Interaction and Collaboration*

No formal structure was set up to disseminate the knowledge gained by MSH and MN to other staff. However, as mentioned previously, due to the need for cooperation between IT staff and the project team, a collaborative climate was generated, which proved beneficial for the success of the project.

### 6.4.4. Control

The following is a descriptive analysis of the project from the control viewpoint.

*Style*

Similar to the B900 project, the diagnostic style of control at CM Ltd was evident in the manner the need for the new system was recognised (i.e. the degradation of reliability and increasing cost of maintaining the old system). The project aimed at incremental improvement of the performance measurement and reporting system, rather than seeing this as an opportunity to connect factory performance to strategic objectives and market opportunities.
Flexibility
In the same manner as the B900 project, it was common for deadlines and milestones to be changed, project priorities altered, systems and procedures modified and staff relocated.

Autonomy
MSH and MN had full autonomy on how they constructed the Criternet. However, WS exerted a lot of control on the choice of measures and details related to their presentation on the Criternet.

6.4.5. Culture
The following is a descriptive analysis of the project from the culture viewpoint.

Typology
Hierarchy culture (mechanistic and internally oriented) in CM Ltd is evident in the Criternet project. The new performance management system is seen as a solution to an internally identified weakness without a clear connection to a market need or threat.

Norms and Values
Both MSH and MN had a good track record of successful projects and had demonstrated their knowledge of the factory processes on a number of occasions. As a result, they were both trusted by WS to develop the performance management system. They were also given some freedom to experiment. It was indeed through experimentation with MS Excel that MSH discovered a number of novel ways to automatically update the data, calculate the metrics, generate graphs and save them in the appropriate format in a manner that was accessible through the intranet site. This inventive solution meant that CM Ltd could use its existing technologies to produce the required measures, while completely eliminating the need for manual processing. In terms of low tolerance for mistakes and resistance to change, similar behaviours were observed in the B900 project.

Climate
The following is the climate analysis based on the SOQ model:

- Challenge/Involvement: This was a challenging and interesting project and, as a result, those involved were highly motivated. However, as the project progressed and
more time was spent on making small adjustments and debugging, the levels of motivation dropped noticeably.

- **Freedom**: The project team were given the freedom to experiment, which as mentioned previously resulted in a creative and novel solution.

- **Trust/Openness**: There was trust and openness among the project team members and the IT team. This was reflected in close collaboration amongst the team.

- **Idea-time**: MSH had a project oriented role and thus was one of the few people at CM Ltd who was given time to work on new ideas for improvement and innovation.

- **Conflict**: This was not a factor in this project.

- **Idea-support**: As mentioned previously MSH and MN were trusted by the directors and thus were given full support for the project. Their support was critical in lifting the priorities of Criternet-related tasks in the IT department’s project list.

- **Debate**: The company climate discouraged debate. Thus, as with the B900 project, most stakeholders conformed to the opinions of the directors.

- **Risk-taking**: There were low risks associated with this project as mainly internal resources were used and the project outcomes had little immediate effect on the ongoing operation of the company.

- **Commitment to group vision**: MSH and MN were both committed to the project objectives. This was helped by having MN and MSH involved from the very beginning of the project, and allowing them the freedom to experiment and be creative.

*Leadership*

MN as the senior member of the project team employed a participative style of leadership, and demonstrated all of the innovation inducing behaviours listed in Chapter 4. This was very instrumental in gaining the full support and commitment of MSH throughout the project.

### 6.4.6. Resources

The following is a descriptive analysis of the project from the resource viewpoint.

*Resource attributes*

Analysis of the Criternet as a resource reveals that it has two out of the five attributes of a resource that leads to competitive advantage:
• It is not a valuable resource, as without connection to the company’s strategy it does not affect its competitiveness.
• It is complementary to the existing technology and resources within the company.
• It is path-dependent as it was developed internally through a novel use of existing technology.
• It is not rare, as there are many commercially available systems around and in use in many companies.
• It is not difficult to substitute it with equivalent technology.

Resource Availability
There was no budget allocated to the project for expenses other than staff time. This pushed the project towards an internally-developed system. In terms of the knowledge, skills and expertise required for the project, there was adequate knowledge about production processes as well as the capabilities of the available IT infrastructure. However, there was the need for much learning by experimentation, as in the absence of financial resources the team could not afford to hire experts to develop the required tools. Furthermore, the IT team were a shared resource very much high in demand. The company’s aging IT systems required much maintenance. There were also other projects that the IT department were working on. Securing the support of the directors was critical for gaining access to the in-house programming resources. However, as most of the measures that were of special importance to the directors were completed, less importance was given to the completion of the remaining measures. As a result many of the seemingly non-essential measures still remain incomplete.

Slack/Scarcity
Scarcity of resources was an important factor in this project. If the company had slack financial resource it would most likely have invested in a commercially available system. However, scarcity of resources forced the company to develop an in-house solution. The multiple project setting and high demand on a shared resource such as IT, also affected the project by increasing its duration and dragging out the eventual project completion.

Dynamic Capabilities
Of the four categories of dynamic capabilities, learning and strategic aligning were the most relevant to the Criternet project. This project, similar to the B900 project, demonstrated that
CM Ltd is limited in terms of its ability for collective learning and sense-making. The company lacks mechanisms, systems or even the culture for assimilating newly acquired information into the collective knowledge of the company. As a result only those with direct interaction with the developed infrastructure behind Criternet become familiar with its capabilities. Consequently the remainder of the organisation is unable to make sense of what it means to have this new capability.

The other shortcoming observed in both B900 and Criternet projects, was strategic aligning. As discussed previously, at CM Ltd the task of strategic aligning can only be carried out by the top executives of the company (CEO, WS and BS). This was evident in the fact that the project was started in order to alleviate the frustrations experienced by the top executives of the company and not as a strategic initiative. Moreover, the strategic benefits of the project were not recognised even after MSH and MN had adapted the BSC framework and explicitly attempted to link the performance measures to the strategic objectives of the factory. This was mainly because the strategic relevance of the performance management system was not shared by the top executives of the company. Therefore, it was not explored any further.

6.5. Conclusions

The following summarises the main insights gained through the multiple-view analysis of the case study projects at CM Ltd:

- The multiple-view model of innovation enabled the comprehensive analysis of the case study projects.
- The case-studies confirm the characteristics identified in the literature review in Chapter 5.
- The directors play a significant role in determining the dynamics of the innovation process at CM Ltd. They affect the innovation process from all viewpoints. Their position as the central decision maker, their in-depth knowledge of all facets of the organisation and their power to influence the activities at all levels of the company, put them in a position to be the main (if not the only) instigators of significant change and innovation in the company. Their attitude towards knowledge management, communication and collaboration directly influences the company’s norms and routines in these areas. They play an important role in creating linkages and alliances with external entities. Their personal objectives, areas of interest and vision for the
organisation have a direct effect on the types of innovative initiatives the company undertakes. Finally their leadership style and behaviour have a strong influence over the company’s culture and climate.

- System and process innovation at CM Ltd is not carried out based on an explicit and well-communicated strategy. Looking back at the various major projects of the company over its history reveals an emerging pattern that can give insights into the company’s implicit strategy and direction.

- The company had limited resources, which posed restrictions on the projects. The main resource limitations were finance as well as technical and managerial expertise. Those who had demonstrated technical and managerial capabilities were shared among multiple projects, had numerous responsibilities and were often busy with their operational duties. Moreover, CM Ltd demonstrated major shortcomings in critical dynamic capabilities, namely collective learning/sense-making and strategic aligning.

- Management of knowledge was not given its due attention at CM Ltd. The preferred mode of learning was through observation or experience, and little effort was made to convert the wealth of knowledge created through observation and experience into explicit forms. Consequently most of the knowledge related to the projects remained in tacit form and in the minds of a handful of individuals who were directly involved with the development processes. Due to limited availability of internal expertise, demonstrably possessing knowledge was a major contributor to lifting the importance and status of the knowledge holder in the eyes of the directors. This appeared to be a significant influence on a company culture that did not encourage sharing of knowledge.
Chapter 7. Framework for Strategic System and Process Innovation in Manufacturing SMEs

7.1. Introduction

In Chapter 3, the notion of strategic system and process innovation was defined and explored in the context of a manufacturing system. This was followed, in Chapter 4, by a comprehensive analysis of the innovation process, resulting in the development of a multiple-view model of innovation and its critical determinants. In Chapter 5 a review of literature was conducted to highlight those characteristics that impact system and process innovation in SMEs. Finally in the previous chapter the multiple-view model of innovation was used to analyse two case studies of system and process innovation in a manufacturing SME. The analysis resulted in providing contextual insights about the dynamics of system and process innovation in manufacturing SMEs.

In this chapter, the in-depth understanding of system and process innovation in SMEs developed so far is used to develop a supporting framework for strategic innovation tailored to the specific needs of SMEs. The framework will act as a conceptual yet practical model of the innovation process that will assist managers and practitioners in successful planning and implementation of strategic systems and process innovation in SMEs. It will have a structure which outlines the necessary phases of the innovation process, as well as a set of guiding principles that can be used to design or select tools and methods suited to the requirements of SMEs at each phase.

7.2. Structure of the framework

Tidd and Bessant (2009) provide a useful structure for categorising issues related to managing innovation. These are:

- issues related to innovation strategy,
- issues related to organising for innovation, and
- issues related to the innovation process.
A review of the SME characteristics discussed in the previous chapters and their impact on the innovation process reveals that they can be classified into the above three categories.

The first group are those characteristics that influence the strategic aspect of innovation in SMEs. These include: emergence, incrementalism, internal orientation, short-termism, the implicit nature of strategy, and the informal and unstructured approach to planning.

The second group consists of characteristics that affect the context in which innovation is to take place. These include the nature of the SME’s relationships with external entities, scarcity of financial and human resources, centralised organisational structure, lack of awareness about knowledge management, as well as an unsupportive organisational culture and climate.

The third group of SME characteristics consists of those that affect how the innovation process is carried out. They include the absence of a systematic approach to solving problems, disregard for soft aspects of change, the centrality of decision-making, lack of planning, poor communication, and lack of attention to diversity and collaboration.

Based on these categorisations, the framework was therefore structured in three phases in order to address each group of characteristics. These phases, called Plan, Prepare and Process, are described in the remaining sections of the chapter.

### 7.3. Phase I – Plan

The main aim of this phase of the framework is to develop a strategic plan for systems and process innovation, highlighting the main strategic themes which become the focus of the company’s innovation activities. The emphasis in this phase is to externalise all the existing yet implicit information that is required for deciding on the strategic innovation themes. By approaching this systematically the gaps in the existing knowledge and strategic outlook will be revealed. More importantly it will also aid the development of a shared mental model within the management of the SME about the strategic intent of the organisation and its effect on manufacturing systems and processes. This shared mental model of the innovation strategy will be instrumental in improving communication and coordination of activities, as well as aligning the interests and activities of various parts of the company with the firm’s strategy.
Based on the insights gained through the analyses presented in the previous chapters, the effectiveness of this shared mental model of strategically aligning future innovation activities depends on two main factors. First, the development of the innovation strategy must be focused on the relationship between the manufacturing system and the firm’s competitive advantage. Second, the knowledge, experience and influence of the owner/manager must be recognised and the developed strategy must be in line with his/her vision, area of interest and personal objectives.

Based on the insights gained through the analyses presented in the previous chapters, the effectiveness of this shared mental model in strategically aligning future innovation activities depends on three main factors:

1. The development of the innovation strategy must be focused on the relationship between internal capabilities and opportunities to enhance the firm’s competitive advantage.

2. The knowledge, experience and influence of the owner/manager must be recognised and the developed strategy must be in line with his/her vision, area of interest and personal objectives.

3. SMEs have limited financial resources. As a result the conditions and requirements set by the internal and external financers of innovation play a crucial part in developing the innovation strategy.

To ensure the first factor is taken into account it is important that those involved in developing the strategic plan of innovation, are fully aware of the firm’s existing capabilities and current levels of performance (Tidd and Bessant, 2009). It is also important that they are aware of the potential market and technology opportunities that exist in the business environment of the firm (White and Bruton, 2010). Based on these sets of information and along with considerations given to the later two factors stated above, an effective and comprehensive strategic plan for system and process innovation can be developed. These important considerations are illustrated in Figure 76.1 and are explored in more detail in the following sections.
7.3.1. Capabilities

Understanding the limitations of the existing capabilities is a key step in planning for development or acquiring new ones. Most SMEs are well aware of their capabilities; however, this knowledge is mainly held by selected few internal experts and is most likely in a tacit form. Externalising the knowledge about the company’s capabilities means that more people in the organisation can make the connection between internal capabilities and external opportunities. Developing a thorough understanding of the firm’s capabilities also means that better and more informed decisions can be made with regards to acquiring new resources and capabilities. This is very important for SMEs as the risk of getting the wrong resource can be an obstacle to initiating significant change in small firms.

In fact, by better understanding the current capabilities the solution for significant improvement in performance might be found in reconfiguring the existing resources and capabilities rather than acquiring new ones. This is particularly relevant to SMEs, as it uses one of their main strengths (resource reconfiguration), which results from their small size, flexibility and centralised decision making. It also means that less capital will be required for reaching the desired levels of performance.
7.3.2. Performance

The main objective of strategic system and process innovation is to improve manufacturing performance. As discussed in Chapter 3, manufacturing performance is multidimensional. It is important to assess the performance of the manufacturing system in each dimension in terms of current, potential (performance frontier) and world class levels of performance. It is very likely that the SME would not have the mechanisms in place to accurately assess their performance with hard measures. Given that this assessment is done with the purpose of highlighting gaps in performance as potential areas of focus for the innovation process, the emphasis should not be on measuring the exact levels of performance. Instead, the focus should be on assessing the relative positions of the levels of performance in each dimension.

While it is encouraged to use quantitative measures, given the dominance of tacit knowledge in SMEs it is recommended that a diverse team of management and employees conduct a group analysis of the company’s manufacturing performance. Although it is the performance of the manufacturing systems that is being assessed, it is important that the group is externally oriented and that the views of customers and insights about performance of competitors are taken into account. It is therefore critical that the assessment team includes knowledgeable people from all areas of the business, especially from the sales and marketing department.

Once a common understanding of manufacturing performance is reached, it is essential that dimensions of performance are prioritised based on their contribution to the firm’s competitive performance. This can be done systematically by dividing the performance dimensions into categories of order-qualifiers and order-winners. After prioritising the performance objectives, the group must analyse the main constraints and trade-off relationships that limit the system’s performance from reaching world class levels. Elimination of these constraints and trade-offs should be the focus of the innovation process.

However, given that the management in SMEs are mainly concerned with short-term operational problems, it is very likely that the focus at this stage is shifted towards operational issues. While it is important to emphasise the long-term strategic issues facing the organisation, understanding the short-term operational problems of the company is not without merit. Survival is a major concern for small businesses and fire-fighting is a major
drain on key resources within the company. It is therefore important to select an innovation path that resolves some of the operational problems on the way to addressing long-term strategic issues. This will also result in buy-in from the management and employees, as their immediate concerns are addressed.

7.3.3. Market

As discussed in Chapter 3, strategic resonance is reached when development of manufacturing capabilities is informed by the dynamic changes in the market. It is therefore necessary to understand the competitive forces in the market and to identify changes in the critical variables of the business environment. A number of techniques such as, for example, Porter’s Five Forces (Porter, 2008) and Prospective Scenario Development (Ratcliffe, 2006) can be used to systematically scan the market, and develop insights, that are used in the strategic planning of innovation. Figures 7.2 and 7.3 illustrate these techniques respectively.

At this stage it is very important to consider the breadth of the scanning process. Making the scope of scanning as wide as possible ensures the peripheral area of the firm’s vision is not ignored. This is important as many of the first signs of shift in the business environment can be noticed by scanning the periphery. Given that most SMEs operate in dynamic and uncertain business environments, having a narrow and deep focus for scanning can be problematic. However, as discussed in Chapter 4, scanning the periphery can be resource-intensive and may lead to too much divergence. It is therefore recommended that techniques that are used for scanning should facilitate rapid information processing, quick sense-making and fast refocusing.

Figure 7.2 Porter’s Five Forces (Porter, 2008)
7.3.4 Technology

Technology plays a crucial role in innovation. Most change in manufacturing SMEs’ systems and processes comes from implementation of new technology. As a result, management of SMEs, especially their owner/managers, generally have a very good understanding of their technological needs. They are also usually well aware of the available technology in the specific areas of their firm’s operation. Very often they develop close relationships with a number of technology providers.

While the strength of these relationships provides the owner/manager with detailed information about the latest developments, it also narrows the scope of the technology scanning process. As with the market scanning, it is very important at the strategic planning stage of the innovation that a wider perspective is used for technology scanning. This ensures
some of the seemingly unrelated developments and trends in technology are taken into consideration.

It is also important not to just view technology as the solution to the strategic problem. In this view adoption of the advanced technology becomes the main objective of the innovation project. Technology, however, can also be viewed as the enabler or facilitator of innovation. Information and communication technology is a rapidly changing field, with many new developments improving connectivity, knowledge management and information processing. The popularisation of open source software and social and professional networking sites provides SMEs with access to latest technology in a very cost-effective manner.

Not only can these technological developments be used to reach new customers and new markets, they also have the potential to enhance the internal information processing and communication activities amongst all functions of the organisation.

7.3.5. Owner/Manager

As discussed in the previous chapters, owner/managers of SMEs play a significant role in determining the nature and direction of change in their firms. They are the key driving force for change in SMEs. Given their standing, power and influence, any major change that does not have their support will either fail or face strong opposition. It is therefore crucial for any plan for strategic innovation to consider the owner/manager’s vision, areas of interest, personal objectives and worldview. It is very likely that this information is not available in an explicit communicable format, and must therefore be externalised. Modelling techniques such as cognitive mapping can be useful to achieve this.

A look back at the history of change and improvement in the firm’s capabilities should also provide insight into the implicit strategy that the owner/manager has been following. Paying attention to the narrations and activities of the owner/manager can also provide a guide to their main areas of interest, their vision for the business and the worldview on which their decision is based.
7.3.6. Finance

Funding is a critical requirement for successful innovation. Given that most SMEs have limited financial resources, it is very likely that any significant innovation project undertaken by the firm would need external funding. As discussed in the previous chapter, most SMEs are mainly aware of traditional sources of capital, and are not very familiar with other sources of funding such as angel investors, venture capitalists or government agencies. It is important at this stage, to identify potential sources of finance and fully understand their requirements. Banks, angel investors and venture capitalists have various stringent requirements, mainly around risk and financial return. Government agencies however, have other specific requirements based around government’s strategy and priorities.

Knowledge about various funding opportunities and their specific requirements is very important for consideration of the direction and nature of the innovation project at the planning phase. For instance, knowing that the government provides funding for projects with high potential for export may have a significant effect on the type of initiative undertaken by the SME.

7.4. Phase II – Prepare

Before the strategic plan of innovation developed in Phase I is implemented and innovation projects are started, it is critical to ensure the antecedent conditions for successful innovation are present. The aim of Phase II of the framework is to assess the current situation and become aware of the elements within the organisation that significantly affect the innovation process. As Isaksen (2007) contends, by deliberately assessing the situation of the firm before any change takes place, the leaders in the organisation can increase the likelihood that they will consider more factors while guiding significant change.

Given that the multiple-view model of innovation presented in Chapter 4 (Figure 7.4) enables a comprehensive analysis of innovation determinants, it will be used to help prepare the conditions necessary for successful innovation.
7.4.1. Process

From a process perspective, preparing for innovation is concerned with setting up mechanisms that enable a number of critical processes. One of these processes, communication, is potentially a weakness in most SMEs. Although the flexible and informal organisational environment of SMEs allows for interaction and informal communication, the owner/managers are generally very selective in their communication with regards to strategic matters. Moreover, the subject of communications between owner/managers and their subordinates is often directives for implementation of decisions that have already been made. However, as discussed in Chapter 4, this is not the most effective method of communication for diffusion of innovation. Instead, the style of communication must be persuasion, which increases participation and reduces resistance to change. It is therefore proposed that mechanisms be established for persuading the company’s employees to participate in the innovation process. This also requires setting up mechanisms for employees to contribute their ideas, concerns and other information relevant to the innovation process.

Another important process which requires preparation is collaboration. Once again SMEs demonstrate limited collaboration capabilities, resulting from the owner/manager’s drive for independence and centralised decision-making. In Chapter 4 diversity was found to be a critical element of collaboration resulting in improved creativity and avoiding early conformance. Preparation must therefore focus on identifying a diverse range of collaborators. Stakeholder analysis (Savage et al., 1991) is a technique that can be used to identify all groups and individuals who may have relevant knowledge, expertise or other resources that are useful for the innovation process.

The analysis can also be used to assess each stakeholder’s position of power, degree of influence, interests and objectives. This helps with understanding the political dynamics that
must be managed in order to get support and approval for the project. It is also important to identify the dominant political narrations in the organisation and to assess whether they are aligned with the innovation strategy or whether a competing narration is to be developed and popularised.

Furthermore, successful innovation requires mechanisms for managing multiple projects, and assigning tasks and resources across organisational and functional boundaries. Most organisations have existing systems for managing projects and existing protocols for sharing resources between functional departments. It is therefore necessary to assess the effectiveness of the existing systems and to understand how task priorities are set in the organisation. There is also a need for a mechanism for active scanning that ensures an inflow of information and ideas from outside the firm throughout the project.

### 7.4.2. Structure

From a structure perspective, preparing for innovation is not about making major structural changes in the organisation but rather about becoming aware of opportunities and obstacles that the existing structure provides. One of the structural characteristics that affects innovation is boundary openness. This is particularly important to SMEs since they have limited access to resources. Opening the firm’s boundaries provides the SME with the opportunity to gain access to resources and capabilities it does not have. However, as pointed out in Chapter 4, the owner/manager plays a critical role in the nature of the SME’s relationships with external entities. His/her attitude towards independence, risk taking and appropriability determine the level of openness the company is willing to embrace. Analysing the existing network ties provides great insight into why the company engages in external alliances and how it exploits them. The analysis should also highlight opportunities to make new connections and to take advantage of some of the existing but unexploited alliances.

In terms of internal organisation the most important factor for SMEs is centralisation. In the right context centrality is beneficial and indeed desired. As discussed in the previous chapters and observed in the case study projects, centralisation is a key success factor at the implementation stage of the innovation process. However, given the special role that the owner/manager of small firms plays in the innovation process, it is near impossible to dismiss the owner/manager’s influence at the early stages. Instead, structures and mechanisms must
be devised that encourage employee participation and delegation of responsibilities, while maintaining the independence and decision making rights of the owner/manager on macro issues.

### 7.4.3. Knowledge

As concluded in Chapter 5, awareness about how knowledge is managed is very low in SMEs. A thorough analysis must therefore be carried out in order to identify existing and required knowledge types, sources, storage mechanisms and sharing processes.

The analysis should begin with evaluating the knowledge requirements of the innovation project, the gaps in the existing organisational knowledge, and the potential sources from which knowledge can be acquired. Moreover, given that there is a bias towards tacit knowledge in SMEs, the preparation activities should consider the means for retaining and sharing tacit knowledge. The analysis should also aim to identify existing repositories of explicit knowledge and potential mechanisms for more effective dissemination of this knowledge type among all stakeholders. Also, use of information technology for managing knowledge must be explored.

### 7.4.4. Control

Control is a critical factor in managing innovation. If exercised appropriately it can lead to successful completion of the innovation process, and if applied incorrectly it stifles creativity, discourages participation and compromises learning. Control in most SMEs is centralised and more in line with the diagnostic style of control. It is also informally enforced and flexible in its application.

The focus of the preparation activities from the control perspective must therefore be on identifying the means for introducing and implementing a more interactive style of control, which emphasises uncertainties, possibilities, and risks. Attention must be given to control mechanisms that provide guidance for seeking new ideas, stimulating new initiatives and giving legitimacy to self-organised teams.
7.4.5. Culture

Culture is one of the most important determinants of innovation. It is however, the most difficult to influence and alter. The aim of the preparation process is therefore not to create an innovative culture (it takes years to develop a new culture), but rather to understand the impact of the existing culture on the innovation process.

Assessment of culture should begin with the Competing Values Framework (see Chapter 4) to identify the dominant typology of culture in the organisation. This provides insights into the nature of innovation that fits the company’s culture type. For instance, if the SME is found to have a clan culture, it is more suited to long-term collaborative innovation projects (Cameron et al., 2006). The cultural assessment should be followed by an assessment of the firm’s climate. The SOQ framework presented in Chapter 4 is a useful tool, which has been demonstrated to highlight the key characteristics of innovative organisational climates.

7.4.6. Resource

Many of the aspects related to the resource perspective have been covered in Phase I, as well as in this phase under structure and knowledge. However, special attention must be paid to the human resource requirements of the innovation process. Many of the SME’s most skilful and knowledgeable staff also have the most number of responsibilities and are high in demand. Consideration must be given to appropriate use of these resources, or mechanisms to alleviate some of their responsibilities and time-consuming activities.

7.5. Phase III – Process

The planning phase of the framework provides a number of strategic themes which guide the creative process in line with the firm’s strategic objectives. The second phase of the framework prepared the antecedent conditions for successful innovation. In Phase III, the organisation will initiate, develop and implement solutions to the issues highlighted by the strategic plan of innovation.

As discussed in Chapter 4, there are three groups of processes that take place concurrently throughout the various stages of the innovation process. These are creative problem solving,
internal diffusion and project management processes. The following sections explore these processes in line with the specific requirements of SMEs.

7.5.1. Creative problem solving

Applying a systematic and structured approach to defining, analysing and solving the innovation problem is a major contributor towards successful innovation. Although there are many tools and methods available for systematic problem solving, it is very likely that most SMEs are not familiar with them. Therefore, the SME might require external resources to aid the application of these methodologies. However, it is less costly and more practical if SMEs apply the general principles behind these techniques in a manner that suits their requirements and in-house expertise. As discussed in Chapter 4, these principles are:

- Defining the problem using a systematic and holistic approach, that considers all stakeholder viewpoints, and various soft and hard aspects of the organisation.
- Analysing the problem in a structured and fact-based approach, with the aim of identifying the root-cause of the problem, i.e. system constraints and trade-offs.
- Devising innovative solutions that eliminate system constraints and trade-offs.

7.5.2. Internal diffusion

Special attention must be paid to the internal diffusion of innovation at all stages of the innovation process. Through internal diffusion, individuals in the organisation become aware of the innovation and form attitudes to it, based on which they support, resist or behave indifferently towards the proposed changes. This is particularly important when these individuals are major stakeholders of the innovation project and have the power and influence to stop or derail the project. As a result, internal diffusion is one of the most important contributors to the success or failure of innovation, and must receive careful consideration. In Chapter 4 three groups of processes were identified which had significant impact on internal diffusion. These were communication, collaboration and politics. Effective use of these processes is thus critical for successfully completing the innovation project.

Effective communication encourages participation and diminishes resistance that is attributed to lack of understanding and fear of change. The main purpose of the communication process should be to persuade the stakeholders through logical presentation of evidence and rationale for advocating the innovative solution. It should also inform the stakeholders about the
support of the influential advocates of the innovation. The critical factors for effective communication are transparency, appropriate codification and credibility.

Effective collaboration leads to increased cooperation and trust while encouraging diversity of opinions and creativity. It requires supportive climate, structural integration and creation of ample opportunities for personal interaction and cooperation. Finally, effective use of political tactics gains the support of the key stakeholders of the project, especially the SME owner/manager. This requires using the results of the stakeholder analysis performed in the previous phase to plan and deliver communications aimed at informing and persuading the stakeholders.

7.5.3. Project management

System and process innovation is complex and brings change to many interconnected elements in the organisation. Successful completion of the innovation process requires effective planning, coordinating and controlling a series of activities and events involving internal and external resources.

In Phase III of the framework, planning is mainly concerned with predicating the activities and resources required to deliver outcomes in line with the strategic innovation plan developed in Phase I. As discussed in Chapter 4, the effectiveness of the planning process is enhanced by prior experience. It is therefore recommended to use the collective experience of all major stakeholders, especially the owner/manager to develop the plan. This reduces the risk by ensuring the plan is based on a comprehensive body of experiential knowledge, and that it has the support of all the main stakeholders. It is also important to view planning as a dynamic process rather than a discrete event. This requires regularly reviewing and updating the plans based on new circumstances and newly-acquired information.

Coordination involves distribution of roles and responsibilities and allocation of tasks and resources to members of the project team. Complexity is a major factor affecting the effectiveness of the coordination process. The small size of SMEs has contradictory effects on the complexity of coordination. On the one hand, small size results in smaller projects and thus they are less complicated to coordinate. However, on the other hand, small size means limited availability of resources and thus an increased prevalence of resource-sharing.
between projects. Given the lack of formalisation and personal styles of management observed in SMEs, sharing of resources can be major cause of conflict, and must be managed in the coordination process. As discussed in Chapter 4, avoiding conflicts associated with resource sharing in multiple project environments requires balancing the interests of the various stakeholders, while setting and communicating appropriate task priorities.

Controlling processes is concerned with defining and enforcing the criteria for ensuring adherence to the project plan, as well as the criteria for making decisions about selection and adoption of the developed innovative solutions. Control in most SMEs is highly centralised around the owner/manager. This can be problematic especially in the early stages of the innovation process as it has a negative effect on motivation and creativity. It is however beneficial at the implementation stage of innovation. The degree of involvement of the owner/manager in the decision-making process should therefore be exercised carefully throughout the innovation process. This can be achieved through formalisation of the control system, in which the role of the owner/manager is defined and the decision-making process is clearly specified. It is important to note, that formalisation does not imply rigour and rigidity. In fact it is critical that certain levels of self-organisation and flexibility are allowed and encouraged at the early stages of the innovation process.

7.6. Strategic System and Process Innovation Framework

In summary, the developed framework has a structure which outlines the necessary phases of the strategic innovation process, as well as a set of guiding principles that can be used to design or select tools and methods suited to the requirements of SMEs in each phase. It is structured into three phases of Plan, Prepare and Process (see Figure 7.5).

First is the strategic planning phase, which aims to overcome SME characteristics such as emergence, incrementalism, internal orientation, short-termism, the implicit nature of strategy, and the informal and unstructured approach to planning. It guides the SME managers to identify the main themes for strategic innovation in their firm, by generating an organisation-wide shared mental model of existing capabilities, available technologies, current and future market trends, current levels of manufacturing performance, specific requirements of the funding providers as well as the owner/manager’s vision, areas of interest and personal objectives.
Second is the preparation phase, which addresses issues such as relationships with external entities, scarcity of financial and human resources, centralised organisational structure, the lack of awareness of knowledge management matters, as well as an unsupportive organisational culture and climate. It achieves this by enabling the managers to deliberately assess the organisational context of innovation with the aim of ensuring appropriate antecedent conditions are in place before making major changes.

Finally, the third phase is concerned with absence of a systematic approach to solving problems, disregard for soft aspects of change, the centrality of decision-making, lack of planning, poor communication, and lack of attention to diversity and collaboration. It provides guidelines for SMEs to overcome these issues while they initiate, develop and then eventually implement solutions in line with strategic themes highlighted in Phase I and using mechanisms put in place in Phase II. Tables 7.1, 7.2 and 7.3 summarise the main guiding principles of the framework.

Figure 7.5 Three phases of the strategic system and process innovation framework
Table 7.1 Guiding principles for Phase I of the framework

### Phase I – Plan: Develop a strategic plan for system and process innovation

**Capability**
- Externalise and share the knowledge about company’s capabilities

**Performance**
- Highlight gaps in performance by assessing relative positions of the levels of performance in each dimension
- Use a diverse team of management and employees to conduct the analysis
- Select an innovation path that resolves operational problems, while addressing long-term strategic issues

**Market**
- Development of manufacturing capabilities should be informed by the dynamic changes in the market
- Scan widely for information and ensures peripheral area of the firm’s vision is not ignored
- Scanning should facilitate rapid information processing, quick sense-making and fast refocusing

**Technology**
- Use a wide perspective for technological scanning
- View technology as the enabler or facilitator of innovation rather the ultimate goal of innovation
- Information technology, specially open source systems, should be exploited as much as possible

**Owner/manager**
- Ensure any plans for major change has the support of owner/manager to avoid failure or strong opposition
- Externalise and consider owner/manager’s vision, areas of interest, personal objectives and worldview

**Finance**
- Knowledge about funding opportunities and their specific requirements is very important to consider at the strategy stage

Table 7.2 Guiding principles for Phase II of the framework

### Phase II- Prepare: Deliberately assess the context of innovation with the aim of ensuring appropriate antecedent conditions are in place before affecting major change

**Process**
- Aim of communication should be to persuade
- Diversity is critical for collaboration
- Understand the political dynamics that must be managed to get support
- Identify the dominant political narrations in the organisation
- Manage multiple projects
- Ensure flow of information and ideas into the firm by active scan

**Structure**
- Open firm’s boundaries to get access to new resources
- Be aware of and exploit the role of the owner/manager in the nature of relationship with external entities
- Encourage employee participation and delegation of responsibilities
- Guide owner/manager’s focus towards strategic and long-term issues
- Formalise the innovation project team

**Knowledge**
- Evaluate the knowledge requirements of the project, identify knowledge gaps and potential sources
- Create means for retaining and sharing tacit knowledge
- Focus should be on generating, retaining and disseminating explicit knowledge
- Use technology to make knowledge accessible

**Control**
- Provide guidance for seeking new ideas, stimulate new initiatives and give legitimacy to self-organisation

**Culture**
- Ensure the cultural orientations of the company match the nature of innovation
- Assess company’s climate using SOQ framework and overcome highlighted issues
- Assess appropriate style of leadership for the nature of the project

**Resource**
- Pay special attention to human resource requirements of innovation
Table 7.3 Guiding principles for Phase III of the framework

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<thead>
<tr>
<th>Phase III – Process: Initiate, develop and implement solutions in line with strategic themes highlighted in Phase I and using mechanisms put in place in Phase II</th>
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<tbody>
<tr>
<td><strong>Creative problem solving</strong></td>
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<tr>
<td>• Define the problem systematically and holistically</td>
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<td>• Analyse the problem in a structured and fact-based approach</td>
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<td>• Devise innovative solutions by eliminating system constraints and trade-offs</td>
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<td><strong>Internal diffusion</strong></td>
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<td>• Persuade stakeholders through logical presentation of evidence and rationale</td>
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<td>• Inform stakeholders about the support of influential advocates of the innovation</td>
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<td>• Ensure all communications are transparent, appropriately codified and credible</td>
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<td>• Create opportunities for personal interaction and cooperation</td>
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<tr>
<td>• Use political tactics effectively to gain support of key stakeholders, specially the owner/manager</td>
</tr>
<tr>
<td>• Repeat organisational narratives that support the objectives of the innovation project</td>
</tr>
<tr>
<td><strong>Project management</strong></td>
</tr>
<tr>
<td>• Use the collective experience of all major stakeholders, especially the owner/manager to develop the plan</td>
</tr>
<tr>
<td>• Regularly review and update the plans based on new circumstances and newly-acquired information</td>
</tr>
<tr>
<td>• Avoid conflicts generated by sharing of resources by balancing the interests of various stakeholders, while setting and communicating appropriate task priorities.</td>
</tr>
<tr>
<td>• Formalise the project control process, and assign specific role to the owner/manager</td>
</tr>
<tr>
<td>• Exercise control with flexibility at early stages of innovation and rigorously at later stages</td>
</tr>
<tr>
<td>• Allow for and encourage self-organisation at early stages of innovation</td>
</tr>
</tbody>
</table>
Chapter 8. Implementation of the Framework – Case Study of a Furniture Manufacturing Company

8.1. Introduction

This chapter outlines the case study of implementation of the innovation framework at CM Ltd. The framework provides a structured guideline for initiating, developing and implementing system and process innovation in manufacturing SMEs. However it does not provide a specific process or procedure to follow. In other words it guides those involved in the strategic innovation process to define a process that is appropriate for their specific company and industry requirements. In the case of CM Ltd, it was decided to follow the three phase approach outlined by the framework (Figure 7.5).

The first phase of the framework is focused on development of a strategic plan for system and process innovation. The principles outlined in Table 7.1 were used to ensure that all important pieces of information were sought and communicated to the main decision makers of the company, in order for them to develop a strategic plan for innovation.

The second phase of the framework aims to set the appropriate antecedent conditions for successful system and process innovation. The principles outlined in Table 7.2 were used to develop a self-assessment tool for CM Ltd. This tool was used to highlight areas of concern and led to development and implementation of a number of initiatives and mechanisms which helped prepare the organisation for the changes brought about by innovation. The third and final phase of the framework was concerned with development and implementation of innovative solutions in line with the strategic plan developed in Phase I. The principles outlined in Table 7.3 were used to ensure systematic and creative methods were used to manage the development, diffusion and eventual implementation of system and process innovation projects.

The following sections describe the implementation of these three phases at CM Ltd in more detail.
8.2. Development of a Strategic Plan (Phase I)

8.2.1 Capabilities

CM Ltd has a broad range of technological and management skills which match the requirements of its complex multi-process manufacturing environment. The manufacturing facilities of CM Ltd is equipped with a wide range of state-of-the-art technologies and systems (see Figure 8.1) geared for efficient batch production. There is also a flexible manufacturing area called the mini-factory, which has some of the core capabilities of the main factory but on a smaller scale. The mini-factory is used to make samples, parts for warranty claims, as well as some ad hoc customisation work. The company also has considerable design capability and experience. In excess of 100 new products are developed each year, accounting for 95% of revenue for the last 5 years. The procurement department is experienced in international sourcing and interfaces with the manufacturing department through a MRP system, which is part of an organisational wide information system. The MRP system is over 20 years old. However, it has been the subject of ongoing major in-house development which has equipped it with many customised features for generating bill of materials, production shop orders, as well as product costing. Moreover, CM Ltd is well experienced in exporting, and has warehousing facilities in New Zealand and Australia.

<table>
<thead>
<tr>
<th>Stores</th>
<th>Board &amp; Foil Manufacturing</th>
<th>Strip Manufacturing</th>
<th>Component Manufacturing</th>
<th>Component Finishing</th>
<th>Packing &amp; Dispatch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8.1 Manufacturing capabilities at CM Ltd

A look back at the history of CM Ltd indicates that it has developed competencies in
acquiring technological capabilities and securing the external funding necessary for the resource acquisition. It also shows that the company is very capable of reconfiguring its design and manufacturing capabilities to suit new market requirements. Furthermore, in terms of human resources, the company has many in-house skills and expertise in areas of design, manufacturing technology, information systems and marketing. Table 8.1 lists some of this expertise.

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Relevant Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>RP</td>
<td>Technical expert</td>
<td>CAM, CNC processing, tool design and configuration, quality management, process expert</td>
</tr>
<tr>
<td>PM</td>
<td>Design Manager</td>
<td>Product design, project management, design strategy, product costing</td>
</tr>
<tr>
<td>AC</td>
<td>Design/IT Resource</td>
<td>Systems design, design data information systems, project management</td>
</tr>
<tr>
<td>PH</td>
<td>Designer</td>
<td>Architectural design, interior design, design for functionality and aesthetics</td>
</tr>
<tr>
<td>GSh</td>
<td>Design Resource</td>
<td>In-depth product/process knowledge, packaging expert</td>
</tr>
<tr>
<td>CS</td>
<td>Engineering Manager</td>
<td>Systems/process design, programming, machine design, project management, process expert</td>
</tr>
<tr>
<td>TH</td>
<td>Finance Resource</td>
<td>Financial systems, reporting, performance measurement, costing system</td>
</tr>
<tr>
<td>JM</td>
<td>IT Manager</td>
<td>ERP implementation, programming, system design</td>
</tr>
<tr>
<td>LC</td>
<td>Marketing Resource</td>
<td>Graphics, customer communication, product knowledge</td>
</tr>
<tr>
<td>CP</td>
<td>Marketing Manager</td>
<td>In-depth market knowledge, branding, strategic planning</td>
</tr>
<tr>
<td>MSh</td>
<td>Project Manager</td>
<td>New product design, innovation management, change management, system/process design</td>
</tr>
<tr>
<td>MN</td>
<td>Manufacturing Manager</td>
<td>Production information system, system design, strategic planning, process expert</td>
</tr>
<tr>
<td>JP</td>
<td>Production Manager</td>
<td>Manufacturing systems, production scheduling, process expert</td>
</tr>
<tr>
<td>RF</td>
<td>Procurement Manager</td>
<td>MRP systems, international sourcing</td>
</tr>
<tr>
<td>SH</td>
<td>Finance Manager</td>
<td>International finance and accounting experience, financial modeling, raising capital</td>
</tr>
<tr>
<td>BS</td>
<td>Director</td>
<td>Exporting, international sourcing, sales and marketing, contract negotiation, strategic planning</td>
</tr>
<tr>
<td>WS</td>
<td>Director</td>
<td>Advanced manufacturing technology, automation, strategic planning, process expert</td>
</tr>
</tbody>
</table>

8.2.2. Market

The main insight from the marketing department with regards to the company’s business environment was the threat of the low-cost imports that were increasingly present in the market. The imports were mainly from developing nations in Asia, including Indonesia, Vietnam, Thailand, India and, of course, China. This was indeed a global phenomenon, and the New Zealand furniture market was no exception to this global trend. These imported goods were often characterised as low quality, and mainly targeted the commodity end of the market. However, their main competitive advantage was their unbeatable prices. A trend was also noticed that the Asian competitors were catching up quickly in quality and performance. As a result they were becoming more of a threat to CM Ltd’s market position.

However, the threat from the Asian market was a global issue and a strong environmental signal whose impact on the business performance was obvious. This had created many debates between the top executives with regards to appropriate strategies to react to this threat. There were two competing views about the response to such a threat. First view, backed by the CEO and sales and marketing managers, was to incrementally reduce manufacturing capabilities and become a furniture design and importing business. The second
view, backed by the founding directors as well as manufacturing and other technical departments was to start importing a limited number of product categories that were significantly losing market share due to competition on price. But they also proposed to maintain the manufacturing capabilities and apply them to new niche markets where few small companies were operating. This debate had put a lot of pressure on the manufacturing department to justify their existence and become more competitive specially through reducing cost.

Although the issue of low-cost imports was important, it was however among those issues that quite often force SMEs into reactive and fire-fighting behaviour. The framework requires broadening the scope of the market scan in order to identify more long-term yet weak signals. Doing so revealed two important trends:

First was the emergence of sustainability as an important business factor. In recent years, issues such as global warming, rising costs of energy (oil, gas, electricity) linked with the paucity of non-renewable resources have catapulted the notion of environmental sustainability in the global society and subsequently in the business arena. In Europe, sustainable business practices had become the norm and the emphasis had shifted from “green consumers” to the “responsible retailers”. However, in other parts of the world, in particular in Asia, South America and Australasia, many organisations still lagged behind with regards to sustainable practices, as the main external drivers towards sustainability were relatively weak (Collins et al., 2007, Williamson et al., 2006, Vives, 2005).

The second trend was the increasing demand for choice and personalisation. Changes in end-user attitudes, habits, knowledge, and quality-of-life desires had resulted in increased demand for personalized products and services. Companies such as Dell Computer had recognised this and pioneered configure-to-order of computers. Adidas, with the opening of their concept store in New York, is now offering made-to-measure shoes that are custom fit for the individual. Consumer trend experts estimate that by 2010 nearly thirty percent of all consumer goods sold in the US will be personalised, up from only six percent in 1970. The same trends had also been noticed in the furniture industry, as shown by the trend analysis of the US market for domestic wood furniture products (see Figure 8.2 (Schuler and Buehlmann, 2003)). However, the furniture industry, both in New Zealand and abroad, was generally operating on a mass or batch production business model, and only small bespoke
manufacturers were providing customisation services. This was therefore a good opportunity for CM Ltd to explore this growing market.

In order to inform the company’s management about these trends and to encourage them to think strategically about the long-term impact of changes in the business environment on CM Ltd, a foresighting workshop was organised. In this workshop, attended by the senior executives and top management of the company, a model of CM Ltd’s business environment was presented, which had divided the entities external to the company into four groups (see Figure 8.3). These groups were society and market, competitors, resources and environment. Key variables, trends and forces of change in each group were identified (see Figure 8.4). The workshop attendees were asked to assess each variable in terms of its significance, potential impact, and whether the company should ignore it, keep its eye on it, or exploit it. The results were collated and presented to the top executives, as illustrated in Figure 8.5.
Figure 8.3 Conceptual model of CM Ltd and its business environment

Figure 8.4 Variables and forces of change in CM Ltd’s business environment
8.2.3. Performance

CM Ltd has been one of the leading companies in their market. Its main strengths in terms of manufacturing system performance has been

- **Volume**: CM Ltd has the ability to produce nearly 500,000 pieces of furniture per year
- **Quality Conformance**: CM Ltd’s products are known for their quality and reliability
- **Delivery Speed**: Lead time reduction has been a major strategic theme of the company
- **Delivery Reliability**: Warehousing facilities have significantly increased reliability due to availability of stock

However, the company does not have a competitive edge in other dimensions of performance such as cost, quality capability, flexibility and sustainability. The management attempted to analyse their current levels of performance with respect to the potential and world class levels. However, in the absence of a suitable tool, this proved to be too difficult. Some of the difficulties faced, were related to consolidating various measures related to one dimension of performance into a single metric which could be used as the basis for comparison. Another problem was reaching consensus about the potential level of performance in a given dimension. Also there was no agreement about what constituted as world class performance.
and whether it was based on the level of performance of the company’s competitors in the existing markets or any company in the furniture industry around the world.

Further, analysis of performance dimensions with regards to what market considers to be order-winners and order-qualifiers was conducted. It was revealed that all of CM Ltd’s areas of strength are in fact order-qualifiers. The order-winning factors are found to be quality capability, flexibility and cost. Sustainability was not found to be a major factor that customers were concerned about. According to the marketing team, the most important order-winning criteria was cost. As discussed earlier, this was mainly driven by the low-cost imports. The warehousing, logistics and distribution systems of the importers seemed to match CM Ltd in terms of volume, delivery speed and reliability. They were behind CM Ltd in terms of quality capability and conformance, but were much more competitive in terms of price.

If according to the results of the market analysis and foresighting workshop, CM Ltd was to pursue sustainability and personalisation as strategic themes to improve their long-term competitiveness, the manufacturing system would have to substantially improve its performance in the sustainability and flexibility dimensions. Analysis of trade-offs between flexibility and other performance dimensions revealed that the common variable which increases with flexibility and impacts all other dimensions negatively is design flexibility. In other words design flexibility was seen to increase inventory, set up time, lead times and mistakes due to increase in complexity. Similarly, sustainability as a manufacturing objective was found to be in trade-off with other competitive objectives when and where the relationship between sustainability and system parameters such as resources, energy, material, waste and emissions, was in contradiction with the relationship between other objectives and these parameters.

Analysis of issues affecting manufacturing performance was also extended to cover the current short-term problems which are the focus of the management team’s day-to-day operations. Table 8.2 lists some of these issues in various stages of the design and production processes.
Table 8.2 Operational design and production issues and problem

<table>
<thead>
<tr>
<th>Department</th>
<th>Stage</th>
<th>Issues and problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Exploration</td>
<td>Communication gaps between Market Research, Design and Production</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emphasis on incremental rather than on breakthrough design</td>
</tr>
<tr>
<td></td>
<td>Planning</td>
<td>Many design projects – difficult to maintain focus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not well integrated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stage-gate management not rigorous enough</td>
</tr>
<tr>
<td></td>
<td>Development</td>
<td>Manual Processes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively high number of errors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not best use of CAD/CAM capabilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of systematic and customer focused communication</td>
</tr>
<tr>
<td></td>
<td>Production</td>
<td>Not well integrated</td>
</tr>
<tr>
<td></td>
<td>Raw material storage</td>
<td>Unreliable delivery from some suppliers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material variances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disorganised</td>
</tr>
<tr>
<td></td>
<td>Board and Foil manufacturing</td>
<td>Quality issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Breakdowns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long idle times</td>
</tr>
<tr>
<td></td>
<td>Strip manufacturing</td>
<td>Material waste</td>
</tr>
<tr>
<td></td>
<td>Component manufacturing</td>
<td>Long idle times</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Too much material handling</td>
</tr>
<tr>
<td></td>
<td>Component finishing</td>
<td>Tooling issues</td>
</tr>
<tr>
<td></td>
<td>Assembly and Despatch</td>
<td>Labour intensive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High cost of packaging materials</td>
</tr>
</tbody>
</table>

8.2.4. Technology

As discussed in Chapter 6, there was a high awareness of relevant advanced manufacturing technology in CM Ltd. Figure 8.6 illustrates an example of a multi-million dollar fully automated CNC panel production line, which WS had seen in operation in one of his trips to a European cabinet manufacturing company. However, the company seemed unaware of the rapidly advancing technologies in area of computer aided graphics and interactive web interface. Many organisations around the world were starting to combine these technologies in order to provide their customers with systems that enabled them to select, configure and visualise products and services that suited them. These systems are referred to as product configurators, and had the potential to substantially enhance the usability, improve the reliability and reduce the costs associated with custom product specification. Figure 8.7 provides some examples of product configurators available on the internet.
Figure 8.6 Example of a fully automated CNC panel production line

Figure 8.7 Examples of product configuration technologies
8.2.5. Owner/Manager

The influence of WS on new developments at CM Ltd was discussed in the case study analysis provided in Chapter 6. It was observed that he was regarded as the main internal expert in matters related to the factory, and decisions related to changes in the manufacturing infrastructure and configuration were his domain of authority. Consequently in order to gain his support, any changes to be proposed as part of this project must be in line with his vision and plans. When WS was asked to express his vision for manufacturing at CM Ltd, he responded via an email saying

"We can meet and talk about this in broad terms but to communicate a lot of this in greater detail would take me some time to gather all the pieces together and in some cases get further information from my contacts overseas and this can take some time”.

In this response “contacts overseas” is referring to a number of European manufacturers of panel processing machinery, with whom WS has developed a close and long-term relationship. This is an indication of the fact that WS’s vision for the manufacturing plant revolves around implementation of advanced manufacturing technology. A look back at the history of the organisation and the development of its manufacturing capabilities, confirms this observation, as most of the changes were driven by WS and involved implementation of production technology from Europe.

The vision of WS (as expressed by him verbally following the email above) for the manufacturing facilities at CM Ltd, was a highly automated plant equipped with advanced machinery and information technology, allowing seamless transfer of data between design and production departments. He had already compiled a short list of machinery that he wished to purchase in the near future. Figure 8.6 (above) illustrates an example of one of the short listed lines. WS viewed manual processes as unreliable and costly and aimed to minimise human intervention as much as possible. He expressed this by saying

“I just want them (the operators) to stack the panels coming out of the machines. They shouldn’t have to do anything else”.

8.2.6. Finance

Apart from the salaries of the existing staff, the company did not have a set budget for system and process innovation. These were dealt with on a project-by-project basis as exceptions to
the annual budget. As mentioned earlier, most of these projects were technology based, and required capital expenditure, which was funded by the bank. Given that the funding was mainly spent on acquiring assets (machinery), and CM Ltd had a good relationship with the bank, they did not face much difficulty for securing funds for purchasing machinery.

However, system and process development mainly required knowledge and expertise of human resources. Other sources of funds had to be found. An extensive search was carried out, which resulted in the identification of a number of government agencies who would provide financial support for technological development projects. These included funds for development of new products or processes that lead to significant increases in export revenue. There were also those funds that targeted operational excellence in manufacturing such as implementation of lean production systems. Another set of funds were given to companies to encourage clean production and reduction of waste and electricity usage.

8.2.7. Conclusion of Phase I

At the end of Phase I, the management of CM Ltd agreed to pursue strategic innovation in two areas of sustainability and mass-customisation. It was commonly agreed that due to the absence of strong market forces driving sustainability, developments in this area are best approached incrementally and without much additional expense. However, the mass-customisation project was seen as critical transformational project, which was required to combat the increasing threat of the low-cost imports. It was decided to seek major government funding in order to provide the technological and knowledge-based resources required for this transformation. The remaining sections of the chapter will present the outcomes of Phase II and III of the framework for each of these strategic innovation projects.

The following sections describe how these programmes were initiated and implemented at CM Ltd, using the strategic system and process innovation framework.

8.3. Environmentally Benign Furniture Design and Production Programme

The first system and process innovation programme saw CM Ltd go from having no sustainability credentials to becoming one of the few furniture manufacturing companies in
Australasia with ISO14001 certification. Along the way they implemented numerous projects on reducing the impact of their products and processes on the environment. A number of these projects received national awards, and recently the company was recognised as a frontrunner of environmental management in their region by winning the sustainable business of the year award. Internally, awareness about sustainability has been increasing rapidly and has become one of the main strategic themes of the company. CM Ltd has also benefited financially from the programme by significantly reducing waste and promoting their environmental credentials in the market (see Figure 8.8). The success of the programme is reflected in the following comment from WS, the founding director of CM Ltd:

“Sustainability is something that we knew we had to do something about, but we were moving too fast in other directions…. We set off on this project and developed the whole thing for our organisation… Now it is integrated right across the organisation and now it is a critical success factor in our business”.

Figure 8.8 CM Ltd sets benchmark in environmental good practice

The following sub-sections describe Phase II and III of the framework for the sustainability project at CM Ltd.

8.3.1 Phase II - Prepare

As explained in the introduction to this chapter, an assessment tool was developed based on the guiding principles of the framework to assist with the preparation phase. Table 8.3 illustrates the use of this tool, and the mechanisms that were used to help set the right antecedent conditions for successful implementation of the sustainability project.
Table 8.3 Preparing mechanisms for successful implementation of the sustainability programme.

<table>
<thead>
<tr>
<th>Project dimension</th>
<th>Objective</th>
<th>Audience/Target</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication</strong></td>
<td>Inform, encourage and educate</td>
<td>All staff</td>
<td>Email, presentations, intranet, internal newsletter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project team</td>
<td>Monthly environmental meetings and their minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Senior executives</td>
<td>Quarterly strategic environmental meetings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Customers</td>
<td>Website, Applying for awards, Eco-labels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supplies</td>
<td>Letters to inform them of environmental policies and plans</td>
</tr>
<tr>
<td><strong>Collaboration</strong></td>
<td>Encourage cooperation and involvement</td>
<td>Factory staff</td>
<td>Raise awareness by measuring and reporting waste production and electricity usage by area of factory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Office staff</td>
<td>Making sustainability part of factory improvement meetings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal experts</td>
<td>Staff suggestion system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Office recycling and power saving schemes</td>
</tr>
<tr>
<td><strong>Politics</strong></td>
<td>Get support</td>
<td>Senior executives</td>
<td>Focus on waste reduction – cost saving</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fit in potential technology implementation projects in line with the director’s vision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Get formal backing of the board of directors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Get funding</td>
</tr>
<tr>
<td><strong>Networking and Boundary openness</strong></td>
<td>Access to external capabilities</td>
<td>Knowledge providers</td>
<td>Strengthen the link with the university</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human resources</td>
<td>Exploit the relationship with university to get cheap student resource for carrying out projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Government agencies</td>
<td>Liaise with appropriate agencies who promote sustainable business practices for funding and publicity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology providers</td>
<td>Where possible involve the technology providers that are linked with the directors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suppliers</td>
<td>Opportunities to recycle waste</td>
</tr>
<tr>
<td><strong>Organisational structure</strong></td>
<td>Formalising the project</td>
<td>All staff</td>
<td>Creation of the role of the environmental officer</td>
</tr>
<tr>
<td></td>
<td>Delegation of responsibilities</td>
<td>Project team</td>
<td>Project champions for each sub-project</td>
</tr>
<tr>
<td><strong>Knowledge source</strong></td>
<td>Bridging knowledge gap</td>
<td>Project team</td>
<td>Collaboration with the university</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Search for relevant books, journals and websites</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Attend relevant seminars and workshops</td>
</tr>
<tr>
<td><strong>Knowledge type</strong></td>
<td>Disseminate tacit knowledge</td>
<td>All staff</td>
<td>Writing internal reports</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Giving presentations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Factory staff</td>
<td>On the job training</td>
</tr>
<tr>
<td></td>
<td>Disseminating explicit knowledge</td>
<td>All staff</td>
<td>Emails, intranet, reports, meeting minutes, presentations, procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Factory staff</td>
<td>Procedures, training presentations</td>
</tr>
<tr>
<td><strong>KM technology</strong></td>
<td>Retain and provide access to knowledge</td>
<td>All staff</td>
<td>Set up and implement a Wiki on the intranet site for storage of knowledge related to the project</td>
</tr>
<tr>
<td><strong>Interactive style of control</strong></td>
<td>Providing guidance for seeking new ideas</td>
<td>Project team</td>
<td>Use environmental impacts assessment to identify areas of focus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Focus on elimination of trade-offs</td>
</tr>
<tr>
<td></td>
<td>Stimulating new initiatives</td>
<td>Project team</td>
<td>Use of cheap student resource for exploration of new ideas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Use of project meetings to discuss and debate new ideas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Staff suggestion system</td>
</tr>
<tr>
<td><strong>Legitimising self-organisation</strong></td>
<td></td>
<td>Project team</td>
<td>Focusing on outcomes and project deliverables</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Celebrating new initiatives</td>
</tr>
<tr>
<td><strong>Culture type</strong></td>
<td>Maintain mechanistic orientation as it matches incremental innovation</td>
<td>Project team</td>
<td>Develop an environmental management system with appropriate procedures, documentation and auditing schedule</td>
</tr>
<tr>
<td></td>
<td>Balance internal orientation with more external orientation to encourage competitiveness</td>
<td>Project team</td>
<td>Include marketing department in the project team</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Include design department in the project team</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Manage PR and external communication initiatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Promote sustainability on the website</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Focus on eco-labels and environmental certification</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td>Creating a challenging and motivating climate</td>
<td>Project team</td>
<td>All administrative tasks associated with the environmental management system were assigned to the environmental officer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The project team were to concentrate on reducing waste and energy usage</td>
</tr>
<tr>
<td><strong>Freedom to experiment</strong></td>
<td></td>
<td>Project team</td>
<td>Student resources were to be used to experiment and explore new ideas</td>
</tr>
<tr>
<td><strong>Encourage debate and expression of dissent</strong></td>
<td></td>
<td>Project team</td>
<td>Senior executives would not attend monthly environmental meetings where debate is to be encouraged</td>
</tr>
<tr>
<td><strong>Commitment to vision</strong></td>
<td></td>
<td>All staff</td>
<td>Regular communication</td>
</tr>
<tr>
<td><strong>Leadership</strong></td>
<td>Empower through leadership</td>
<td>Project team</td>
<td>Apply participative style of leadership</td>
</tr>
<tr>
<td><strong>Resources</strong></td>
<td>Knowledge and expertise</td>
<td>Project team</td>
<td>As discussed above</td>
</tr>
<tr>
<td></td>
<td>Additional human resources</td>
<td>Project team</td>
<td>University students</td>
</tr>
<tr>
<td><strong>Funding</strong></td>
<td></td>
<td>Government agencies</td>
<td>Search for appropriate funding</td>
</tr>
</tbody>
</table>
Communication
The instructions given to the project team by the senior executives of the company were to approach this programme incrementally and with little budget for utilising external resources. Furthermore, the main notion behind environmentally benign furniture design and production is not complex and foreign to most people. It would therefore be easy to communicate the concept to all stakeholders. Moreover, after convincing the board of directors that this programme should be carried out, the remainder of the staff should need little influence or persuasion to support the programme. The aim of the communication mechanisms should therefore be to keep the stakeholders informed about the programme, to encourage participation in the programme, and to educate the stakeholders if necessary about various aspects of sustainable business practices.

Collaboration
Factory staff are major stakeholders of the project, as their day to day actions have immediate and significant impact on the environment. The factory processes produce most of the waste and consume the largest portion of electricity usage of the company. Cooperation and involvement of the factory staff in the sustainability programme can be enhanced by raising their awareness about the impact of their processes on the environment. Already existing factory improvement meetings can also be used to capture their ideas for improvement of their area’s sustainability performance.

Although most of the office staff have little direct impact on the environment, many of them are in positions of responsibility, and their decisions could have a major impact on the environment. It is therefore important to engage them with the programme. It is also critical to directly involve the technical experts of the company in the programme. They not only provide knowledge and expertise to the programme but they also give credibility to the programme in the eyes of the senior executives.

Politics
Getting the support of the senior executives of the company, specifically BS and WS, was essential for the success of the programme. It was therefore important to highlight the immediate benefits of the project, especially the financial benefits, in all communications with the directors. It was also important to have one of the members of the board of directors as the official sponsor of the project. Given that this programme was not in the main interest
areas of WS and BS, they were not chosen as the sponsors. Instead the manager of the finance department, SH, who was also on the board of directors, became the programme sponsor. He has special interest in sustainability in general, and was keen to promote corporate responsibility at CM Ltd.

Network

Given the unavailability of financial resources for this programme, it was necessary to find cost effective external resources. The relationship with the University of Auckland provided the opportunity to not only get access to expert knowledge, but also to use students as additional low-cost human resources for the programme. In return, the university lecturers and students would benefit by having a real case study company to apply their theoretical knowledge. Another group of stakeholders who could provide cost effective support for the programme was CM Ltd’s suppliers of raw material. Exploiting its close relationship with some of its main suppliers was a good opportunity to explore cost effective recycling opportunities. It was also important to strengthen the relationship with a number of government agencies promoting sustainable business practices, in order to find potential funding and ways to publicise and promote CM Ltd’s work in the area of sustainability.

Organisational structure

A new position of environmental officer was created to formalise the programme. This was important as it gave the programme legitimacy. The role also provided an opportunity to address the issues related to centralisation at CM Ltd. For this, the environmental officer had to show leadership as the programme champion and liaise with the senior executives in order to maintain their support. Moreover, by delegating responsibilities for various sub-projects to internal experts who had the trust of the directors, the environmental officer could reduce the direct involvement of senior executives in the programme.

Knowledge

The focus of preparations in the area of knowledge is to capture and convert tacit knowledge to explicit knowledge, in order to easily retain and distribute it. So mechanisms such as a Wiki page on the company’s intranet system was set up and deliberate attempts were made to document and disseminate learnt knowledge as much as possible through reports, presentations and procedures. Figure 8.9 illustrates how this knowledge was made available to the staff at CM Ltd.
Control, Culture and Climate

Control, culture and climate are three interrelated areas that impact on people’s behaviour and their engagement with the programme. One of the main types of behaviour which needed to be promoted was generation of new ideas and new initiatives. While much of this depended on how the environmental officer (project champion) would behave and lead the programme, there were other mechanisms that were used to encourage experimentation with new ideas. One of these was the use of student resources for most of the exploratory and experimental work. This approach faced little opposition from the senior executives. Another important cultural issue was the fit between the current culture type and that needed for the success of the programme. Given the incremental nature of the programme, the mechanistic orientation of existing culture at CM Ltd was a desirable characteristic. By focusing the programme activities on a well documented environmental management system, the programme would match this favourable cultural characteristic. However, mechanisms needed to be put in
place to shift the cultural orientation from internal to external, in order to link the programme
to the company’s competitive performance.

8.3.2 Phase III – Process

**Systematic Problem solving**

By analysing the programme objectives systematically, it can be argued that in order for sustainability to become an order-winning criteria for CM Ltd’s products, the customer must become aware of the product’s sustainability credentials. This information is either presented in the marketing material for the product, or it is inferred in the company’s brand profile as perceived by the customer. Either way, this information indicates a claim made by the company to the customer that the product about to be purchased is harmless towards the environment or that in production of this product the company ensured that impacts on the environment were minimised. To strengthen the credibility of this information, independent third party organisations are employed to verify the claim. They do so by first checking that the company has a system to assess the impact of the product or process on the environment. They then check if the system is used regularly and that is yields results by reducing the impact of the product or process on the environment.

The innovation problem is therefore defined as development and implementation of a system that is used willingly by employees of CM Ltd to eliminate the harmful effects of their products on the environment and to reduce the impact of their business processes on the environment, in a manner that is verifiable by a credible independent third party organisation, so that it can be promoted to the customer in order to influence their purchasing decision. Following the systematic definition of the problem statement, a stakeholder analysis was carried out to identify the key players and influences on the problem. Table 8.4 displays the results of this analysis. Based on this result, the following sub-objectives were defined for the programme:

- Develop an Environmental Management System (EMS) and verify it by an independent organisation, whose label is recognised and valued by the customer
- Comply with relevant laws and regulations
- Reduce environmental impact of products and processes
- Promote the environmental credentials to customers and retailers to increase sales
- Liaise with government agencies and NGOs to acquire funds and resources
A systematic approach was used to achieve these objectives. First a thorough analysis of available eco-labels and environmental certifications was carried out. They were assessed based on international recognition, government support and cost of compliance. Based on this analysis, it was decided that the company would work through the Enviro-Mark programme (see Figure 8.10) and eventually reach ISO 14001 certification in a step by step process. This provided a structured and systematic approach to the development of the company’s EMS and ensuring compliance with environmental laws and regulations.

Reducing the environmental impact of products and processes was also approached systematically. Life-cycle inventory analysis, impact and aspects assessment and trade-off analysis were among the systematic tools used to analyse, prioritise and resolve CM Ltd’s impact on the environment (Seidel et al., 2007; Shahbazpour and Seidel, 2006). Figure 8.11 illustrates the results of the systematic analysis of the environmental impact of CM Ltd.

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**Table 8.4 Stakeholder analysis for the sustainability project**

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Stake in project</th>
<th>Power and influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory staff</td>
<td>Impact on operational performance, Operate machinery that generate waste and consume power, Discharges affect their health and safety</td>
<td>Strong influence on generation of waste and energy consumption</td>
</tr>
<tr>
<td>Office staff (includes management)</td>
<td>Decisions may lead to generation of waste and energy use, Discharges affect their health and safety</td>
<td>Influence limited by role</td>
</tr>
<tr>
<td>Senior executives</td>
<td>Promote CM Ltd as a socially responsible company, Increase profitability, Preserve New Zealand environment</td>
<td>Full control of resources</td>
</tr>
<tr>
<td>Departmental managers</td>
<td>Contribute to company’s competitiveness, improve department’s performance, Preserve New Zealand environment</td>
<td>Limited control of resources</td>
</tr>
<tr>
<td>Customers</td>
<td>Buy and use product, Preserve New Zealand environment</td>
<td>Purchasing decision</td>
</tr>
<tr>
<td>Retailers</td>
<td>Sell more products, Promote their stance with regards to sustainability and social responsibility</td>
<td>Control marketing and exposure of CM Ltd’s products and brand</td>
</tr>
<tr>
<td>Certifiers</td>
<td>Promote their certification or eco-label, Ensure customers have trust in their label or certification, Assess the environmental management system</td>
<td>Verify the environmental credentials</td>
</tr>
<tr>
<td>Non-governmental organisations</td>
<td>Promote sustainability in New Zealand business by providing expertise and other resources</td>
<td>Persuade to implement sustainable practices</td>
</tr>
<tr>
<td>Local and National governments</td>
<td>Protect New Zealand’s population and environment, Generate a prosperous society and economy</td>
<td>Laws and regulations</td>
</tr>
<tr>
<td>Government agencies</td>
<td>Promote sustainability in New Zealand business by providing funding, publicity and other resources</td>
<td>Persuade to implement sustainable practices</td>
</tr>
</tbody>
</table>

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Figure 8.10 Enviro-Mark programme as a structured pathway towards ISO 14001
Figure 8.11 Results of the systematic analysis of CM Ltd’s environmental impact
**Internal Diffusion**

As discussed previously, a planned approach was used to communicate and collaborate with the stakeholders and gain their support. This was implemented based on the following strategies:

- Generate interest in the EMS by using it as a portal for communication and collaboration (see Figure 8.9).
- Raise awareness about sustainability by giving educational presentations and making knowledge resource available and easily accessible.
- Create excitement and interest in the project by promoting and celebrating achievements, such as winning awards or getting environmental certification.

These proved very effective and now sustainability is one of the main points of differentiation for CM Ltd. This is reflected in the following excerpt from an email sent by the CEO to all staff, after it was announced that CM Ltd had just achieved Enviro-Mark Platinum certification:

> "Congratulations to all involved in this effort. It is going to become very important for our future that we establish strong reasons for us to be a ‘supplier of choice’. What is being achieved here is exactly how we should go about doing this. The big question now is how are our marketing people going to fully utilise these achievements. I still do not think we are taking anywhere near enough advantage of this and yet we constantly battle against imported products. Well let's do something more aggressive with the Enviro-Mark and shout from the rooftops about a benefit that the vast majority of imports cannot deliver”

It is important to note that at the beginning of the project the CEO was very pessimistic about the importance of sustainability to the company’s competitive performance, and agreed to go along with the programme due to the overall support of the board of directors. Effective communication, along with success in delivery of programme outcomes, was critical in gaining his support for the project.

**Project Management**

Project management was a weak point of the programme. The environmental policy statement (updated annually) was used to set targets for each of the sub-objectives discussed earlier. The environmental meeting at the beginning of the year was used to collectively agree
on projects and initiatives to be carried out in order to meet the targets. The meeting was also used to allocate responsibilities and set deadlines for each project. Planning and coordination of these projects were left to the individual project champions to self-organise. The environmental officer would rely on each project champion to request assistance or additional resources. If required, student resources were used to assist the project champions. The environmental officer would use the meeting minutes as check list to assess the status of each project on a monthly basis. If a project champion was missing the deadline for his project on a consistent basis, the strategic environmental meetings, held every quarter, were used to raise this issue with the directors and request that the project was given a higher priority on the departmental project list.

This was not an effective project planning approach. However, it did not seem to have a detrimental effect on the overall project outcomes. Upon reflection, this absence of a more structured planning and coordination approach can be attributed to:

- lack of urgency for the project,
- incremental and ongoing nature of the project,
- low levels of task complexity,
- lack of formal planning process in the company.

### 8.4 Customer Driven Furniture Design and Production Programme

The second system and process innovation programme initiated at CM Ltd in this case study was customer driven furniture design and production. This was extremely challenging and ambitious. Based on the paradigm of mass customisation, it aimed to totally reconfigure CM Ltd’s existing batch production system. This project constituted the biggest challenge in the company’s history, comparable only to the implementation of Computer Integrated Manufacturing in the early 1990s. To implement the new paradigm, it was necessary to develop and implement new technological solutions at every stage of the value chain. The major areas of innovation were:

- Co-design: Development of systems that enabled customers to become directly involved in the design of products through selection of size, colours and features.
- Innovative Modular Design: Reducing internal complexity through design of modular and standard components to be modified according to the customer’s needs.
• Design and Manufacturing Interface: Development of seamless, automated and flexible information system interface between design and manufacturing.

• Lean and Agile Production Processes: Redesign of factory layout and process configuration in areas of packaging, warehousing and despatching.

• Agile Production Planning and Scheduling: Development of a new production planning and scheduling system, which can cope with the mix of standard products as well as fulfilling customised or contract orders.

Figure 8.12 Graphic illustration of the mass-customisation project used in the internal communications.

At the time when the researcher terminated his employment at CM Ltd, the company had completed the planning stage, acquired near half a million dollars of funding from New Zealand Foundation for Research Science and Technology, and was at the early stages of development in the areas listed above. However, due to the sudden downturn of the global economy and the ensuing financial challenges, the programme has been put on hold.

8.4.1 Phase II – Prepare

As with the sustainability project, a number of mechanisms were devised and put in place to prepare the antecedent conditions for successful implementation for the mass-customisation programme. These are presented in Table 8.5.
Table 8.5 Preparing mechanisms for successful implementation of the mass-customisation programme.

<table>
<thead>
<tr>
<th>Project dimension</th>
<th>Objective</th>
<th>Audience/Target</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Inform, encourage, educate and persuade</td>
<td>All staff</td>
<td>Introductory workshops&lt;br&gt; Create internal brand for the programme&lt;br&gt; Fortnightly forum&lt;br&gt; Email, presentations, intranet, internal newsletter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project team</td>
<td>Weekly meetings and their minutes&lt;br&gt; Regular reporting to the board of directors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Senior executives</td>
<td></td>
</tr>
<tr>
<td>Collaboration</td>
<td>Encourage cooperation and involvement</td>
<td>Factory staff</td>
<td>Making flexibility issues part of factory improvement meetings&lt;br&gt; Communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Office staff</td>
<td>Staff suggestion system&lt;br&gt; Fortnightly forum open to all staff&lt;br&gt; Create opportunity for recognition and reward</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal experts</td>
<td>Include in the project team</td>
</tr>
<tr>
<td>Politics</td>
<td>Get support</td>
<td>Senior executives</td>
<td>Fit in potential technology implementation projects in line with the director’s vision&lt;br&gt; Get formal backing of the board of directors&lt;br&gt; Get funding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Departmental managers</td>
<td>Make sure operational problems are addressed along the way as the project progresses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Influential staff</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All Staff</td>
<td></td>
</tr>
<tr>
<td>Networking and Boundary openness</td>
<td>Access to external capabilities</td>
<td>Knowledge providers</td>
<td>Strengthen the link with the university</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human resources</td>
<td>Exploit the relationship with university to get cheap student resource for carrying out projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Government agencies</td>
<td>Liaise with appropriate agencies who promote technology and innovation for funding and publicity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology providers</td>
<td>Where possible involve the technology providers that are linked with the directors&lt;br&gt; Strengthen existing links with the CAD software provider</td>
</tr>
<tr>
<td>Organisational structure</td>
<td>Formalising the project</td>
<td>All staff</td>
<td>Creation of the role of Business Innovation Manager</td>
</tr>
<tr>
<td></td>
<td>Delegation of responsibilities</td>
<td>Project team</td>
<td>Project champions for each sub-project</td>
</tr>
<tr>
<td>Knowledge source</td>
<td>Bridging knowledge gap</td>
<td>Project team</td>
<td>Collaboration with the university</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Search for relevant books, journals and websites&lt;br&gt; Attend relevant seminars and workshops</td>
</tr>
<tr>
<td>Knowledge type</td>
<td>Disseminate tacit knowledge</td>
<td>All staff</td>
<td>Writing internal reports and giving presentations&lt;br&gt; Collaboration</td>
</tr>
<tr>
<td></td>
<td>Disseminating explicit knowledge</td>
<td>Factory staff</td>
<td>On the job training&lt;br&gt;</td>
</tr>
<tr>
<td></td>
<td>Retain and provide access to knowledge</td>
<td>All staff</td>
<td>Emails, intranet, reports, meeting minutes, presentations, procedures&lt;br&gt; Procedures, training presentations</td>
</tr>
<tr>
<td>KM technology</td>
<td>Providing guidance for seeking new ideas</td>
<td>Project team</td>
<td>Use fortnightly forums to introduce possibilities&lt;br&gt; Visually illustrate future possibilities and scenarios&lt;br&gt; Focus on elimination of trade-offs</td>
</tr>
<tr>
<td></td>
<td>Stimulating new initiatives</td>
<td>Project team</td>
<td>Use of cheap student resource for exploration of new ideas&lt;br&gt; Use of project meetings to discuss and debate new ideas&lt;br&gt; Staff suggestion system</td>
</tr>
<tr>
<td></td>
<td>Legitimising self-organisation</td>
<td>Project team</td>
<td>Focusing on outcomes and project deliverables&lt;br&gt; Celebrating new initiatives</td>
</tr>
<tr>
<td>Culture type</td>
<td>Shift cultural orientation from mechanic to organic</td>
<td>Project team</td>
<td>Encourage flexibility and new initiatives</td>
</tr>
<tr>
<td></td>
<td>Shift cultural orientation from internal to external</td>
<td>Project team</td>
<td>Involve marketing and design as much as possible&lt;br&gt; Emphasise the need for in-depth understanding of customers</td>
</tr>
<tr>
<td>Climate</td>
<td>Creating a challenging and motivating climate</td>
<td>Project team</td>
<td>The nature of this project is technically challenging&lt;br&gt; Use internal branding to induce excitement in the project</td>
</tr>
<tr>
<td></td>
<td>Freedom to experiment</td>
<td>Project team</td>
<td>Student resources were to be used to experiment and explore new ideas</td>
</tr>
<tr>
<td></td>
<td>Encourage debate and expression of dissent</td>
<td>All staff</td>
<td>Lead by example and encourage debate and criticism&lt;br&gt; In fortnightly forums engage in debate with the senior executives and departmental management</td>
</tr>
<tr>
<td>Commitment to vision</td>
<td>Project team</td>
<td>All staff</td>
<td>Regular communication</td>
</tr>
<tr>
<td>Leadership</td>
<td>Inspire and transform</td>
<td>All staff</td>
<td>Apply a transformational style of leadership</td>
</tr>
<tr>
<td>Resources</td>
<td>Knowledge and expertise</td>
<td>Project team</td>
<td>As discussed above</td>
</tr>
<tr>
<td></td>
<td>Additional human resources</td>
<td>Project team</td>
<td>University students</td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td>Technology providers</td>
<td>Find potential technology partners in the area of web interface design&lt;br&gt; Seek major government funding</td>
</tr>
<tr>
<td></td>
<td>Funding</td>
<td>Government agencies</td>
<td></td>
</tr>
</tbody>
</table>

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Communication
Unlike the sustainability programme, the customisation programme was transformational and complex to understand. As a result, communication played a critical role in gathering support and encouraging participation in the programme. The purpose of communication was therefore to inform the stakeholders, while at the same time much emphasis had to be put on educating and persuading them. A series of company-wide introductory workshops were planned and delivered with the aim of informing and persuading the staff across the entire organisation about the programme and how they could get involved. Furthermore, to maintain the momentum gained through these workshops, a series of fortnightly breakfast forums were organised, to which all staff were invited. As discussed in the sections below, these forums became one of the main features of the programme.

Politics
WS was assigned by the board of directors as the strategic sponsor for this programme. His vast knowledge and experience and influence in the company’s strategic decision making process made him the ideal candidate for the role.

Collaboration, Networking, Organisational Structure and Knowledge
Similar intranet based mechanisms to those put in place for the sustainability projects were used. Consequently the details of the mechanisms will not be repeated here.

Control, Culture and Climate
This was a large scale and complex programme, and was therefore accompanied by significant uncertainty and risk. The natural tendency of the company’s leadership was to impose strict control to manage the uncertainty. However, the success of this programme required considerable involvement and expression of creativity from all staff. The breakfast forums created a good opportunity to apply subtle control over the direction of the programme by facilitating and guiding discussions towards main programme objectives. At the same, time it encouraged expression of new ideas and new initiatives from the general staff.

The forums also created an opportunity to influence the culture and climate that governed the programme. For instance by engaging in constructive debate with the senior executives in the forum, the programme champion could lead other staff to engage in the debate and voice their
opinions. Also by reacting positively to criticism, the programme champion would encourage expressing of dissent, which is one of the key requirements for creativity and innovation.

8.4.2 Phase III - Process

Systematic Problem solving

Customer driven furniture design and manufacturing is a complex proposition, which would have a significant impact on all aspects of the CM Ltd business. It was therefore necessary to define the concept and then identify its implications on systems and processes. Simply put, customer driven furniture design and manufacturing means allowing customers on a mass scale to influence the design of their piece of furniture in such a way that it is customised for their specific requirements, can be purchased at a reasonable price, and delivered within a reasonable lead time. This poses a number of challenges:

- First is a marketing challenge, which involves answering the following questions:
  - What type of furniture do customers like to customise on a large scale?
  - What level of input do the customers like to have in the design of their furniture?
  - What is a reasonable price for the required level of customisation?
  - What is considered a reasonable lead time for the required level of customisation?
- Second is a design challenge, which involves development of systems that allow the customers to define, configure, design, match, or modify their individual solution from an information base of options and pre-defined components.
- Third is a manufacturing challenge, which requires production of the customised furniture according to the exact requirements of the customer, without significant increases in cost and lead time.
- Fourth and final challenge involves reducing complexity of work processes, information flows and data handling associated with the proliferation of product and manufacturing data, by fully integrating the company’s information systems and communication tools.

Figure 8.14 provides a detailed schematic of these challenges, which was used to communicate the programme to various stakeholders.
Figure 8.13 Screenshots of the Wiki page created for the “i4 project” on the company’s intranet system.
Customer Driven Furniture Design and Manufacturing

Marketing Challenge
The success of a new customer driven furniture design and manufacturing initiative hinges on:
- development of innovative brands
- incorporation of brand characteristics in all communications touch points with the customers
- establishment of reliable communication channels to and from customers

Design Technology Challenge
Implementation of customer driven furniture design requires the development of technologies and systems to integrate customers in the design process by enabling them to define, configure, design, match, or modify their individual solutions from an information base of options and pre-defined components. The prerequisites for achieving this are:
- the creation of the technological basis of a co-design platform:
  - development of an integrated product data information system
  - development of customized product architecture based on principles of modularity and parameterization
  - development of CAD and IT tools to create associativity between customer input and CAD product models
- the development of interactive, intelligent IT and CAD tools and user interfaces
- development of tools for establishment of product family libraries and sub-assembly platforms
- the development of a web-based, interactive co-design system:
  - development of web-based customer integration module for CAD system
  - development of integration systems within the CAD function with the following functionality:
    - order processing function
    - reporting requirements

System Integration Challenge
Some of the main impediments to the implementation of customer driven furniture design and production are the exponential increase in complexity of work processes, information flows and data handling associated with the proliferation of product and manufacturing data, and the potentially dramatic reduction of productive work time caused by the reduction of lot sizes and increased number of resulting operations.
To avoid these problems it is crucial that all design and manufacturing activities are fully integrated using state of the art information technology and systems, product data management and communication tools.
Also crucial to the feasibility of customer driven furniture design and manufacturing is seamless flow of information from the customer co-design system to the flexible machinery on the shopfloor.

Manufacturing Technology Challenge
The business model involving customer driven furniture design and production requires a state of the art production system and manufacturing technologies that combine the features of effective computer integrated batch production with the flexibility and variability of small series and one-off production of customised items. The current manufacturing process already satisfies the former requirements, whereas the technologies and systems for customised manufacturing and its integration in the existing batch production system will have to be developed in this project. This will be achieved through:
- design and establishment of a state of the art customisation cell
- development of production systems incorporating process postponement and agile system design
- development of optimised workflow in progress flow and inventory system

Figure 8.14 Customer driven furniture design and manufacturing defined through four challenges of market, manufacturing, design and systems.
A systematic approach was used at the early development stage of the programme. After conducting root-cause analysis of the challenges mentioned earlier, it was discovered that the answer to all of them revolved around the trade-off between design flexibility and cost (and lead time). Resolving this trade-off relationship should lead to innovative solutions to the above challenges.

Shahbazpour and Seidel (2007) have addressed this trade-off using TRIZ Separation Principles. They illustrate that this trade-off can be resolved if design flexibility is minimised at some part of the value chain and increased at others. In the case of furniture customisation, this implies that at some point during the production of the piece of furniture the customer’s specific requirements are introduced and prior to that, standard components/products were being manufactured. This entry point of customer’s specific design requirements is referred to as the customer decoupling point (9), and divides manufacturing into two stages of standardised pre-decoupling-point processes and flexible post-decoupling-point processes. As illustrated by Figure 8.13, the level of customisation increases as the decoupling-point is moved to the earlier stages of the production.

![Diagram of manufacturing processes](image)

Figure 8.15 Customer decoupling-point and levels of product customisation (Lampel and Mintzberg, 1996)

This concept was used to guide the marketing team in defining the levels of customisation required in each of their product categories. It was also used to guide the design team in developing ‘families’ of products that start out generic and can be configured by a system that interfaces with the customer. The decoupling point concept was further used by the manufacturing team to re-orient their processes in a way that early stages of the production is geared for lean mass-production, while the later stages become agile, producing smaller batches.
Internal Diffusion

A number of key initiatives were implemented in order to engage people in the programme and gain their confidence and support. These were the introductory workshops, creation of internal branding for the project and fortnightly breakfast forums.

The introductory workshops were conducted immediately after the decision was made by the board to go forward with the programme. The first of the introductory workshops was conducted by the CEO and the project champion, MSH, and was attended by the departmental managers. This was very important for gaining the support of the managers, as they could see the CEO expressing his support and confidence in the programme. This was then followed by five workshops to introduce the concept to around fifty of the company’s employees (including the production managers). In order to alleviate potential resistance due to the complexity of the programme, the presentations were structured around four easy to understand principles. These principles were extracted from the results of the foresighting workshop carried out with the senior executives. They were image, innovation, information and individualisation. Hence the programme was internally named the “i4 project”.

At the end of each workshop, the attendees were asked to fill a survey form asking for feedback regarding the programme concepts, its suitability for the company and interest in getting involved with the programme. A summary of the responses to each question on the survey is presented in Appendix B. The response overall, was enthusiastic with majority of people supporting the project. There was also general consensus about the suitability of the name of the programme, i4 project.
The other strategy used for internal diffusion of the programme was the creation of an internal brand for the programme. The need for this came about as the researcher was informally told on a number of occasions by staff that similar projects had been performed in the past, and had never worked due to the culture and decision making structure of the company. There was therefore a need to dissociate the programme from the failures of the past. The name, i4, seemed to have the support of most workshop attendees, so it was kept. A simple logo was designed for the i4 project, as shown on the top left hand corner of Figure 8.15. It was also planned to make sure that the i4 principles of image, innovation, information and individualisation were manifested in all points of communication. For instance, attention was given to visual impact and professionalism of the PowerPoint slides as well as the meeting invitation sent via email for i4 presentations to the staff.

A major contributor to the profile of the i4 brand as well as to the diffusion of the programme was the fortnightly breakfast forum. Originally started due to request by some staff to maintain the momentum generated in the introductory workshops, the forum soon became a permanent fixture in the meetings calendar of the company. The sessions were normally planned for 30 minutes. However, some sessions exceeded one hour due to the interesting debates and discussions that took place in the forum. Each session started with a progress report about the i4 project followed by two short presentations on topics related to the four principles of i4. After observing the dynamic discussions taking place in the forum, it was realised that this was a great mechanism for creating a new climate that supported innovation, creativity, debate and experimentation (see Figure 8.16).
Figure 8.18 Sample presentation slides from the i4 breakfast forum on the concept of product configurator
Project Management

Due to high levels of complexity and uncertainty associated with the programme, a very detailed project plan was developed. The plan was constructed around the challenges outlined at the systematic problem definition stage, and spans over 3 years. Given that the company had not had any prior experience in a programme as complex as this, case studies of previously implemented mass-customisation projects were used to provide insights for the planning template. A copy of the proposed project plan can be found in Appendix A. It contains detailed breakdown of programme objectives, estimation of resource allocation and the need for external experts, market entry plan, and assessment of the critical risks associated with the project, as well as a number of milestones as stage-gates.

The plan was essential for gaining the support and confidence of the senior executives of the company. It was also instrumental in applying for and securing government funding of nearly half a million dollars for the programme.
Chapter 9. Discussion

In Chapter 7 it was claimed that the proposed framework is tailored to the specific needs of the manufacturing SMEs by addressing the following critical issues:

- Absence of strategic approach to innovation,
- Absence of systematic and structured approach to problem solving and innovation,
- Impact of owner/manager on culture, structure and control,
- Lack of awareness about managing knowledge,
- Scarcity of resources.

As observed from the case studies in Chapter 8, the framework was successful at enabling the case company to apply a strategic approach to system and process innovation. For the first time ever, two system and process innovation programmes were started, which focused on long-term competitiveness of the company, while addressing also the short-term business issues.

By including the owner/manager’s vision, interests and personal objectives in the strategic planning stage, the framework was helpful in directing the innovation drive of the owner/manager to its rightful domain (i.e. strategic decision making). It also complemented his/her knowledge and business overview with strategically significant information from the company’s business environment, to help make better strategic decisions. Moreover, the preparation phase of the framework provided a structured and systematic approach to understand the drivers and obstacles of innovation, and to develop mechanisms to use the drivers and overcome the obstacles. It also proved helpful in identifying sources of knowledge and setting up mechanisms to acquire, store and disseminate it. Similarly the preparation phase provided the mechanisms for seeking new resource providers and exploiting existing alliances for accessing new resources.

Furthermore, a number of other important observations can be made after analysing the presented case studies. First was the ability of the framework to accommodate two completely different innovation programmes with different requirements. The sustainability programme was relatively simple, incremental and ongoing. It required mechanistic orientation along with a balance between internal and external cultural orientation. It did not
require much funding and external resources. It also required a participative style of leadership. On the other hand, the mass-customisation programme was complex, transformational and finite. It required a persuasive style of communication, a transformational style of leadership, as well as an organic and external cultural orientation. Its continuation was dependent on securing government funding, and required significant external knowledge and expertise. It also required a considerable amount of detailed planning.

The second observation is related to sequence of the phases of the framework. In Chapter 6 a sequential structure for the framework was proposed, which started with planning, and followed with preparation and processing. However, throughout the innovation programmes presented in the previous chapter, on many occasions the preparation phase continued simultaneously as the process phase. This indicates that these phases are indeed dynamically connected, and at any given time they can be modified based on the changes in the others.

The third observation is related to tools and methods selected or developed throughout the project. On many occasions to carry out the requirements of the framework, the team had to develop special tools. For instance, in Phase I, the business environment was analysed based on a tool developed in-house based on the collective knowledge of the project champion and some of the managers. Also in Phase II, an organisational assessment tool was developed to help develop mechanisms for preparation of the company for innovation. Both of these tools were influenced by the guiding principles of the framework. However the effectiveness of the developed tools were limited by the ability and experience of their developers. On one occasion, when analysing the levels of performance no appropriate tool was found or developed and consequently, no consensus was reached. Although developing tools was not in the scope of the project, it is a potential area for future research.

The framework was also instrumental in promoting a systematic approach to problem solving. In both of the innovation programmes at CM Ltd, the innovation problem was defined and analysed systematically, trade-offs were identified and creative approaches were used to develop solutions that addressed the root causes. However, it can be argued that the successful use of systematic approach as demonstrated in the two projects was mainly due to the background and skill set of the project champion, MSH. This was also observed in Chapter 6, when analysing the manufacturing performance measurement system project. In
that case study, the systematic approach used to structure the measurement system, was mainly due to the background of the individuals in the project team. This leads to a very important observation that the successful implementation of the framework at this stage is very much depended on the individual or the group who implement it. This is because the framework by design was made to be flexible and more like a guide than a prescribed process. A potential solution would be to develop a complete toolset for the three phases of the framework. The guiding principles of the framework can be used as selection criteria for existing tools. They can also be used to help specify the requirements for development of new tools. As pointed out earlier, this is a promising area for future research, which may lead to the development of a series of tools target to various aspects of innovation management in manufacturing SMEs.

Finally, in conclusion the framework has been found to successfully guide the development and implementation of strategic system and process innovation in the manufacturing SMEs.
Chapter 10. Conclusions and Recommendations

This section includes a review of the original research objectives presented in section 1.3, an overview of the achievements and original contributions of the work, as well as a discussion about future research.

10.1. Review of objectives

Objective 1
The first objective of this study was to develop a comprehensive model of strategic system and process innovation. This objective was achieved as presented in Chapter 4. First, a systems-based multiple-view approach was devised in order to conduct an in-depth analysis of the current state-of-the-art understanding in the area of innovation and factors that affect its success. Subsequently, a large body of literature related to management of innovation was systematically analysed from six viewpoints of process, structure, knowledge, control, culture and resource. The analysis was carried out with the aim of identifying key factors affecting innovation from each specific viewpoint and to develop an understanding of the nature of their impact on successful innovation. This was then followed by a synthesis process, which resulted in construction of single-view models of innovation determinants for each perspective. Each single-view model illustrates the relationship between the identified factors and various aspects of successful innovation. The models were also accompanied with a table providing higher degree of detail about the factors and their impact on innovation. Finally a consolidated model was developed as a conceptual arrangement of the individual single-view models together as a six-sided prism, with each side of the prism representing one viewpoint. The value of the model was demonstrated by using it to carry out an in-depth analysis of two system and process innovation case studies in a manufacturing SME (see Chapter 4).

Objective 2
The second objective was to identify the unique characteristics that govern strategic system and process innovation in SMEs. This objective was also achieved as presented in Chapters 5 and 6. First, a thorough review of literature was conducted and a number of characteristics
were identified which affected the dynamics of innovation in SMEs. The results were the identification four key characteristics of SMEs with significant effects on innovation:

- lack of planning and strategic approach,
- the influence of owner/manager,
- resource deficiencies,
- lack of knowledge management.

The researcher was then embedded as a manufacturing analyst in a manufacturing SME in New Zealand, to gain further contextual knowledge about innovation management in SMEs. For a number of years the researcher took part in the day to day activities of the company, working on numerous improvement projects at all levels of the organisation. Two of these projects, one technology based and the other related to performance management of the factory, were chosen for further analysis. Given the in-depth involvement of the researcher in both projects, he was able to collect and provide detailed information about how these projects were initiated, developed and implemented. This body of information was analysed using the multiple-view model developed in Chapter 4. This analysis was presented in Chapter 6 and three groups of characteristics were highlighted as key factors to be addressed by the framework for system and process innovation.

**Objective 3**

The third objective was to develop a framework for successful planning and deployment of strategic system and process innovation in SMEs. This was also completed as presented in Chapter 7. The developed framework has a structure which outlines the necessary phases of the strategic innovation process, as well as a set of guiding principles that can be used to design or select tools and methods suited to the requirements of SMEs in each phase. It is structured into three phases of plane, prepare and process.

First is the strategic planning phase, which aims to overcome SME characteristics such as emergence, incrementalism, internal orientation, short-termism, the implicit nature of strategy, and the informal and unstructured approach to planning. It guides SME managers to identify the main themes for strategic innovation in their firm, by generating a company-wide shared mental model of existing capabilities, available technologies, current and future market trends, current levels of manufacturing performance, specific requirements of the
funding providers as well as the owner/manager’s vision, areas of interest and personal objectives.

Second is the preparation phase, which addresses issues such as relationships with external entities, scarcity of financial and human resources, centralised organisational structure, the lack of awareness of knowledge management matters, as well as an unsupportive organisational culture and climate. It achieves this by enabling the managers to deliberately assess the organisational context of innovation with the aim of ensuring appropriate antecedent conditions are in place before affecting major change.

Finally, the third phase is concerned with absence of a systematic approach to solving problems, disregard for soft aspects of change, the centrality of decision-making, lack of planning, poor communication, and lack of attention to diversity and collaboration. It provides guidelines for SMEs to overcome these issues while they initiate, develop and then eventually implement solutions in line with strategic themes highlighted in Phase I and using mechanisms put in place in Phase II.

**Objective 4**

The fourth and final objective of the study was to verify the framework through case study application in a manufacturing SME. This objective was completed as presented in Chapter 8. The framework was successfully applied to a manufacturing SME and enabled its managers to apply a strategic approach to system and process innovation. For the first time ever in this organisation, two system and process innovation programmes were started, which focused on long-term competitiveness of the company while also addressing the short-term needs of the business. These were “Environmentally Benign Furniture Design and Production” and “Customer Driven Furniture Design and Production”; and they both achieved great success.

The first programme saw the case company go from having no sustainability credentials to becoming one of the few furniture manufacturing companies in Australasia with ISO14001 certification. Along the way it implemented numerous projects which incrementally reduced the impact of its products and processes on the environment. A number of these projects received national awards. The second programme was very challenging and ambitious. Based on the paradigm of mass customisation, it aimed to totally reconfigure the company’s existing batch production system. This programme constituted one of the biggest challenges in the
company’s history. At the time when the researcher terminated his employment at the case company, it had completed the planning stage, acquired near half a million dollars of funding from New Zealand government, and was at the early stages of development.

The framework proved instrumental in promoting a systematic approach to strategic development and creative problem solving. By including the owner/manager’s vision, interests and personal objectives in the strategic analysis of Phase I of the programmes, the framework was helpful in directing the innovation drive of the owner/manager towards strategic decision making. It also complemented his knowledge with strategically significant information from the company’s business environment, to help make better strategic decisions. Moreover, the preparation phase of the framework provided a structured and systematic approach to understand the drivers and obstacles of innovation, and to develop mechanisms to use the drivers and overcome the obstacles. It also proved helpful in identifying sources of knowledge and setting up mechanisms to acquire, store and disseminate it. Similarly the preparation phase provided the mechanisms for seeking new resource providers and exploiting existing alliances for accessing new resources.

10.2. Original contribution and achievements

By achieving the research objectives, the study presented in this thesis makes a positive contribution to the research fields of system and process innovation, integrated innovation models, characteristics of SMEs, strategic innovation in SMEs and manufacturing strategy in SMEs. Specifically, this research makes two original contributions to the fields above. These are the innovation framework and the multiple-view model of innovation.

**The innovation framework**

The primary contribution of the work presented in the thesis is the framework for strategic system and process innovation in manufacturing SMEs. The framework, whose successful application was demonstrated in this study, is a rare development in its field because it overcomes two major limitations in the existing body of research.

Firstly it addresses system and process innovation in SMEs, which is a topic that has received very little attention from researches. Indeed, process innovation (regardless of the size of the company) seems to be a neglected area of research let alone in the context of manufacturing...
SMEs. In a recent study, Becheikh et al. (2006) systematically reviewed over one hundred empirical studies published between 1993 and 2003, and found a mere 1% of these studies were focused on process innovation. More importantly, this neglect of process innovation is not limited to academics and is also prevalent among practitioners and managers. A study by Linder et al. (2003) conducted on forty managers revealed that these executives primarily thought about new products when considering innovation, and ignored other types of innovation such as system and process innovation. Add to this the reported paucity of research on innovation in SMEs (O'Regan et al., 2006) and the rarity of those studies offering practical tools and methods for SME (Hudson et al., 2001), it can thus be argued that the proposed framework is an important development in this area.

Secondly, the framework was developed on the foundations of in-depth understanding of both system and process innovation and the unique characteristics of SMEs. Majority of the studies conducted in the area of innovation and SMEs have been survey studies focused on identifying success and failure factors (O'Regan and Ghobadian, 2002, O'Regan et al., 2006, Lagace and Bourgault, 2003, Chu, 2003). Although their findings are crucial for understanding the determinants of successful innovation, they do not provide in-depth knowledge of contextual information that is critical for grasping the dynamics of a complex phenomenon such as system and process innovation in SMEs. In the absence of this thorough understanding of the requirement of SMEs for successful innovation, any tools or frameworks that are proposed will only touch the surface. This is evident in the concluding remarks of the authors of a comprehensive survey study of innovation in 702 manufacturing SMEs (O'Regan et al., 2006). They conclude that “any future research should consider a more in-depth approach. It would have been beneficial to augment the quantitative data with qualitative in-depth case studies or an ethnographic approach”. In comparison, the study presented in this thesis, based the development of the proposed framework on years of practical experience with manufacturing improvement projects in a SME, as well as an exhaustive analysis of literature in the area of innovation. It is therefore concluded that the framework is a rare development in this area.

Multiple-view model of innovation

The other major contribution of this thesis has been the multiple-view model of innovation presented in Chapter 4. Understanding of complex phenomena such as change and innovation requires in-depth analysis of innumerable interconnected factors. Consequently, innovation
has been studied from a broad range of individual and diverse perspectives and disciplines. This diversity of research has previously limited the accumulation and integration of knowledge regarding innovation and associated management practices (Tidd, 2001, Fagerberg, 2004). Becheikh et al. (2006) argued along similar lines and concluded that there was a need for a framework that brings together the variables related to the innovation process as well as the internal and contextual factors driving it. A number of researchers have recently developed models identifying key drivers of innovation, and have conceptualised their relationship with the innovation process. However, after reviewing these models and the list of the identified determinants it was concluded that these existing models are limited by the viewpoints used in their development.

To overcome this problem, the study presented in this thesis employed a systems-based, multiple-view approach to analyse a large body of relevant literature, resulting in the identification of over one hundred factors from six perspectives impacting innovation. The value of the model was proven by demonstrating its use in carrying out an analysis of two system and process innovation case studies in a manufacturing SME. Developing in-depth understanding of system and process innovation, such as the one represented in Chapter 4, would not have been possible using any of the existing models of innovation. It is therefore concluded that the multiple-view model of innovation presented in this study is a significant contribution to the field of innovation management.

10.3. Recommendations for future research

There are a number of notable extensions to the work presented here, that have not been explored as part of this study. First is to develop SME specific strategic innovation tools and methods based on the guidelines provided by the system and process innovation framework presented in this thesis. For instance in Phase 1 of the framework, there is a need for a simple and practical tool for manufacturing SMEs to assess their performance along multiple dimensions and compare them to their competitors. Moreover, a number of tools can be developed to externalise and communicate much of the tacit knowledge that management of SMEs hold about their areas of internal capabilities, relevant technological developments, their vision and strategy for the business as well as their understanding of the changes and trends in the market. Similarly, in other phases of the framework there are gaps in terms of tools that have been developed with the specific requirements of SMEs in mind.
The second area of future research is the continuing development of the multiple-view model of innovation. The model as presented here is extensive, but by no means is it complete. In fact it can be argued that as long as there are new developments in innovation management research the model will not be complete. However, the existing structure and list of determinants provide a sound foundation for identifying gaps in our collective knowledge about innovation. Furthermore, the existing model was constructed as an aid for the development of the innovation framework. Consequently the majority of innovation determinants in the model are at the organisational level of analysis. There is a strong case for adding another dimension to the model and identify innovation determinants at macro, meso, organisational, group and individual levels of analysis.

The third notable area for future studies is the application of the multiple-view innovation model in other contexts. In this study the model was used to better understand the dynamics of system and process innovation in manufacturing SMEs. Since the model was developed independently of the specific context of this study, it can be applied in a similar fashion to understanding innovation in other contexts. For instance it could be used to understand innovation in micro-enterprises, start-ups or even multinational organisations.
References


Appendix A. Detailed Plan for Customer Driven Furniture Design and Production Programme
Project Plan

Technical Deliverables:

Design Technology Challenge

Implementation of customer driven furniture design requires the development of technologies and systems to integrate customers in CM Ltd’s design process by enabling them to define, configure, design, match, or modify their individual solution from an information base of options and pre-defined components. The prerequisites for achieving this are the creation of the technological basis of a co-design platform and the development of a web-based, interactive co-design system.

1.1 Technological basis for a co-design platform

1.1.1 development of a product architecture with both scale and module-based, and parameter-driven product families,
   a. product architecture for pilot product family - storage
   b. product architecture for kitchens, office, entertainment

1.1.2 development of tools for establishment of product family libraries and sub-assembly platform,
   a. Prototype for specification of product families, construction rules and parametric constraints
   b. Expanded prototype for specification tool to include sub-assembly platforms and modular interfaces
   c. Final product specification tool for product family libraries and sub-assembly platform.

1.1.3 development of an integrated product data information system,
   a. product data information system prototype for pilot product family
   b. expanded product data information system

1.1.4 development of interactive, intelligent IT and CAD tools and user interfaces for CM Ltd’s design team
   a. tools to generate new product families,
   b. tools to select and modify product families,
   c. tools to generate machine data and drawings,
   d. tools to generate BOM and routings;

1.1.5 development of CAD and IT tools to create associativity between customer input and CAD product models,
   a. prototype toolbox for interconnection of customer input and integrated product data information system with limited features and options.
   b. expanded prototype toolbox with added functionality for more complex features and customer options.
   c. fully working prototype applied to the pilot product – storage
   d. expansion of the tool box to include other product families

1.1.6 development of the specification of the interactive co-design system
   e. prototype specification based on limited features and options
Interactive co-design system

1.2.1 development of web-based customer integration module for CAD system,
   a. prototype for pilot product – storage
   b. expanded prototype to include other product families
   c. fully operational web-based customer integration module

1.2.2 development of integration systems within the CAD function
   a. prototype including the product data information system, order processing function and reporting tools.
   b. fully operational system

Manufacturing Technology Challenge

The business model involving customer driven furniture design and production requires a state of the
art production system and manufacturing technologies that combine the features of effective computer
integrated batch production with the flexibility and versatility of small series and one-off production of
customised items. CM Ltd’s current manufacturing process already satisfies the former requirements,
whereas the technologies and systems for customised manufacturing and its integration in the existing
batch production system will need to be developed in this project. The following aspects need to be
covered in the development work:

2.1 Development of a customisation cell including the following areas:
   2.1.1 analysis of technology and capability gaps and development of process requirements specification,
      a. capability gap report
      b. process and technology requirement specification
   2.1.2 optimisation of machine and work centre layout and product flow structure
      a. fully specified work centre and process layout
      b. fully specified product flow system
      c. fully specified work-in-progress control system for customised products and parts
   2.1.3 development of a planning and control system for shop floor control and job tracking
      a. prototype of planning and control system for low volume and limited product mix customised manufacturing
      b. prototype of job tracking system for the customisation cell
      c. expanded planning and control system for high volume and limited product mix customised manufacturing
      d. complete planning, shop floor control and job tracking systems for high volume manufacturing of the complete range of customised product families

2.2 Design and optimisation of the customisation process
   2.2.1 identification of customer decoupling points between mainstream batch production and customisation
      a. process designs with clearly identified customer decoupling points
   2.2.2 integration of process flow of customisation cell with mainstream batch production process,
a. prototype of information flow systems for interfaces between processes downstream and upstream of the decoupling points
b. prototype of work-in-progress storage and flow systems for interfaces between processes downstream and upstream of the decoupling points

2.2.3 Optimisation of logistics for raw materials and finished goods of the customisation process,
   a. optimised information and work-in-progress flow system across the entire customer drive manufacturing value chain
   b. supply chain of externally sourced raw material and finished goods optimised in line with the overall customer driven furniture design and manufacturing strategy
   c. prototype of order processing and fulfilment process for pilot product – storage
   d. expanded order processing and fulfilment process to include all other product families

2.2.4 Planning and organisation of new technology uptake
   a. full specification of manufacturing technology investment in line with the requirements of the developed mass customisation systems and processes
   b. selection and purchase of new machinery
   c. new machinery implemented as planned
   d. new machinery integrated within current systems and fine tuned for optimal performance

**Systems and Process Integration Challenge**

Some of the main impediments to the implementation of customer driven furniture design and production are the exponential increase in complexity of work processes, information flows and data handling associated with the proliferation of product and manufacturing data, and the potentially dramatic reduction of productive work time caused by the reduction of lot sizes and increased number of resetting operations. To avoid these problems it is crucial that all design and manufacturing activities are fully integrated using state of the art information technology and systems, product data management and communication tools. The following steps are necessary to achieve this:

3.1 Design and implementation of an integrated manufacturing information and product data management system

3.1.1 development of detailed system specifications and selection of software and hardware solutions and vendors
   a. report of the analysis of the interfaces and interconnections between the external sourcing system, product design information system, order processing and interactive customer co-design system, finance and performance reporting system, process planning, scheduling and control systems, purchasing and logistics system and production system.
   b. full system specification document

3.1.2 design and implementation of integrated information and product data management system
   a. functional and reliable integrated manufacturing information and product data management systems
   b. optimised interfaces between subsystems
**Project and commercial “Stage-Gates”:**

<table>
<thead>
<tr>
<th>Name and Description</th>
<th>Performance Measures: Go/Kill Point?</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customisable Product Architecture for Pilot Product Family – Storage Cabinet</td>
<td>Successful parametric design of customisable storage cabinets (technical stage gate)</td>
<td>December 2007</td>
</tr>
<tr>
<td>Manufacturing systems and processes for low-to-mid volume customisation</td>
<td>Successful manufacturing of customised products (technical stage gate)</td>
<td>June 2008</td>
</tr>
<tr>
<td>Library of customisable product families, platforms and Interfaces</td>
<td>Complete range of customisable products (design stage gate)</td>
<td>September 2008</td>
</tr>
<tr>
<td>Integrated product data system with associated tools for CM Ltd’s design team</td>
<td>Software tools and systems operating reliably (technical stage gate)</td>
<td>September 2008</td>
</tr>
<tr>
<td>Pilot launch of customisable cabinets for local storage, kitchen and TV/Audio markets</td>
<td>Meeting budgeted revenue targets (marketing stage gate)</td>
<td>March 2009</td>
</tr>
<tr>
<td>Strategic partnerships for selected export markets</td>
<td>Established agency agreements with strategic partners (marketing stage gate)</td>
<td>April 2009</td>
</tr>
<tr>
<td>High volume customisation system and processes</td>
<td>Fulfilling all customer orders on time (technical stage gate)</td>
<td>July 2009</td>
</tr>
<tr>
<td>Internet based interactive co-design system</td>
<td>Web site and tools operating reliably and interfacing with product design information system, order processing system and production planning system (technical stage gate)</td>
<td>March 2010</td>
</tr>
<tr>
<td>Completing a number of commercial contracts locally and in selected export market</td>
<td>Meeting budgeted revenue targets (marketing stage gate)</td>
<td>March 2010</td>
</tr>
<tr>
<td>Direct sales of customised furniture using the web interface</td>
<td>Meeting budgeted revenue targets (marketing stage gate)</td>
<td>July 2010</td>
</tr>
</tbody>
</table>

Note: A “stage gate” is a milestone at which point technical or commercial feasibility of the project “as planned” is assessed and if necessary adjustments to the plan are made or if project is found not be technically or commercially viable, the project is stopped.
Risk estimate for each objective:
An ‘early prototyping’ approach has been applied in all project areas to minimise the technical, commercial and organisational risks, to maximise skill development and technology transfer opportunities, to allow testing and fine-tuning of developed solutions, and to create early business benefits through implementation of partial solutions in areas with maximum commercial scope. A good example for this approach is in the Design Technology Challenge, where scale and module-based and parameter-driven product families will initially be developed and introduced for the ‘storage’ product family as a pilot development. The storage family has a relatively simple product topology, consists of a range of individual products in a number of local and export markets, and represents significant commercial value to CM Ltd. The new concept can therefore be developed and tested relatively fast, minimising the technical and organisational risks and maximising skill development opportunities. To mitigate the commercial risks, it will initially be applied to local markets to test customer reaction, before it is transferred to other markets. The experience gained in this pilot application will then be applied to the rest of CM Ltd’s product spectrum. A similar approach will be applied in other areas of the project development.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Risk Estimate</th>
<th>Risk Score</th>
<th>Justification</th>
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<tbody>
<tr>
<td>1. Design Technology Challenge</td>
<td></td>
<td></td>
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<tr>
<td>1.1 Technological basis for a co-design platform</td>
<td>Low</td>
<td>This area has been thoroughly investigated in our feasibility studies mentioned above. We have developed a very good understanding of its technical and organisational aspects, and our internal staff and external experts are well prepared for the tasks involved. We will apply a low-risk strategy for its development based on extensive prototyping and testing, and a step-by-step approach.</td>
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<tr>
<td>1.2 Interactive co-design system</td>
<td>Med</td>
<td>This is a core area of our development that requires extensive prototyping and testing. We have access to relevant information from the EUROShoe and other projects, and are well aware of the technical pitfalls and commercial risks involved. We will therefore implement an early prototype of the co-design system for the storage products family in the local market and work closely with our marketing experts, technology providers and key retailers. This will enable us to select the best design option and optimise the system before we apply it to the wider product spectrum and to our international target markets.</td>
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<tr>
<td>2. Manufacturing Technology Challenge</td>
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<tr>
<td>2.1 Development of Customisation Cell</td>
<td>Low</td>
<td>We have a long and successful history of developing advanced manufacturing technology. A number of studies were targeted to maximise our expertise in this area. Our work plan is based on a proven step-by-step approach, and we therefore foresee very few risks in this area.</td>
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<td>2.2 Design and optimisation of the customisation process</td>
<td>Med</td>
<td>This area is critical to the success of our project, and due to its nature and novelty we have little prior experience in it. We have therefore carefully analysed its technical and organisational requirements and critical factors and have structured our implementation plan carefully to minimise the associated risks. We also have the benefit of having access to the experience gained in international developments, such as the EUROShoe project.</td>
<td></td>
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<td>3. Systems and Process Integration Challenge</td>
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<td>3.1 Integrated manufacturing information and product data management system</td>
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<td>We have a very good understanding of the features and integration requirements of our current processes and systems from our earlier feasibility studies. However, the exact technologies and systems required for their integration under the co-design paradigm can only be specified and implemented in tandem with the developments in Objectives 1.2 and 2.2. We have therefore allowed for an extensive analysis and specification phase, which will allow us to optimise our approach and minimise the technical and organisational risks involved. Our internal and external experts are well prepared for the necessary tasks, and we will apply a carefully structured and controlled step-by-step approach to phase in the developments with minimum disruption to the operation of the plant.</td>
<td></td>
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<tr>
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Market entry plan
With the implementation of the planned marketing strategy, it is estimated that CM Ltd’s customised products and services will capture niche market share in NZ and Australia as outlined in the following tables. The market share percentages are based on many years of experience CM Ltd has had with entering and releasing new products in these markets.

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<th>YEM ’10</th>
<th>YEM ’11</th>
<th>YEM ’12</th>
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<td>TV/Audio</td>
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<td>1.3%</td>
<td>1.6%</td>
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<td>0.8%</td>
<td>0.9%</td>
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<td>Custom Kitchen and Bathroom</td>
<td>Direct Consultation or</td>
<td>Local</td>
<td>Residential</td>
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<tr>
<td>Custom Home storage and</td>
<td>Retail</td>
<td>Export</td>
<td>Commercial</td>
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<td>Custom Office desk and storage</td>
<td>Agent</td>
<td>Local</td>
<td>Residential</td>
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<tr>
<td>Custom TV and Audio Cabinets</td>
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<td>Commercial</td>
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Appendix B. Staff Survey and Results at CM Ltd
Survey

1. Do you agree that the "back to business as usual" attitude is restricting CM Ltd’s capability to make significant changes in its business?
   □ No  □ Partly  □ Yes

2. Do you know where to go when you have ideas? And are they implemented?
   □ No and No
   □ I don’t know where to go, so it will only happen if I do it myself.
   □ I know where to go, but nothing happens with my ideas
   □ I know where to go and I receive feedback on the ideas.
   □ I know where to go and it’s implemented straight away.

3. What should be the nature of change at CM Ltd (tick the one(s) appropriate)
   □ Culture  □ Structure  □ Capabilities  □ Products

4. Can you rank the I’s from the most level of importance (1) to least(4)?
   □ Image  □ Innovation  □ Information  □ Individualisation

5. Please write down in one line, what CM Ltd is:

6. Please write down in one line, what CM Ltd should be:

7. What image would fit the i4 project:
   □ Cool  □ Different  □ Necessary  □ Sideline  □ Too Big  □ ..................

8. How do you feel about the i4 project?
   □ Negative; it won’t change anything  □ Nothing; we don’t need it
   □ Positive; might work, doesn’t hurt  □ Fantastic; this is what we need, go for it
   □ Superb; and how can I help?  □ .................. ; ...........................................

9. Is the name of the project appropriate?
   □ Yes  □ No  □ If no, please suggest a different name: .................................

10. The length of the presentation was:
    □ 1  □ 2  □ 3  □ 4  □ 5
    Too long  Too short

    Comment:

11. The length of the group discussion was:
    □ 1  □ 2  □ 3  □ 4  □ 5
    Too long  Too short

    Comment:

12. What did you think of the presentation?
    □ 1  □ 2  □ 3  □ 4  □ 5
    Boring  Interesting
Results

1- The “back to business as usual” attitude is where good ideas are put aside because daily problems consume all available time. 65% thinks that this is true and 31% thinks it’s partly the case. According to 96% of CM Ltd staff, “back to business as usual” restricts CM Ltd, at least partly, in making significant changes in business.

2- When CM Ltd staff have ideas most of them feel that they will not be implemented. 26% do not know where to go, 30% know that but see no results or feedback from their ideas. Another 41% know where to go and receives feedback, not many see implementation. 56% Cannot effectively share their ideas.

3- The nature of change for CM Ltd should be primarily cultural and structural. 89% of replies think we need a culture change, 59% think structural change is required. Still over 40% of the respondents think that also the capabilities and product have to change.

4- The ranking of the four i’s should be Innovation -> Image -> Information -> Individualisation

5- When asking people what CM Ltd is the responses are uninspired. 14 of 23 responses were similar to “a furniture manufacturer”, without adverbs or adjectives. 3 respondents expressed that CM Ltd is a conservative company, 2 people underline CM Ltd’s potential and 3 have words like ‘leading’ and ‘best’.

6- We also had 23 answers to the question what CM Ltd should be. This time only 4 people follow a formal approach in which they call CM Ltd successful or product producing. 9 people involve innovation and progress, breaking away from traditional approaches. The vast majority, the rest, want to challenge CM Ltd and put it to the cutting edge at one way or another. Two quotes: “One to be judged by” and “The first choice when looking for a furniture solution” stand out. One respondent would like CM Ltd to ‘furnish your imagination’

7- 81% of respondents felt the right word to describe the i4 project was ‘necessary’. 8% think that it’s different. A respondent commented that the i4 project was something that leads to ‘winning’.

8- The feeling about the i4 project is 100% positive. More then 50% even thinks that it is fantastic and additionally 25% would like to help immediately. Responses include encouragement and high spirit: “Let me help us to achieve this!”

9- The project name ‘i4’ was thought to be appropriate according to 91%. Two other suggestions come up namely, “Evolve” and “Alchemy”.

10- The length of the presentation was good according to 85%, nobody thought it should have been shorter.

11- When it comes to the group discussion, 68% wanted to continue longer. People were happy (even looking forward to) voicing their ideas and trying them on other people. Interactive involvement was regarded as the chance for everybody to speak up and the chance to listen to others. Strategic thinking is found to be complex. The use of regular forums is encouraged.

12- 86% of the respondents found this presentation not business as usual, 56% found it ‘Interesting’ with the remark that there was no superlative to be selected. Only 1 person thought the presentation was not interesting, where 10% didn’t feel it was special.