A Taxonomical Study of Agility Strategies and Supporting Supply Chain Management Practices

Submitted by **Rundong Wang** to the University of Exeter
as a thesis for the degree of
Doctor of Philosophy in Engineering
In May 2011

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: ……..
Rundong Wang

Acknowledgements

I would like to acknowledge all the help and support I have received from the following people during the course of my PhD studies.

Firstly, my sincere gratitude goes to my supervisor Professor David Zhang. His friendly and constant guidance, feedback and constructive comments on my work helped me greatly in the completion of this research.

Secondly, I would like to sincerely thank my research colleague Dr. Mark Errington. His generous helps not only in my academic research but also in my extracurricular life have made my overseas study experience full of fun.

Thirdly, I would like to thank all my friends and XMEC colleagues for their on going support and patience throughout the course of my PhD.

Finally, my special appreciation goes to my parents who have always encouraged and supported me in my whole life. Without their support it would not be possible to accomplish this challenging job.

I dedicate this thesis to my beloved parents as a sign of my endless gratitude.

Abstract

Since the turn of the century, manufacturing industry has witnessed significant structural changes. Agility, which aims to provide companies with competitive capabilities so that they can prosper from dynamic and continuous changes in the business environment, has become a prevailing manufacturing strategy. However, how to develop a manufacturing strategy based on agility, and how to design and manage global supply chain networks effectively to implement these strategy, are not fully understood.

This thesis presents survey based research that was carried out on a number of U.K. manufacturing companies. The research revisited the taxonomy of agility strategies for manufacturing industry developed by Zhang and Sharifi (2007) and investigated the methods of supply chain management employed by different strategic groups. The findings show that whilst the three broad types of agility strategies discovered in previous work (Zhang and Sharifi, 2007) have remained two sub types of agility strategies have been identified. They are named Responsive players, Quick operators, Quick innovators, Proactive players 1 and Proactive players 2. Responsive players placed a high emphasis on supplier selection related practices; Quick operators placed a high emphasis on sourcing management related practices; Quick innovators placed a high emphasis on relationship management related practices; and Proactive players 1 and 2 placed high emphases on almost all practices.

This research has made contributions to the theory development of agility strategy and has provides a managerial guide with companies to improve the implementation of agility strategies in supply chains.

List of contents

List of tables

List of figures

List of publications

Wang RD, Zhang DZ. A taxonomical study of agility strategies and supply chain management, *20th International Conference on Production Research*, Shanghai, China, 2nd - 7th Aug 2009, *Proc. of 20th International Conference on Production Research*, pages 6.49.1-6.49.6.

Wang RD, Zhang DZ. A taxonomical investigation of agility strategies and supply chain management, *16th International Annual EurOMA Conference*, Goteborg, Sweden, 14th - 17th Jun 2009, *Proc. of 16th International Annual EurOMA Conference*, pages P87.1-P87.10.

Chapter1 Introduction

1.1 Introduction

This chapter gives an overview of the research. A brief description of research background is provided in section 1.2. Research problems and questions are discussed in section 1.3, and the objectives of this PhD research are given in section 1.4. Some propositions for the research, based on preliminary studies, are posed in section 1.5. Section 1.6 explains the organisation of this thesis and section 1.7 concludes this chapter.

1.2 Research background

Since Skinner (1969) first suggested that manufacturing should be considered as a strategic issue rather than a technical one, the relationship between manufacturing decisions and corporate strategy has been established. At that time, in Skinner's (1969) words, "most top managers regarded manufacturing as the gateway to grubby routine, where days are filled with high pressure, packed with details, and limited to low-level decision making – all of which is out of the sight and minds of top-level executives." He believed that "top executives tend to avoid involvement in manufacturing policy making, manufacturing managers are ignorant of corporate strategy, and a function that could be a valuable…tool of corporate strategy becomes a liability instead." He asserted that "manufacturing is part of a strategic concept that relates a company's strengths and resources to opportunities in the market."

Skinner's assertion has received a number of echoes from both practitioners and academics, and increasing attention has been drawn to the research field of manufacturing strategy

since then. Lots of efforts had been made on developing the concept of manufacturing strategy before the turn of the century, while many researchers were engaged in examining different aspects of manufacturing strategy. A general model of the domain of manufacturing strategy was proposed by Swink and Way (1995) in their review work, in which manufacturing strategy was broadly divided into two domains – content and process. The content of manufacturing strategy mainly concerns strategic types and strategic choices and performance that consists of competitive priorities, process design and infrastructure. The process of manufacturing strategy is associated with strategy formulation and implementation of strategic decisions. In other words, the content aspects are related to the conceptual and theoretical side, while the process aspects have regard to the practical side. The content aspects are the dominant research theme in the literature, and comparatively, the process aspects have received much less attention from researchers (Dangayach and Deshmukh, 2001).

Since the passage of the General Agreement on Tariff and Trade (GATT) and the World Trade Organisation (WTO) were developed in 1994 and 1995 respectively, coupled with a multitude of other international trade agreements, worldwide industries face a new era of intense global competition (Dangayach and Deshmukh, 2001). What have been brought out by this new era are various changes. These changes become the toughest challenges that firms face in the new business environment. Utilization of traditional operations management, such as mass production operations or even lean operations, is no longer sufficient for firms to conquer the changes.

In fact, the importance of managing changes and uncertainties is pointed out in management studies and research long before. Thompson (1967) indicated that one of the

most important tasks for organisations is to manage uncertainties. Drucker (1968) stated that entrepreneurial tasks are searching for changes, responding to changes, and exploiting changes as opportunities.

As many studies revealed that turbulence and uncertainty in the business environment have become the main cause of failures in the manufacturing industry (Hayen, 1988, Hamel and Prahalad, 1994, Lanners and Logan, 2004), a group of researchers from Iacocca Institute in USA conducted a project which was aimed at making America once again a leader in manufacturing. An influential report was resulted as a consequence. The report, evoking a big echo in academia, soon became a focal point of manufacturing studies. The concept of agile manufacturing emerged.

Numerous supportive works have followed the report, and focuses have been placed on the necessity of developing new visions, revisits of the traditional philosophies and mindsets, and the comparison between different manufacturing thinking. Although the essence of agility described in the initial report of Iacocca Institute looks at manufacturing from a strategic point of view with objectives of coping with rapid changes and taking advantages of changes as opportunities, little work has been done on linking agile manufacturing and manufacturing strategy.

Most previous work in the area regards agile manufacturing as a result of evolution of mass customization and lean production. In other words, these studies still treat agile manufacturing as operational effectiveness. While it is more accurate to develop agility on a strategy basis, there is a lack of such kind of work in aforementioned researches, until

more recently, an initial theory building work in agile manufacturing strategy was conducted by Zhang and Shrifi (2007).

1.3 Research problems and questions

Agile manufacturing strategy is explicitly proposed in Zhang and Sharifi's (2007) work. It is the first time that agility is discussed as a manufacturing strategy. In the research work, based on an empirical study of UK manufacturing industry, three types of agility strategies had been discovered by using a taxonomical approach. The data used in the study was collected around 2000.

Since then, significant changes have taken place in the manufacturing industry. The changes are characterized by the increased intensity of global outsourcing and global marketing, the rising energy and materials costs, and problems associated with the quality and security of supply networks. Such changes, along with continued pressures from rapid technology advancement, shrinking product life cycles and increased market fragmentation, have caused significant structural changes in manufacturing industry across the globe. Furthermore, recent global financial crisis had a huge impact on manufacturing industry. These issues all raise important questions concerning the present knowledge about agility strategies. Is Zhang and Sharifi's taxonomy still valid in today's industry? If not, what are the changes to the taxonomy? Can new findings update their model into a more applicable and robust framework?

On the other hand, in recent years, the nature of competition has increasingly shifted from 'organisation versus organisation' toward 'supply chain versus supply chain' (Christopher

and Towill, 2000, Slone, 2004, Hult et al., 2007). Failure of properly designing and managing supply chains can hamper the sustainable development of a company (Slone, 2004).

Business environment has been more dynamic and unpredictable. Turbulence and volatility become the norm as life cycles shorten and global competition pressures create additional uncertainty. The mentioned volatile and uncertain factors will undoubtedly affect integration and operations of the supply chain, and need to be considered in supply chain design and management. All of these necessitate the extension of utilization of agility strategies into supply chain context. It is worth looking at if there are differences on supply chain design and management between firms who are with different agility strategies; and what practices firms choose to design and manage their supply chains.

Based on what have been discussed above, the research questions can be summarised as follows:

- Are there still different types of agility strategies in today's industry and what are the basic types? Do the types of agility strategies discovered by Zhang and Sharifi still exist?
- Do firms identified with different agility strategies design and manage their supply chains differently? Are there clearly identifiable patterns of choices of supply chain design and management practices corresponding to each type of agility strategies? If yes, what are the patterns?
- Do the choices of agility strategies and ways of supply chain design and management relate to agility drivers companies suffered? Do they relate to the nature of market, characteristics of products, and product life cycles? If yes, how are they related?

1.4 Research objectives

While agility that aims to provide firms with competitive capabilities to prosper from dynamic and continuous change in the business environment has been increasingly accepted as a prevailing manufacturing strategy, the competition is no longer just between organisation and organisation but rather between supply chain and supply chain. How to properly design and manage the supply chains in today's unprecedentedly dynamic business environment becomes the determinant of business success for firms.

The preliminary studies in the subject, however, show that little empirical work has been done on extending the consideration of agile manufacturing strategy into supply chain context. Although some previous researches have made attempts on developing agile supply chain which is regarded as the interchangeable terms of responsive supply chain (Yusuf et al., 2004, Baramichai et al., 2007), the focus of those researches is on supply chain building issue and stays at the theoretical level. This research focuses on managing supply chain with implementing agility strategies. In other words, this research aims to identify how firms who have adopted agility strategies design and manage their supply chains.

Attempting filling the gap identified in the preliminary study, the objectives of this research are:

1. To develop a taxonomy of agility strategies for manufacturing industry and to compare the ways of supply chain design and management conducted by firms affiliated to different strategic groups;

2. To examine the most significant differences between agility strategies with respect to supply chain design and management practices;
3. To find the relationship among agility strategies, agility providers of supply chain management practices and agility drivers.

1.5 Research propositions

Significant structural changes in manufacturing industry since the turn of the century, caused by the transformation of business environment, are believed to have had a huge influence on the reform of the manufacturing strategy. Based on this point along with the preliminary studies carried out, five research propositions are formed as shown below:

Proposition 1 – There has been changes to the types of agility strategies discovered in Zhang and Sharifi's (2007) work.

Proposition 2 – Different types of agility strategies will have different patterns of choices of supply chain design and management practices.

Proposition 3 – The pressures companies suffered from to agility drivers will have an impact on the choices of agility strategies.

Proposition 4 – The pressures companies suffered from to agility drivers will have an impact on the ways of supply chain design and management.

Proposition 5 – The nature of market, characteristics of products and product life cycles have impacts on the choices of agility strategies and the corresponding ways of supply chain design and management.

1.6 Thesis outline

An overview of the thesis chapters is given as follows:

Chapter 1 provides an overview of the research. This chapter describes research background, defines the research questions, sets the objectives for the research, and overviews the structure of the thesis.

Chapter 2 will present an in depth review of manufacturing strategy and supply chain management literature. It aims to establish a theoretical foundation for this research and to show the needs of carrying out this study. The gaps in the literature are identified and the motivation of the research is presented along with the literature review.

Chapter 3 will describe how this research is carried out. The research questions are proposed after the presentation of the gaps identified in the literature and the motivation of the research in Chapter 2. A discussion of research methods that were used in the course of this research will be presented.

Chapter 4 will present the framework proposed for this research. A framework for using supply chain management practices (SCMPs) to support implementation of agility strategies has been developed based on the framework of defining agility as a manufacturing strategy developed by Zhang and Sharifi (2007). The description of the framework and the details of the constructs of the framework are given along with literature support.

Chapter 5 will describe the development of questionnaire survey for this study. The development of the survey instrument and the execution of the survey are depicted in this chapter. The tools and methods for data analysis are provided. The reliability of the instrument for survey is assessed. The characteristics of samples are analysed and reported.

Chapter 6 will report clustering analysis and canonical discriminant analysis. By clustering analysis of agility capabilities strategic groups will be identified. Through canonical discriminant analysis underlying dimensions that separate groups from each other will be recognized. A comparison of strategic groups identified in this study and the groups discovered in Zhang and Sharifi's (2007) work will be conducted. Discussions between the findings of the two studies will be provided.

Chapter 7 will report a more in depth analysis of agility drivers and agility providers along with discussions. Agility drivers representing external and internal pressures companies suffered and agility providers representing the way of the management of supply chains are investigated in accordance with resultant strategic groups. The relationships between the pressures groups suffered, the agility strategies groups chosen and the ways of supply chain management groups conducted are examined. Discussions of findings are provided.

Chapter 8 will conclude the research and provide suggestions for further work. By revisiting the research questions, the answers derived from the research findings are provided. The suggested propositions are confirmed. The contributions of this research are reported.

1.7 Summary

This chapter provided an introduction to the conducted research including the research background, the research problems and questions to be addressed, the research objectives to be achieved, and the suggested research propositions. An overview of the structure of the thesis was provided at the end of this chapter.

A preliminary study was carried out to develop a background and capture a preview of the subject of the research. The study mainly involved initial references to the literature and original works in the area of manufacturing strategy and agility concept. Some background of the research was established, and the problems to be addressed and the questions to be answered were identified by recognizing the gaps in the research area.

The research focuses on identifying the changes on the types of agility strategies and examining the ways of supply chain design and management of firms on different types of agility strategies, aiming at providing guidance on the implementation of agility strategies in supply chain management. Three objectives were established to guide the progresses of the research. Five propositions were posed to be confirmed during the research.

The following chapters detail how the research questions will be answered, how the propositions will be confirmed, and how the objectives of the research will be achieved.

Chapter2 Review of the literature

2.1 Introduction

This chapter provides a review of relevant literature pertaining to this research. The review is virtually presented in two parts. The first part gives a historical view from the development of manufacturing strategy through emergence of the concept of agility to using agility as a strategic weapon to compete in the rapidly changing business environment. The evolution of manufacturing strategy is studied first, followed by a description of the emergence of the concept of agile manufacturing and the development of agility-based manufacturing strategy.

The second part presents the survey of literature related to supply chain management issues. Since the mode of competition in the contemporary business environment has transferred from single organisation versus single organisation to supply chain versus supply chain (Christopher, 2000), questions such as what and how supply chain management practices can be used to support the implementation of agility strategies has been considered. This part of the literature review is to understand better the theoretical foundation of supply chain management issues.

The purpose of this chapter is to understand how agility has developed as a subject, to identify gaps in the literature and to form research questions for this project.

2.2 Research on manufacturing strategy

2.2.1 A strategic view of manufacturing

There is a growing and consistent awareness in academia and industry that manufacturing is no longer just a technical issue but rather increasingly moving towards the issues of strategy. Failing to recognise the linkage between manufacturing decisions and corporate strategy can lead to non-competitive manufacturing systems which are expensive and time-consuming to change (Skinner, 1969). Skinner (1969) initially introduced the view of taking manufacturing from a strategic perspective. He revealed that more often than not top management delegated a large portion of basic policy decisions to lower levels in the manufacturing area without any concern. This is because of the conventional notion that manufacturing was treated by top managers as a technically oriented component and it was thought to be the grubby routine filled with high pressure, packed with trivial details and limited to low-level decision making. The necessities of making strategic decisions in manufacturing area were conventionally out of the sight and minds of top-level managers. However, it is the conventional notion that often resulted in a 'missing link' between manufacturing policy and corporate strategy (Skinner, 1969). Based on this recognition, incorporating manufacturing into the firm's strategic direction was suggested as a solution to the 'missing link'. Many other researchers agree with this point of view (Skinner, 1978, Allen and Hamilton, 1982, Swamidass and Newell, 1987, Anderson et al., 1989). Since this point, the term of manufacturing strategy has been used to refer to this solution.

During the early stage of manufacturing strategy development, manufacturing strategy was defined in different ways. Skinner (1978) described manufacturing strategy as the

manufacturing task which is: *"a statement of manufacturing philosophy in the sense that 'philosophy' relates ends and means and links them together conceptually with a total plan and its rationale."*

Mayer and Moore (1983) defined manufacturing strategy as *"a plan that describes the way to produce and distribute the product."* They believed that manufacturing strategies concerned *"the choice of process technology, degree of vertical integration, the number and location of facilities, factory focus and the manufacturing infrastructure."*

Hayes and Wheelwright (1984) defined manufacturing strategy as a consistent pattern of decision making in manufacturing. They explained that
"It cannot be overemphasised that it is the pattern of decisions actually made, and the degree to which that pattern supports the business strategy, that constitutes a function's strategy, not what is said or written in annual reports or planning documents."

Some authors describe manufacturing strategy as a long-range plan for the manufacturing function (Schroeder et al., 1986, Anderson et al., 1989). Anderson et al. (1989) further explained that *"this plan must be integrated with the business strategy and implemented throughout operations. It consists of four interrelated elements: mission, objectives, policies and distinctive competence."*

"Operation strategy" was often used as interchangeable terms of "manufacturing strategy." Although the definitions of manufacturing strategy vary, it is generally agreed that:

"an operations strategy is a strategy for the operations function of an organisation which is a part of the business strategy or strongly integrated with the business and corporate strategies." (Anderson et al., 1989)

Skinner (1969) emphasised that the relationship between production operations and corporate strategy must be closely linked. By contrasting two different patterns of demands, he pointed out the importance of linking manufacturing policies with market demand patterns. Booz Allen and Hamilton (1982) advocated linking manufacturing strategy with competition. They said that manufacturing strategy "must not only be measured against corporate objectives, but against potential responses from the competition as well." Furthermore, they concluded that organisations should evaluate and adjust current competitive position and direction on the basis of chosen strategy.

While Romano (1983) asserted that "management must now shift its focus from the narrow elements of operations to the broader, strategic ones," Wheelwright and Hayes (1984) examined this issue from a new perspective. They proposed four stages for manufacturing strategy: (I) internally neutral, (II) externally neutral, (III) internally supportive, and (IV) externally supportive. The first two stages refer to efforts of keeping operations from interfering with business strategies. In stage I manufacturing's role of companies is simply to produce goods – internally neutral, while at stage II companies' manufacturing play a role of meeting the standards imposed by their major competitors – externally neutral. The third stage specifies the case where operations strategy is derived from business strategy. Companies at stage III have an internally supportive manufacturing organisation to which a coordinated set of manufacturing decisions is made. The fourth stage represents making full use of operations to build corporate competence. In this case, companies at this stage treat

their manufacturing organisation as a key role in helping the entire company achieve an edge over its competitors. Anderson et al. (1989) explains that the third stage is very like the view of Skinner (1969) and Booz Allen and Hamilton (1982) while the fourth stage more closely approximates Romano's (1983) standpoint.

Many researchers, including Skinner (1969), Hayes and Schmenner (1978) and Wheelwright (1984), thought that the main role of manufacturing is to support corporate objectives, and thus, operations capability should be adjusted to achieve the objectives. On the other hand, however, other authors argued that operations capability can determine business strategy. Hayes (1985) argued that corporate objectives should not always, as is commonly assumed, determine operations means. Sometimes operations means should determine corporate objectives. "Building operations competence, the means, as a basis for strategy is especially effective in environments which are changing or difficult to forecast." (Anderson et al., 1989)

Although the question of which comes first between business strategy and operations strategy was argued, the consensus is that manufacturing function should be integrated with corporate strategy. Manufacturing strategy and corporate strategy should be consistent and these two should be conducted in a concomitant manner.

2.2.2 Approaches for manufacturing strategy development

The traditional approach of manufacturing strategy development was initially proposed by Skinner (1969). The approach was initiated on the basis of the idea of matching manufacturing structure and infrastructure with business strategy using a formally detailed

planning process. The approach is the essence of the top-down approach of manufacturing strategy development. In this approach, manufacturing function plays the role of supporting business strategy by performing specified manufacturing tasks that are derived from business strategy.

The top-down approach has been accepted and widely used by many companies and has formed the basis for many observations, recommendations and refinements in the literature of how to develop manufacturing strategy (Fine and Hax, 1985, Hill, 2000, Kotha and Swamidass, 2000). The stages of the top-down process are summarized as follows:

(1) Analysing competitive situation;

(2) Analysing possessed resources and properties;

(3) Formulating company strategy;

(4) Clarifying objectives for manufacturing;

(5) Distinguishing limitations or constrains of the industry, both in terms of the economics and the technology;

(6) Prioritising and setting objectives for manufacturing;

(7) Working out programmes of implementation and monitoring and translating objectives into action plans.

Although many companies develop their manufacturing strategies by following the top-down approach, there is an argument that the traditional top-down approach is not the only one universal process for manufacturing strategy development (Swamidass et al., 2001). More often than not, it may be even not applicable to companies. Hayes and Wheelwright (1984) argued that:

"the development of manufacturing strategy is an interactive process involving planning and execution at various levels and in a variety of areas. In the end, it is the pattern of decisions actually pursued that determine the firm's manufacturing capabilities."

Swamidass et al. (2001) found that there were some alternatives to the traditional approach for manufacturing strategy planning. Based on cases investigations, three alternative methods were identified: (1) a coherent and incremental pattern of actions; (2) the use of manufacturing improvement programs; (3) manufacturing competency development. According to the investigation, firms, in which manufacturing plays a basic role in strategy, without a formal or well-defined strategic plan, develop their manufacturing strategies by utilizing a pattern of incremental decisions in manufacturing. To those firms whose structure is more decentralized and decision making is delegated to lower levels, the employment of manufacturing improvement programs through bottom-up process is more logical. This is because that in a decentralized setting, the improvement programs serve as a substitute for the formal manufacturing strategy development process. Manufacturing competency development is used by firms in which core competence development drives their manufacturing strategy. Spring and Boaden (1995) mentioned this notion of using competencies as a dynamic basis for manufacturing strategy development in their reappraisal work of Terry Hill's manufacturing strategy framework. De Lima et al. (2009) made an effort to integrate operations strategy content to an operations performance measurement system design by developing a four-phase process. The process included four phases. These were to define competitive gaps, identify decision area gaps, generate new actions and carry out planning process.

From the literature, one point can be clearly derived. There is no unified approach for manufacturing strategy development. Following Hayes and Wheelwright's (1984) words,

different firms with different strategic intentions desire different manufacturing capabilities. This can lead to the differences of manufacturing strategy development and the differences in approaches taken.

2.2.3 Models of manufacturing strategy

The domain of manufacturing strategy research is often broadly divided into two separate parts. These are content and process (Adam and Swamidass, 1989, Leong et al., 1990, Swink and Way, 1995, Filippini, 1997). While content refers to the strategic choices, plans, and actions that make up a strategic direction, process refers to the process of designing, developing and implementing strategy. Leong et al. (1990) made the initial step to synthesize the predominant thinking with respect to process and content of manufacturing strategy. They proposed two separate models for process and content by articulating the distinction between these two. The process model stemmed from the aforementioned traditional top-down approach of manufacturing strategy development combined with several iteration processes of decision making and review. The content model mainly incorporated competitive priorities and decision areas into the content domain of manufacturing strategy. Decision areas within the content model covered two decision categories: structural and infrastructural decisions. “Whereas structural decision categories address the ‘bricks and mortar’ decisions of capital spending, infrastructural decisions affect the people and systems that make manufacturing work.” (Leong et al., 1990)

By following the convention adopted by Adam and Swamidass (1989), Swink and Way (1995) presented a general model of manufacturing strategy in their review work. The model, with more detailed division, classified strategy content into two domains: strategic

types and strategic choices and performance. Within the strategic choices and performance domain, there are three sub-dimensions: competitive priorities, process design and infrastructure. With different perspective from Leong et al.'s (1990) model, strategy process was generally divided into two areas: "strategy formulation and justification" and "implementation of strategic decisions." This model was proposed to help researchers better understand the distinct manufacturing strategy research areas. Some propositions were also provided by those authors under each sub-dimension. Dangayach and Deshmukh (2001) provided a review of manufacturing strategy literature. They categorize the literature into content-related and process-related issues. In their classification, content simply referred to the strategic choices while process aspects consisted of design, development and implementation of manufacturing strategy. In one of the first empirical studies of the content of manufacturing strategy, Schroeder et al. (1986) conducted a survey of manufacturing strategy in 39 companies. The results indicated that great efforts were made by companies to relate manufacturing strategy to business strategy. Yet, the manufacturing distinctive competence was not considered sufficiently in business strategy formulation. This conclusion is very similar to one of the aforementioned alternatives to the traditional approach for manufacturing strategy planning described by Swamidass et al. (2001): developing strategy on the basis of manufacturing competency. By linking manufacturing flexibility, environmental uncertainty and role of manufacturing managers in strategic decision making (RMMSDM) to manufacturing strategy research and practice, Swamidass and Newell (1987) provided a path analytic model for manufacturing strategy development.

In summary, manufacturing strategy consists of two distinct parts: content and process. Content refers to manufacturing tasks and manufacturing choices, whereas process refers to the implementation of such decisions.

2.2.4 Taxonomy of manufacturing strategies

The development of configurations, typologies and taxonomies is considered as the fundamental to strategy research. It is particularly useful when the research goal is the determination of the dominant patterns in organisations, or when the relationships between individual variables are either poorly understood or too complex to be modelled using traditional approaches (Miller, 1996, Ketchen and Shook, 1996, Zhao et al., 2006). Because of these reasons, taxonomy has been used by several researchers to identify the existence of the patterns of manufacturing strategies in different places or at different times.

Perhaps the most influential taxonomy work in manufacturing strategy field was done by Miller and Roth (1994). In their well-known taxonomic study of 164 American manufacturing companies, they required companies to rate the importance of eleven competitive capabilities (low price, design flexibility, volume flexibility, conformance quality, performance quality, speed, dependability, after sale service, advertising, broad distribution, and broad line) to their organisations. From this study three distinct clusters of manufacturing strategy groups were identified:

- Caretakers – those companies whose strategy is uniquely preoccupied with low price over all other competitive capabilities;
- Marketeers – companies who place high emphases on product quality and delivery reliability;
- Innovators – companies who treat product performance and quality as the top priorities of their business development with an avoidance of price competition.

“Market differentiation” and “market scope” were highlighted as the two key underlying dimensions that companies compete on.

This influential taxonomy work was later updated by Frohlich and Dixon (2001) who used two sets of data: newer North America data and global data. The newer data was collected 7 years later than the one used by Miller and Roth (1994) and the global data was collected in 1998. The global data covered countries in South America, Western Europe and Asia-Pacific. Whilst most of the competitive capabilities used in Miller and Roth’s (1994) work were kept as clustering criteria, one capability (advertising) was dropped in newer North America survey and two capabilities (advertising and broad distribution) were dropped in the global survey. The findings of the replication study partially supported Miller and Roth’s (1994) identification, but notable changes appeared in North American companies. While the consistency of the existence of “Caretakers” and “Innovators” was confirmed, “Marketeers” was replaced by a new group named “Designers” in the study. Compared to “Marketeers”, “Designers” placed more emphases on design flexibility and broad product lines.

In addition to the change in North America, the observations from South America, Western Europe and Asia-Pacific were quite different. Three additional strategy types were found in other continents – one each in South America, Western Europe and Asia-Pacific. “Caretakers” is the only manufacturing strategy universal across time and location. While “Innovators” showed as an uncommon strategy in Western Europe and Asia-Pacific occupying a small percentage of the whole sample, “Caretakers” and “Designers” tended to make up larger percentages of respondents in other continents than in North America. “Idlers” – companies who place very little emphasis on any of the competitive capabilities

– account for a small percentage of South American companies. “Servers”, an emerging strategy that was oriented around after-sales service, shared a large percentage of Western Europe companies. A relatively small number of Asia-Pacific companies, simultaneously emphasising on low price and design flexibility, were identified and labelled as “Mass Customizers.”

This replication work demonstrated that patterns of strategies can vary over time due to changes taking place in the marketplace and business environment. Moreover, types of manufacturing strategies may vary across the regions around the globe. Although some types of strategy can be found across the world, some other types only exist in certain regions. Differences in local culture, political policies, levels of economic development, degrees of advanced technology utilization and other internal and external factors may be the reasons for this phenomenon. The replication study also revealed the importance of checking the stability of taxonomy of manufacturing strategies, regularly and in different regions.

There are many other authors that have made contributions to the development of taxonomy in manufacturing strategy field. Kathuria (2000) examined the patterns of emphases on competitive priorities among small manufacturers in United States in a cross-section of industries. Four clusters were identified using four basic manufacturing priorities – cost, delivery, quality and flexibility – as clustering criteria. A cluster given the title “Starters” was identified with low relative emphasis on all four priorities. This is in sharp contrast with the “Do All” cluster that simultaneously placed high emphasis on all four competitive priorities. While cost and quality were put on the top priority by “Efficient Conformers,” delivery was most highly ranked by “Speedy Conformers.”

Sum et al. (2004) carried out a similar study on small and medium enterprises (SMEs) in Singapore. Three strategic clusters were found. Similarly to “Starters” in Kathuria’s work and “Caretakers” in Miller and Roth’s work, “All-rounders” placed relatively low emphasis on all competitive priorities. “Efficient innovators” and “Differentiators” were distinguished by the degree of emphasis placed on cost and quality. “Efficient innovators” were found to compete by offering high flexibility, good delivery and good performance quality to pursue competence in innovation without any compromise on cost; while “Differentiators” were found to compete on conformance quality, delivery and flexibility at high cost. “Efficient innovators” were observed as being more cost-effective but possibly at the expense of relatively lower conformance quality.

Other authors, Zhao et al. (2006), investigated the stage of manufacturing strategy development in China. They developed a taxonomy of manufacturing strategies by choosing a representative city as the source to collect data. Nine competitive capabilities, same with those in Frohlich and Dixon’s (2001) study, were used as the taxons. Four clusters were identified:

(1) “Quality Customizers” – conformance quality and design flexibility were ranked the highest two within the cluster;

(2) “Low Emphasisers” – relatively low emphasis was placed on all the competitive capabilities compared to the other clusters;

(3) “Mass Servers” – conformance quality, broad product line, cost and speed were the most emphasised competitive capabilities in the cluster; and

(4) “Specialized Contractors” – speed, cost, and performance quality were the strongest emphasised capabilities in the cluster but flexibility attributes such as changes in volume and design were with the least emphasis.

More recently, Martin-Pena and Diaz-Garrido (2008) classified Spanish companies into two strategic groups – manufacturers pursuing excellence and manufacturers focusing on quality and delivery. Through developing a taxonomy of manufacturing strategies in Spain, Martin-Pena and Diaz-Garrido (2008) discovered that while some firms placed focus on developing one or two capabilities as the competitive weapon other firms were competing by pursuing all competitive capabilities without compromising business performance. This demonstrated that the trade-off approaches advocated by Skinner (1974) can be overcome. "Companies could offer and be competent in multiple priorities" but "must adopt new strategic perspectives and initiatives to develop their markets with a broader portfolio of manufacturing priorities rather than focussing on any particular one." (Martin-Pena and Diaz-Garrido, 2008)

Zhang and Sharifi (2007) made the initial effort on developing a taxonomy for agile manufacturing strategy. Through an empirical study of UK manufacturing industry, they discovered that there exist clear patterns in companies' needs for agility as well as in their emphases of agile capabilities. Three clusters with responsiveness, quickness, and proactiveness as the focal point were identified.

All the taxonomies mentioned above contribute to theory development in manufacturing strategy research area. They provide a means of understanding the strategic posture of operations (Ketchen et al., 1993, Miller and Roth, 1994, Ketchen and Shook, 1996, Frohlich and Dixon, 2001). By identifying strategic clusters with similar manufacturing tasks and choices, taxonomies provide insights to describe and track how manufacturers dynamically adjust their priorities in a rapidly changing business environment to react to ever changing markets and customer demands.

Two critical points can be learned from the taxonomies that outlined in this section: firstly, different types of strategies can exist in the same marketplace; and secondly, the types of strategies can vary in different regions. Furthermore, even in the same regions, the types of strategies can be changing as the time passes by. For this reason, it is important to check the stability of taxonomy regularly and in different regions, in order to develop robust theories of manufacturing strategy.

2.3 Agility-based manufacturing strategy

Uncertainty or change in the business environment has always been a key concern for management researchers and practitioners. In the late 60s Thompson (1967) declared that one of the most crucial tasks for any organisation was to manage uncertainties. The concept of entrepreneurial task was described by Drucker (1968) as the search for changes, response to changes, and exploitation of changes as opportunities. In today's dynamic business environment, the rate of change is increasing rapidly. Turbulence and uncertainty in the business environment have become the main cause of failures in manufacturing industry (Hayen, 1988, Hamel and Prahalad, 1994, Lanners and Logan, 2004). This has led to the emergence of the concept of agility and necessitates the consideration of agility as a manufacturing strategy.

2.3.1 Emergence of agility concept

The concept of agility was initially introduced in a two-volume report from the Iacocca Institute at Lehigh University in 1991. The report was the result of an industry-led project facilitated by the Iacocca Institute at Lehigh University. It described how US corporations need to move forward to once again become a leader in manufacturing (Nagel and Dove,

1991). In the report, agility was narrated as "a comprehensive response to the business challenges of profiting from rapidly changing, continually fragmenting, global markets for high quality, high performance, and customer configured goods and services."

Several definitions of agility have been given by other researchers. DeVor (1997) defined agility as the ability of a producer of goods and services to deal with continuous changes in markets, technologies, business relationships and all facets of the business enterprise, and to prosper from those changes. Yusuf et al. (1999) depicted agility as:
"the successful exploration of competitive bases (speed, flexibility, innovation proactivity, quality and profitability) through the integration of reconfigurable resources and best practices in a knowledge-rich environment to provide customer-driven products and services in a fast changing market environment."

Youssef (1994) defined agility from a manufacturing system point of view as *"…extraordinary capabilities (Internal capabilities: hard and soft technologies, human resources, educated management, information) to meet the rapidly changing needs of the marketplace (speed, flexibility, customers, competitors, suppliers, infrastructure, responsiveness)"* and the ability to *"shift quickly (speed and responsiveness) among product models or between products lines (flexibility), ideally in real-time response to customer demand (customer needs and wants)."*

Although definitions may vary, two essential aspects of agility can be elicited: a rapid response to change; and making good use of the changes. These two key points were pointed out in the work of Zhang and Sharifi (2007), as they stated that:

"agility is a manufacturing strategy that aims to provide manufacturing enterprises with competitive capabilities to prosper from dynamic and continuous changes in the business environment, reactively and proactively."

2.3.2 Disentangling leanness and agility

There are a large number of discussions of leanness and agility in the literature. However, there is considerable confusion over these paradigms in terms of their content and any temporal dependencies that might exist in their implementation. In order to clarify the issue and provide better foundation for theory development, researchers made attempts to disentangle leanness and agility. Naylor et al. (1999) stated that "agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace" while "leanness means developing a value stream to eliminate all waste, including time, and to enable a level schedule." They went on to argue that while both lean and agile systems emphasised supply integration, waste reduction, and lead time compression, the significant difference lay in their emphasis on flexibility for market responsiveness. An agile system put more emphasis on rapid reconfiguration and robustness, whereas a lean system put more emphasis on simplifying and optimizing the production schedule. Christopher and Towill (2000) advocated this view and further stated that "leanness may be an element of agility in certain circumstances, by itself will not enable the organisation to meet the precise needs of customers more rapidly." Narasimhan et al. (2006) discussed leanness and agility in two ways: (1) as manufacturing paradigms and (2) as performance capabilities. By conducting an empirical investigation, they concluded that leanness and agility are two different concepts and appear distinctly

different at the performance and practice aspects. According to their work, agility appears to represent a higher state of plant performance and capabilities.

In spite of the difference in nature of leanness and agility, the integration of leanness and agility in operations and production of firms was suggested by Naylor et al. (1999). They suggested that a decoupling point can be positioned in a supply chain. The decoupling point is defined as the stocking point that separates activities that respond directly to customer orders from activities that are driven by forecasts and demand planning. A lean system can be applied upstream from the decoupling point while an agile system can be applied downstream from the point (Naylor et al., 1999, Stratton and Warburton, 2003). Leanness and agility can be well harmonized by appropriately positioning the decoupling point in the supply chain to best suit the need for responding to a dynamic demand downstream and providing level scheduling upstream (van Hoek et al., 2001, Yang et al., 2004, Yang et al., 2007). Yusuf et al. (2004) indicated that lean and agile models of supply chains had no negative interaction influence on competitive and performance measures and that they can be integrated for greater synergy in their impacts. Additionally, Agarwal et al. (2006) adopted the AHP (analytic hierarchy process) methodology to model the metrics of lean, agile and leagile supply chains. The framework for modelling performance of three supply chains provided an aid to decision makers in analysing variables' influence on operations process for the performance improvement.

2.3.3 Pioneering works related to agility

The literature related to agility can generally be classified into four categories. The first is concerned with conceptual models and frameworks for achieving agility. This includes

work investigating the characteristics agility has, the factors that enable an agile enterprise, and the relevant competitive capabilities and the methodology to support agile implementation. The second consists of work that proposes approaches or paths to obtain capabilities that can facilitate the realization of an agile strategy. The third category concerns work on measuring and assessing the level of agility within an organisation. This includes exploration of rules for assessment, identification of criteria for measuring agility and establishment of agility index. This is in order to help firms identify principal obstacles of achieving agility and continue improving their ability to conquer obstacles, and in turn reaching higher level of business performance. The fourth category is about work in which attempts/efforts were made on developing the agility concept on a supply chain basis. Most of the work identified under this category focuses on discussions of how to develop an agile supply chain. In this case, 'responsive supply chain' was considered as interchangeable with the term of 'agile supply chain'.

2.3.3.1 Models and frameworks for agility

Nagel and Dove (1991) presented a general overview of the concept of agility. In their paper, they provide a list of characteristics of agile manufacturing organisations which are innovative management structures, flexible technology and skill base of knowledgeable workers. In their research (Nagel and Dove, 1991) they observed and analysed agility in four scenarios after their transformation from mass production systems to agile and customer preference-driven systems. They found features which were common to all four cases. These were flexible production technologies, organisational flexibility, rapid product development, a knowledgeable, involved work force and the integration of prevailing social values into managerial decision making. Goldmen et al. (1995) considered agility to be formed by four dimensions. These were enriching customers, cooperating to enhance

competitiveness, organising to master change/uncertainty and leveraging the impact of people and information. Gunasekaran (1998) discussed his seven enablers of agile manufacturing and presented a framework for the development of agile manufacturing systems. This work considered four constructs – value-based pricing strategies, co-operation, organisational changes and investments in people and information – as the essential elements of an agile enterprise. It suggested that virtual enterprise formation tools, physically distributed teams and manufacturing, rapid partnership formation tools, concurrent engineering, integrated product/production/business information system, rapid prototyping tools and electronic commerce were key methods that should be implemented in an agile system. Through analysing some drivers of agility identified in the literature, Yusuf et al. (1999) suggested that the realization of agility can be considered to be formed from four key aspects: core competence management, virtual enterprise, capability for reconfiguration and knowledge-driven enterprise. These four aspects are very similar to the aforementioned four constructs proposed by Gunasekaran (1998). Core competence management, virtual enterprise and capability for reconfiguration can be treated as the counterparts of value-based pricing strategies, cooperation and organisational changes with different expression but similar contents. Investment in people and information is actually a prerequisite of becoming a knowledge-driven enterprise. A list of agility attributes was also produced in their work (Yusuf et al., 1999). These were integration, competence, team building, technology, quality, change, partnership, market, education and welfare. Sharp et al. (1999) developed a theoretical model for agile manufacturing and incorporated ten pillars in the model as enablers of agility. This work was based on a review of enablers proposed by other researchers and analysing the characteristics of agile manufacturing enterprises. They concluded that the essential components of being an agile manufacturing enterprise are focus on core competencies, virtual enterprise, rapid prototyping, concurrent

engineering, multi-skilled and flexible people, continuous improvement, team working, change and risk management, information technology and empowering.

Most recently, Vazquez-Bustelo et al. (2007) developed an integrated agile manufacturing model and empirically tested it using data obtained from Spanish manufacturers. Environment factors, such as dynamism and hostility, were incorporated into the model. By conducting a survey and using a structural equation model to analyse the data, Vazquez-Bustelo et al. (2007) confirmed four hypotheses initially proposed. The results indicated that:

(1) turbulent environments with high levels of dynamism and hostility have a positive influence on the adoption of agile manufacturing practices;

(2) agile manufacturing has a multidimensional nature and the adoption of agile manufacturing is reflected in the systematic integration of agile human resources, agile technologies, value chain integration, concurrent engineering and knowledge management;

(3) the adoption of agile manufacturing positively impacts manufacturing strength; and

(4) the development of manufacturing strength with combination of strengths in cost, flexibility, quality, delivery, service and environment leads to better business performance.

Some attempts had been made to establish a model and methodology that could be used as a guide to agility implementation. A preliminary method to measure changes in the business environment for helping firms to move towards agility was introduced by Preiss et al. (1996). This was implemented by formulating a series of worksheets in order of priority that can guide the company to deal with issues according to the sequence of importance. Four steps for implementing agility were suggested in their work. These were understanding market forces, recognising enterprise level attributes, obtaining enabling

infrastructures, and implementing business practices. Based on a number of industrial case studies, Bessant et al. (2001) proposed a reference model to seek to explain and guide the development of agility within manufacturing enterprises. Zhang and Sharifi (2000) proposed a methodology to implement agility through identifying drivers and providers of capabilities needed to cope with these drivers. Assessment tools that consist of a number of questions were also presented. By asking questions, companies will be able to recognise their current position in the marketplace and the desired position in the future. The model can then be used to determine the agility capabilities required by the company to reach this point. By following the targeted capabilities, companies are able to identify relevant agility providers to achieve agility.

The literature survey has shown that agility has a multidimensional nature. Following the methodology proposed by Zhang and Sharifi (2000, 2001), agility can be implemented through identifying drivers and providers. However, as drivers for different companies can be different, companies may require different agility capabilities to cope with drivers based on the position they desire. Due to this, it is clear that the agility providers that companies need to acquire for achieving the targeted capabilities may vary.

Zhang and Sharifi (2007) have conducted an investigation in order to address this point. The investigation found that based on different market positions and different manufacturing tasks, companies employed different agility strategies. According to the different agility strategies, the operations of companies were different. The ways of the choices of manufacturing practices were various.

2.3.3.2 Acquiring agility capabilities

Agility capabilities have been widely discussed in the literature. Organisations have to obtain some capabilities related to agility in order to carry out appropriate responses to changes taking place in their business environments (Sharifi and Zhang, 1999). Sharifi and Zhang (1999) divided agility capabilities into four major categories:

(1) Responsiveness – the ability to identify changes and respond fast to them, reactively or proactively, and recover from them;

(2) Competence – the ability to provide productivity, efficiency, and effectiveness of activities towards the aims and goals of the company;

(3) Flexibility – the ability to process different products and achieve different objectives with the same facilities; and

(4) Quickness – the ability to carry out tasks and operations in the shortest possible time. Responsiveness was examined by Holweg (2005) from three dimensions of product responsiveness, process responsiveness and volume responsiveness while Koste and Malhotra (1999) defined 10 flexibility dimensions by using four constituent elements of flexibility – range-number, range-heterogeneity, mobility and uniformity.

Although various capabilities have been considered as important elements of agility (Sharifi and Zhang, 2001, van Hoek et al., 2001), two of them have earned much more attention than the rest – flexibility and responsiveness. The agility literature shows that there is a common agreement that flexibility and responsiveness are vital paths to agility (Narasimhan and Das, 1999, Holweg, 2005).

Approaches or ‘paths’ to obtain agility capabilities required for the realization of agility have been proposed by a number of researchers. Narasimhan and Das (1999) suggested that

manufacturing agility can be fulfilled by operational flexibility practices in terms of volume flexibility, modification flexibility, and delivery flexibility. For example, they suggested that through developing a supply base with strong responsiveness to order quantity and specification changes, volume flexibility could be enhanced and this would lead to attainment of volume agility. Also, it is believed that avoiding the use of cross-functional teams in purchasing can be helpful to promote volume agility. Narasimhan and Das (1999) emphasised the multidimensional nature of agility and stated that "different operational environments may require firms to associate different meanings with manufacturing agility." This implied that agility capabilities can be various and can be attained by different ways.

Narasimhan and Das (2000) examined the linkage of sourcing practices and flexibility. A taxonomy of manufacturing flexibility was developed in their work. They proposed that this would be useful for evaluating the relative managerial importance of different flexibility dimensions and could be used to better understand and define potential roles for purchasing in the pursuit of manufacturing flexibilities. The taxonomy classified flexibility into three levels: Machine/shop level-operational flexibilities, plant level-tactical flexibilities and firm level-strategic flexibilities. By investigating the impacts of the sourcing practices on three levels of flexibility, Narasimhan and Das (2000) claimed that specific sourcing actions are closely related to manufacturing flexibility. Additionally, by deploying specific sourcing practices to target specific manufacturing flexibilities, agility-based competitive advantages can be pursued. This was supported by the findings of the work of Swafford et al. (2006a). Process flexibilities were regarded as an important antecedent of agility in the study. By testing the proposed model of supply chain agility with empirical data, Swafford et al. (2006a) discovered that the level of flexibility in

procurement/sourcing and manufacturing processes directly and positively impacts manufacturing agility, and distribution flexibility indirectly impacts the level of manufacturing agility. Youssef (1994) reported the benefits of implementing computer-based technologies in manufacturing process. In his paper he explained that when technologies were utilized to a certain extent and were integrated with other available technologies for a relatively long period, better quality, high flexibility, quick responses to customer needs and cost efficiency can be developed. The business performance of the company can be raised.

By investigating agility in the supply chain, Swafford et al. (2006b) found that flexibility within the supply chain has a significant influence on supply chain agility. The speed of improvement on delivery reliability and responsiveness to changing market needs, as well as the speed of reducing manufacturing lead time, was identified as the primary determinant of supply chain agility. In addition to this, it was found that information technology at the corporate level has strong correlations with supply chain agility. This was interpreted by Swafford et al. (2006b) as that *"firms derive higher levels of supply chain agility through integrating information across the supply chain activities rather than integrating information within these activities."* The study concluded that firms with flexibility in their supply chain functions enjoy higher levels of supply chain agility and market share. Narasimhan et al. (2006) emphasised volume flexibility and product flexibility as crucial capabilities of agility performers and suggested some practices of acquiring those capabilities. Drawing on empirical evidence from case studies, Holweg (2005) suggested that overall responsiveness can be reached by achieving volume, product and process responsiveness simultaneously. This can be realized through developing an appropriate synthesising way based on company's particular situation. The achievement of overall

responsiveness will lead to better business performance and expedite the achievement of agility (Holweg, 2005).

2.3.3.3 Agility measurement and assessment

Agility theory is developing quickly and authors agree that the concept and the constructs of agility framework have been well defined (Gunasekaran, 1998, Sharifi and Zhang, 1999, Sharifi and Zhang, 2001). The development of relevant measurement and assessment tools are needed for the comprehensive and robust theory building. In order to help firms identify principal obstacles of achieving agility and continue improving their ability to conquer obstacles, efforts to explore rules for assessment, identify criteria for measuring agility and establish an agility index have been made by researchers (van Hoek et al., 2001, Tsourveloudis and Valavanis, 2002, Yang and Li, 2002, Yusuf et al., 2004, Lin et al., 2006, Swafford et al., 2006b).

Yang and Li (2002) established an agility evaluation index system for mass customisation. Tsourveloudis and Valavanis (2002) proposed a set of quantitatively defined agility parameters to measure agility for enterprises. The parameters were grouped into four categories of production, market, people and information infrastructures. The production category was comprised of changeover effort, versatility, range of adjustments/adjustability, substitutability, operation commonality, variety of loads, part variety, and part commonality. Reconfigurability, modularity index, expansion ability, and range of volumes were included in the market infrastructure category. Training level and job rotation, and interoperability and networking were classified into people infrastructure and information infrastructure, respectively. The parameters were defined based on fuzzy logic, and all parameters contribute to the overall agility of the company. Using IF-THEN rules to combine these

parameters, Tsourveloudis and Valavanis (2002) exemplified the usage of the proposed method. This approach was suggested by them to be able to evaluate a certain enterprise with certain performance criteria.

From a supply chain perspective, van Hoek et al. (2001) made an attempt to establish an audit of agility in the supply chain. A framework for agility with the supply chain setting was developed by those authors. Van Hoek et al. (2001) compared the traditional management approach to the emerging agility concept from four aspects of enriching the customer, cooperating to compete, mastering change and uncertainty and leveraging people and information. They concluded that information sharing, partnering and cross-functionality, as well as techniques such as build to order, teaming and cycle time compression were important and helpful to the development of agility in the supply chain.

Yusuf et al. (2004) proposed a conceptual model for assessing an agile supply chain, which consists of four dimensions. These were value chain practice, competitive objectives, impact of change drivers and business performance. In addition, the level of adoption of seven core dimensions of alliance practice attained from the survey was studied by Yusuf et al. (2004) along with investigation of three dominant supply chain patterns – traditional alliance, lean alliance and agile alliance. Lin et al. (2006) proposed an agility evaluation model based on fuzzy logic and multi-criteria decision-making to provide a means for both measuring agility in supply chain and identifying the major hindrance to improvement of agility levels. Conventional evaluation approaches were studied and the limitations of the conventional approaches such as inappropriateness and ineffectiveness for handling complex and uncertain situations were identified by Lin et al. (2006). To address these limitations, a fuzzy agility index that focused on the application of linguistic approximation

and fuzzy arithmetic was generated for addressing problems associated with agility measurement.

The research of Swafford et al. (2006b) moved a step further towards the development of an agility assessment tool. Differing from the work mentioned above, this work has evaluated agility from the value chain point of view. Along with the establishment of a framework for assessing value chain agility, a survey was conducted. Apart from the identification of the benefits of pursuing flexibility in the value chain functions, the results also indicated that integrating information across the value chain can contribute to higher levels of agility.

2.3.3.4 Agility in the context of supply chains

The aforementioned work helps to define the nature and the characteristics of agility, proposes approaches to acquire prerequisite capabilities of achieving agility, and establishes evaluation model to assess agility. However, it does not explain how to develop a manufacturing strategy based on agility and how to achieve agility in a practical way. In today's dynamic business environment, supply chain management competition becomes more and more important (Christopher and Towill, 2000). Extended consideration of agility as a manufacturing strategy into entire supply chains is essential. An amount of research has been carried out in this area and this is discussed below.

Shortly after the concept of agility emerged, Narasimhan and Das (1999) made an attempt to link manufacturing agility with supply chain management. As flexibility is one of the most regularly mentioned capabilities related to agility, they identified several supply chain management practices regarding modification flexibility, volume flexibility and delivery

flexibility during manufacturing process. Through analysis of data from their survey, Narasimhan and Das (1999) identified supply chain management practices that could be useful in the pursuit of manufacturing agility. Schonsleben (2000) pointed out that the involvement of agility is a fundamental principle of effective logistics networks, and the use of information technology can support the implementation of agility in these networks. This point was echoed by Lau et al. (2006). In their work, mobile-commerce related technologies were recommended in order to streamline the information flow involved in managing supply chain network operations. Wireless technology, mobile computing and internet programming techniques were identified to be able to enhance the application of information technology in various activities ranging from product design to after-sales services.

In accordance to the nature of agility concept, Christopher (2000) described agile supply chains as a combination of four basic elements. These were market sensitivity, virtual feature, process integration and network based information technology. Christopher (2000) emphasised that the capability of reading and responding to real demand, making demand data visible by sharing information promptly, leveraging collaboration between partners, as well as forming a confederation of efficient network, were important to the pursuit of agility. Additionally, reducing complexity was believed to be a major priority for becoming truly agile (Christopher, 2000). This has been advocated by Prater (2001). While the introduction of some factors may be able to increase supply chain agility, they can also lead to increases in complexity. Increases in complexity tend to work against the implementation of agility in supply chain management. This is a particular problem when a firm has an international supply chain. Factors, such as geographic areas covered by the supply chain, the number of transportation modes used and the differences regarding the

speed of the different transportation modes, could result in an increase in operations complexity. Uncertainty can also be increased. To deal with such kind of complexity, as well as reducing uncertainty, some standard approaches have to be used. Consequently, flexibility would be compromised, and in turn agility is compromised. Therefore, Prater (2001) claimed that in an international environment businesses cannot be "all things to all people," due to the high level of complexity and uncertainty. Firms can only focus on key aspects of an agile supply chain to ensure effective and efficient operations. Tradeoffs need to be made between flexibility and uncertainty.

Shaw et al.(2005) examined the influence of industry culture on agility in supply chains. Based on experiences drawn from industrial case studies, Shaw et al. (2005) made an effort to illustrate reconfigurability (the key asset capability underpinning agility) in a practical manner in order to help companies improve performance of their supply chains. Agarwal et al. (2007) developed an ISM-based model to examine the variables of an agile supply chain. By involving 15 variables identified in the literature and using an interactive learning process, the influence of one variable on other variables was analysed. Baramichai et al. (2007) developed a framework for agile capability creation and a matrix tool to help companies create and improve their agility level. By introducing a method of implementation of the matrix tool, the business changes and the appropriate approaches for supplier-buyer supply chain configuration were seem to be related. The appropriate methods for supplier-buyer relationship establishment were also linked in accordance with the utilization of the tool. The tool also provided a means for managers to determine business process and the infrastructures needed to support the creation of agile capability.

2.4 The motivations of this research

Most work in the literature considered agility as a holistic concept, involving a number of capabilities or dimensions. Zhang and Sharifi (2007) used similar methods to Miller and Roth's work (1994) to develop a taxonomy for agile manufacturing strategy. Through an empirical study of the UK manufacturing industry, they discovered that clear patterns in companies' needs for agility existed as well as patterns among their emphases of agile capabilities. This led to the definition of three clusters of companies. These were named responsive players, quick players and proactive players.

As supply chain management is increasingly dominating the success of today's business competition (Christopher and Towill, 2000), much of attention has been placed on this issue in the past decade. Recently the amount of relevant research works has increased tremendously. Some of the works that have been discussed have made attempts to relate agility concept to supply chain management. However, almost all of them have not considered the multidimensional nature of agility. Zhang and Sharifi (2007) identified that different types of agility strategies existed in the marketplace and emphasised different capabilities that were essential in each strategy. In the light of these findings, a question has been inspired: Do firms with different agility strategies manage their supply chains in different ways? If yes, it will be interesting to ask what the different ways of supply chain management are. The answer to these questions can not only make a contribution to the theory building of agility strategy, but more importantly can provide practical guidance of supply chain management to firms.

Some prior works regarding supply chain management have been reviewed in order to ground necessary knowledge for further investigation of the research questions.

2.5 Supply chain management

The essence of agility concerns quick response to internal and external changes and taking such changes as advantages to compete in the dynamic business environment. However, the competition in today's marketplace is no longer just between companies but rather in fact between supply chains (Christopher, 2000). When it comes to survival and being competitive in new business era which is characterised by changes, considering agility just within organisations is far less than sufficient. How to approach agility through good supply chain management is the key in order for firms to enhance their competitiveness and leverage the performance of their supply chains. This in turn will enable them to maintain strategic competing position in an ever changing business environment.

With aims of identifying how agility strategies can be properly implemented by firms in their supply chain management procedure, the literature related to supply chain management has been reviewed and studied. This was done for two reasons: firstly to establish knowledge about issues involved in supply chain management, and secondly to identify relevant practices including both technical and managerial aspects that can help improve responsiveness, flexibility, effectiveness and efficiency in supply chains.

2.5.1 Supply chain management

The term supply chain management (SCM) was originally introduced by consultants in the early 1980s (Oliver and Webber, 1992) and has subsequently gained tremendous attention

(La Londe, 1998), especially in recent years. This has been evidenced by remarkable increases in professional and academic publications, conferences, professional development programs and university courses in the area (Lancioni, 2000, Burgess et al., 2006).

The term SCM has been used to explain the planning and control of materials and information flows as well as the logistics activities not only internally within a company but also externally between companies (Cooper et al., 1997). Researchers have also used it to describe strategic and inter-organisational issues (Harland et al., 1999), to discuss an alternative organisational form to vertical integration (Thorelli, 1986, Narus and Anderson, 1995), to identify and describe the relationship a company develops with its suppliers, and to address the purchasing and supply perspective (Morgan and Monczka, 1996, Farmer, 1997). This indicates the multidimensional nature of the supply chain management discipline. Lancioni (2000) has included this multidimensional nature into the proposed seven insights for supply chain management development in the future. The remaining six insights he proposed were continual customer focus and accurate forecasts of supply chain requirements, optimal supply chain design, the need for agility in the supply chains, the use of the internet in supply chain operations, measuring supply chain performance, and effective management of the supply chain.

Due to such multidimensional characteristics of supply chain management, there appears to be little consensus on the definition of the term “supply chain management” (New, 1997, Mentzer et al., 2001, Lummus et al., 2001, Kauffman, 2002). This has been pointed out by Kathawala and Abdou (2003) that SCM “has been poorly defined and there is a high degree of variability in people’s minds about what is meant.” In an attempt to overcome this issue, Mentzer et al. (2001) drew comparisons between previously proposed definitions of SCM

in the literature. Their findings illustrated that SCM involves multiple firms, multiple business activities, and the coordination of those activities across functions and across firms in the supply chain. Mentzer et al. (2001) held the belief that it was possible to develop a single and encompassing definition of SCM, by summarizing all the disparate aspects of supply chain management. Their work resulted in the following broad definition of SCM:

> Supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.

Burgess et al. (2006) commented that this definition is "broad, not confined to any specific discipline area and adequately reflecting the breadth of issues that are usually covered under this term."

Based on the findings of Mentzer et al. (2001), Lambert and Cooper (2000) presented a framework for supply chain management and used case studies to illustrate the concepts they described. Multiple firms, multiple business activities and the coordination of the activities across functions and across firms in the supply chain were incorporated into the proposed framework which corresponded to the constructs of "supply chain network structure," "supply chain business process" and "supply chain management components," respectively.

The members of the supply chain, the structural dimensions of the supply chain, and the different types of process links across the supply chain were thought to be the three primary aspects of "supply chain network." These aspects concern members involved in the supply

chain, supply chain structure (horizontal or vertical) and business process links between members of a supply chain. Through defining primary members and supporting members of a supply chain, Lambert and Cooper (2000) defined the point of origin (where no previous primary suppliers exist) and the point of consumption (where no further value is added and the product or service is consumed).

Key processes involved in supply chain management were introduced by Lambert and Cooper (2000). These included customer relationship management processes, customer service management processes, demand management processes, customer order fulfilment processes, manufacturing flow management processes, procurement processes, product development and commercialization and returns processes. Furthermore, nine components were introduced by Lambert and Cooper (2000) as the management components for successful SCM in order to leverage the level of integration and business process management. These were planning and control, work structure, organisational structure, product flow, facility structure, information flow facility structure, management methods, power and leadership structure, risks and rewards and culture and attitude.

By taking the buyer-supplier relationship as the central point, Chen and Paulraj (2004) developed a framework for supply chain management. Differing from the aforementioned Lambert and Cooper's (2000) framework, this framework stemmed from a paradigm of strategic management theory that emphasises the development of "collaborative advantage," as opposed to "competitive advantage." (Chen and Paulraj, 2004) Chen and Paulraj (2004) explained that the business world within the collaborative paradigm "is composed of a network of interdependent relationships developed and fostered through strategic collaboration with the goal of deriving mutual benefits." In keeping with this view,

the buyer-supplier relationship was located at the central point of the framework along with a number of key aspects. These were supply base reduction, long-term relationships, communication, cross-functional teams and supplier involvement. Due to the fact that supply chains do not always focus on a single firm, a construct of supply network structure was included into the framework. This is the same principal shown in Lambert and Cooper's (2000) framework where multiple firms are involved in a supply chain. Similarly, this construct reflected a decentralized, horizontal and non-power based structural link among the supply chain members (Chen and Paulraj, 2004). Logistics integration was incorporated into the proposed framework as the third essential construct for supply chain management. This construct was concerned with the integration of information and materials along the supply chain. This can be regarded as the same construct as the nature of collaboration activities of a supply chain mentioned in the work of Mentzer (2001).

In addition to the three main constructs, the framework included other supporting constructs. Buyer-supplier relationships require buying firms take strategic initiatives that foster superior relationships and provide mutual benefits (Krause and Ellram, 1997, Chen and Paulraj, 2004). By recognising this need, the constructs of competitive priorities, top management support, and strategic purchasing were adopted to examine their effect on the effective management of the supply chain. Other supporting constructs in the framework were environmental uncertainty, customer focus and information technology. The constructs of supplier performance and buyer performance were used to represent the overall performance of the entire supply chain.

The works discussed above can be regarded as the most comprehensive ones among the identified literature with respect to supply chain management theory and concept. Burgess

et al. (2006) contributed a structured literature review on supply chain management research. Based on a systematic analysis, the 100 selected relevant articles from refereed journals were classified into seven constructs of supply chain management according to their research focal points. These constructs concerned leadership, intra-organisational relationships, inter-organisational relationships, logistics, process improvement orientation, information systems, business results & outcomes, and others. The first three constructs were labelled as the "soft" people-focused constructs that deal with social relationships, while the remaining four constructs were labelled as the "hard" system-dominated constructs that deal with technological and infrastructural issues. All these constructs including the aforementioned ones have formed the initial image for SCM aspect involved in this research with respect to supply chain management theory, concept and relevant elements.

2.5.2 Taking supply chain management as a strategic tool

While the concepts and the theories concerning supply chain management have been continuously built and refined, the practical implications that strategic management of the supply chain may bring have been studied by researchers (Gunasekaran and Ngai, 2005, Burgess et al., 2006). Supply chain management has become a significant strategic tool for firms striving to improve quality, customer service and competitive success in the new century (Tan et al., 2002). It is important to develop tools in a practical manner so that they can be applied in a real environment.

A large number of researches have been identified which seek to study SCM issues from a practical point of view. Jones and Riley (1987) studied the elements of supply chain

management and suggested that successful supply chain management can be achieved by the integration of companies involved in the supply chain. The integration can be achieved through:

(1) recognising end customer service level requirements;

(2) defining where to position inventories along the supply chain, and how much to stock at each point; and

(3) developing the appropriate policies and procedures for managing the supply chain as a single entity.

Following this idea, Scott and Westbrook (1991) proposed a pipeline approach to supply chain integration. The approach contains three steps: Firstly, mapping the pipeline – to identify the current competitive state of the supply chain and recognise where improvements are possible in terms of lead times and inventory levels; Secondly, positioning the organisation in terms of supplier relations – to understand the nature of the supplier relations in the chain in order to identify opportunities for collaborative activities; Thirdly, selecting the actions which enhance supply chain effectiveness – to identify operational improvements which will most swiftly increase competitiveness. Scott and Westbrook (1991) also stressed that information flows and materials flow must be addressed together and that the assessment of the possibilities and implications must be carried out from an overall supply chain perspective rather than that of an individual organisation. Fisher (1997) developed a classification scheme for distinguishing between products types and supply chain design types. That author proposed that companies with innovative products should develop responsive supply chains while companies with functional products should develop physically efficient supply chains. Sundaram and Mehta (2002) compared three different SCM approaches (independent approach, semi-integrated

approach and integrated approach) based on a hypothetical supply chain model. The model considered five levels of entities in a supply chain including second-tier suppliers, first-tier suppliers, plants, warehouses, and retailers. In an independent approach, decision-making occurs at each level of the supply chain with minimum collaboration. In a semi-integrated approach, coordination among the constituents of the supply chain is involved to some extent. In an integrated approach, the supply chain is treated as a whole system which involves integration of all the decision-making processes across the supply chain. The results of the study showed that the higher the level of supply chain integration the better performance of the supply chain. They also found that optimizing each process of the supply chain in isolation from others does not guarantee optimization for the whole supply chain.

To examine the impact of supply chain capabilities on business performance, Morash (2001) has investigated firms with two different strategies supported by different capabilities. For excellent firms, that author found that congruency between strategic intent and normative value existed for competitive advantage. This means that for firms who have chosen a supply chain strategy and value focus the application of specific supporting capabilities to such strategy could result in intended good performance. Otherwise, time and resources could be wasted. For example, firms with customer closeness strategies can use customised logistics and increase agility level to improve their business performance. This can be supported particularly by demand-side capabilities, such as customer participation in strategy formulation, continuous interactions, collaborations and communications with customers. Firms with operational excellence strategies can use time-based operations (e.g. JIT) or lean networks to promote their business performance. This can be supported by supply-side capabilities, such as inventory velocity, supply synchronization, minimum total

cost in the network (Morash, 2001). Moreover, that author suggested that demand-side competitive advantages may be easier for firms to attain, more difficult to imitate, and more sustainable. This is because very few firms in an industry can achieve a minimum cost advantage from supply-side capabilities. In contrast, demand-side capabilities can be reconfigured, recombined, and resequenced based on the firms needs to meet changing requirements of specific customers, to segment and appeal to particular market segments, or to create competitive advantages that can serve as entry barriers to potential competitors and new entrants to the market.

The correlation between supply chain management capabilities and business performance has been verified further by Tracey et al. (2005). They categorized capabilities into different groups, and demonstrated that outside-in capabilities including inbound transportation, material warehousing, inbound inventory control and production support have positive indirect effects on the business performance (measured from four dimension: perceived value, customer loyalty, market performance and financial performance). They also found that inside-out capabilities which consisted of outbound transport, finished goods warehousing, outbound inventory control and packaging have significantly positive direct effects on the same four measures of the performance. Finally, they found that planning capabilities referring to purchasing, customer order processing, strategy development and information dissemination have significantly positive direct effects on the three of the four performance measures but not financial performance. This work empirically demonstrated the importance of supply chain management capabilities for manufacturing firms.

The significant impact of supply chain management on firm performance has been clarified further by some researchers through examining the effects of the application of relevant practices. Tan et al. (1998) identified ten purchasing-related practices and seven customer relations-related practices and examined the correlations of them with firm performance from nine dimensions based on a survey. The results indicated the impact of the companies' customer relations and purchasing practices on the effectiveness of their supply chain management and their financial and market performance. Four years later, the scope of the practices study was enlarged by Tan et al. (2002) from purchasing and customer relations to the entire supply chain. In addition, several supplier evaluation practices were proposed in the work (Tan et al., 2002). This survey-based work revealed that although the identified SCM practices could address various aspects of supply and materials issues appearing in a supply chain and some of them are positively correlated with firm performance, some others affect firm performance in a negative way.

To echo the call from Tan et al. (2002) for further exploring the impact of SCM practices on performance by including other areas of the organisation and their perspective, Li et al. (2006) empirically examined the impact of SCM practices on competitive advantage and organisational performance. Five dimensions of SCM practice were developed by Li et al. (2006). These were strategic supplier partnership, customer relationship, level of information sharing, and postponement. Organisational performance has been defined with the two underlying dimensions of marketing performance and financial performance. Competitive advantage was measured by price/cost, quality, delivery dependability, product innovation, and time to market. The results showed that significant positive correlations existed among SCM practices, competitive advantage, and organisational performance. Higher levels of use of SCM practices can result in enhanced competitive advantage and

improved organisational performance. Similar findings can be found in the work of Chow et al. (2008) in which the associations among supply chain practices, competencies, and organisational performance were empirically investigated in the US and Taiwan.

Zhou and Benton (2007) emphasised the importance of information sharing in supply chain management. The study discovered that there was a positive interaction between information sharing and supply chain management practice. Zhou and Benton (2007) found that effective information sharing significantly enhances the effectiveness of the application of supply chain practice, and the importance of effective supply chain practice increases when the level of information sharing increases. The critical roles of both effective information sharing and effective supply chain practice in achieving good supply chain performance have also been confirmed by the study.

Although many of the studies discussed herein imply that the adoption of supply chain management can lead to better performance, some studies show a lack of effective adaptation from traditional management mode to the modern supply chain management approach. Storey et al. (2006) conducted a three-year detailed study of six supply chains in Europe. Unlike the aforementioned supply chain management studies carried out in USA, this study reported the substantial gaps between theory and practice. The results showed "few practitioners were able or even seriously aspired to extend their reach across the supply chain in the manner prescribed in much modern theory." Quayle's (2003) investigation of supply chain management practice in UK of small to medium sized enterprises also reflected the insufficiency of the adaptation from conventional management manner to the contemporary supply chain management manner. In addition to the three major drivers of implementation of supply chain management, Storey et al. (2006)

proposed market polarisation a fourth driver. This designation was based on the fact that the traditionally mid-high markets served by some of the companies studied have disappeared and been replaced by a polarised high-end/low-end market profile. A broad range of products provided by some other companies have naturally fallen into polar extremes of the volume: variety continuum. Nevertheless, the supply chain strategy used to deliver these products is not significantly different. The misalignment of SCM strategy and practice appeared to have serious implications for supply chain management. Due to this, Storey et al. (2006) claimed that interplay and misalignment between SCM theory and practice can be one of the main challenges for supply chain management.

Slone (2004) used a case from Whirlpool to exemplify that the gap between SCM theory and practice can be overcome by formulating a strategy based on recognising real conditions, focusing on central competitiveness, engaging talent by an appropriate incentive scheme, and continuously improving operations. Ketchen and Hult (2007) made an attempt to bridge organisation theory and supply chain management, while Halldorsson et al. (2007) developed a complementary theory based on four different organisation theories to diminish the gap between SCM theory and practice. Halldorsson et al. (2007) found that it was difficult to properly solve inter-firm governance structure and management decisions in a supply chain with only one theory. They proposed that utilizing different theories in a complementary manner in accordance with different theoretical backgrounds and realistic situations could be used to overcome the conflicts between SCM theory and practice in some situations. Seuring (2009) developed a product-relationship-matrix by extending operations management and strategy theory into supply chain environment. By conducting 5 case studies that author demonstrated that the developed matrix can be applicably used to help companies to develop their various supply chain strategies.

From a novel strategic point of view, Hult et al. (2007) examined the relationships between cultural competitiveness, knowledge development and supply chain performance. They discovered that the interaction between cultural competitiveness and knowledge development had a positive association with performance, and market turbulence moderated these relationships. They found that there was a positive influence of market turbulence on knowledge development and a negative influence of market turbulence on the culture of competitiveness. They proposed that managers could be able to use this in order to decide whether their emphasis should be placed on the development of either a culture of competitiveness or knowledge development in their supply chains. They proposed that this would be particularly useful to leverage the firm's performance, in cases where they were not confident about the level of market turbulence they would face. Hult et al. (2007) pointed out that in cases where managers were unlikely to be able to foresee the degree of turbulence a focus on both of cultural competitiveness and knowledge development could be used to ensure success.

Other works that have contributed to the development of supply chain management subject in terms of both theoretical and practical aspects have been identified in the literature survey process. These include an integrated decision model for improving supply chain efficiency developed by Li and O'Brien (1999); a set of measurement items for supply chain management performance proposed by Min and Mentzer (2004); and a framework for the development of build-to-order supply chain established by Gunasekaran and Ngai (2005).

The subject of supply chain management has a multidimensional nature, and for this reason is a very complex subject. Although research into supply chain management has been

carried out for some time, revolutionary paradigms and multiple methodologies for doing such research within the field are required to contribute to knowledge and to push the subject development forward (Carter et al., 2008). This research will seek to link agile manufacturing with supply chain management from a strategic perspective. It will utilize a taxonomical approach, make an effort to diminish the gap between theory and practice, and will contribute to the knowledge development in the area of agile manufacturing and supply chain management.

2.6 Summary

This chapter has reported a detailed review of the literature associated with the research area. As the scope of the research covers both manufacturing strategy and supply chain management, a wider range of literature titled with the management of manufacturing and supply chain has been reviewed. Agility, as the central concept involved in the research, has been the main focus of literature investigation. Previous work related to agility was analysed. The review of the literature was to establish the basis for this research and identify gaps that need to be filled.

Overall, several conclusions can be drawn from this chapter as the findings of the review:

1. Much attention has been placed on manufacturing strategy in the past decades by academics since the realization that manufacturing was no longer a solely functional component but rather a strategic component in an organisation.
2. Manufacturing strategy has evolved according to the variation of business environment. The strategies that firms used in their manufacturing component have been altered on

the basis of the dominant mode of customer demand and need to be aligned with corporate strategies.

3. The development of taxonomies is an important research strategy, particularly for the determination of the dominant patterns in organisations. However, the validity of taxonomies needs to be checked periodically and geographically.
4. Today's business environment has become more dynamic and unpredictable than before. Agility, aiming at offering competitive capabilities to firms for surviving and prospering from a rapidly changing business environment, has been advocated by researchers as the ideal strategies for the new business era characterized by changes.
5. While many researchers considered agility as a holistic concept, Zhang and Sharifi (2007) developed a taxonomy in agile manufacturing strategy and discovered clear patterns in companies' needs for agility as well as in their emphases of agile capabilities.
6. Competition in contemporary business environments has transferred from single organisation versus single organisation to supply chain versus supply chain.
7. Considering agility strategies within supply chains context is important to business success in today's rapid changing marketplace. Efforts have been made by some researchers to develop knowledge about agile supply chains, but the significance of identification of dominant patterns of supply chain management practices corresponding to different agility strategies has been overlooked.

To address it, several questions have been formed to study, and the methods that would be used to answer the questions have been investigated. The following chapter details the research questions and the research methods.

Chapter3 Research questions and methodology

3.1 Introduction

This chapter gives a description of how the research is carried out. Research questions formed based on the survey of literature and suggested propositions are presented firstly. Subsequently, a description of how the research is going to answer the research questions is provided

3.2 Research questions and propositions

Based on the review of literature, it was found that most of the research works in agility area considered agility as a holistic concept. While Zhang and Sharifi (2007) by developing a taxonomy for agility strategies revealed the multidimensional characteristics of agility and discovered three types of agility strategies, they do not emphasise supply chain management as a method for achieving the strategies. In today's business environment competition has shifted from company versus company to supply chain versus supply chain (Christopher and Towill, 2000). What and how supply chain management practices can be used as agility providers to support the implementation of agility strategies have become the critical questions and are urgent to be answered. As a following research project of Zhang and Sharifi's (2007) taxonomy work and based on the literature investigation, several research questions have been formulated, which are listed as below:

1. Are the basic types of agility strategies as identified in Zhang and Sharifi's taxonomic theory valid in the changing situation? If not, what are the changes to the strategy types?
2. How companies on different agility strategies design and manage their supply chains? Are there clearly identifiable patterns of choices of supply chain design and

management practices corresponding to each type of agility strategies? If yes, what are the patterns?

3. Do the choices of agility strategies and ways of supply chain design and management relate to agility drivers companies suffered? Do they relate to the nature of market, characteristics of products, and product life cycles? If yes, how are they related?

Based on these proposed research questions, some proppositions have been formed for the research:

Proposition 1 – There have been changes on the types of agility strategies discovered in Zhang and Sharifi's (2007) work.

Proposition 2 – Different types of agility strategies will have different patterns of choices of supply chain design and management practices.

Proposition 3 – The pressures companies suffered from agility drivers will have an impact on the choices of agility strategies.

Proposition 4 – The pressures companies suffered from agility drivers will have an impact on the ways of supply chain design and management.

Proposition 5 – The nature of market, characteristics of products and product life cycles have impacts on the choices of agility strategies and the corresponding ways of supply chain design and management.

3.3 Choice of the research method

In order to answer the research questions properly, empirical methodology are adopted. This is because of an increased recognition that operations management (OM) is an applied discipline (Meredith et al., 1989, Flynn et al., 1990, Filippini, 1997, Forza, 2002), and as an

applied discipline, it is essential that the outcomes of OM research are relevant and useful to practitioners such as operations managers.

3.3.1 The need of empirical research

"Since 1980, the operations management discipline has witnessed increased deployment of empirical research designs, particularly survey research, to understand better such issues as manufacturing strategy…" (Rungtusanatham et al., 2003) This is because that research using empirical data is of critical usefulness to supplement mathematics, modelling, and simulation to develop and test theories in OM (Malhotra and Grover, 1998, Forza, 2002). It is believed that with increased scientific recognition of the OM field, empirical methodologies can reduce the gap between management theory and practice and increase the usefulness of OM research to practitioners (Forza, 2002). Meredith et al. (1989) stressed that "…if the fruit of our research fail to be applicable in the real world, then our endeavours are relegated to the point of being irrelevant."

In order to ensure that the research is relevant to those who will use it, it was thought that field research methods gathering empirical data from real world such as survey should be used in order to understand and solve problems in industrial context.

3.3.2 Follow the step

While the value of empirical research in OM has been increasingly recognized, survey is widely acknowledged as the most commonly used empirical method (Flynn et al., 1990, Malhotra and Grover, 1998, Forza, 2002, Rungtusanatham et al., 2003). As it is reported by Forza (2002),

"The number of survey research based articles increased steadily from the mid-1980s to the early 1990s, and increased sharply from 1993. By 1996, empirical research based articles accounted for approximately 30 per cent of the research published in the main OM outlets, and survey-based articles accounted for 60 per cent of this empirical subset."

The latest statistical results of survey research in OM were reported by Rungtusanatham et al. (2003). The results indicated that there has been a quantum leap in the number of survey research articles published in the six most reputed OM journals since 1995. The sharp rise was also proved by Frohlich (2002). The reason why survey research is on a dominant position among empirical studies may be explained by its capability of producing generalisability to an entire population of firms (Flynn et al., 1990).

Since this research aims at providing practical guidance to manufacturing enterprises, the generalisability of the research outcomes is one of the concerns. Based on this concern and given the empirical nature of the research, it was thought that survey would be an appropriate method to fulfil the objectives of the research. To follow up the dominant trend in OM research, it was decided to adopt survey as the research method.

3.4 Ensuring rigour in the research

A systematic approach for empirical research proposed by Flynn et al. (1990) was followed in order to ensure the research was as sufficiently rigorous as possible. The approach includes five stages which are establishing the theoretical foundation, selecting a research design, selecting a data collection method, implementation and data analysis.

In addition, a road map for design and execution of survey research developed by Forza (2002) was referenced as guidelines to perform this survey research. The following diagram shows the procedure of the implementation of the research. This section details actions that were taken in accordance with this procedure.

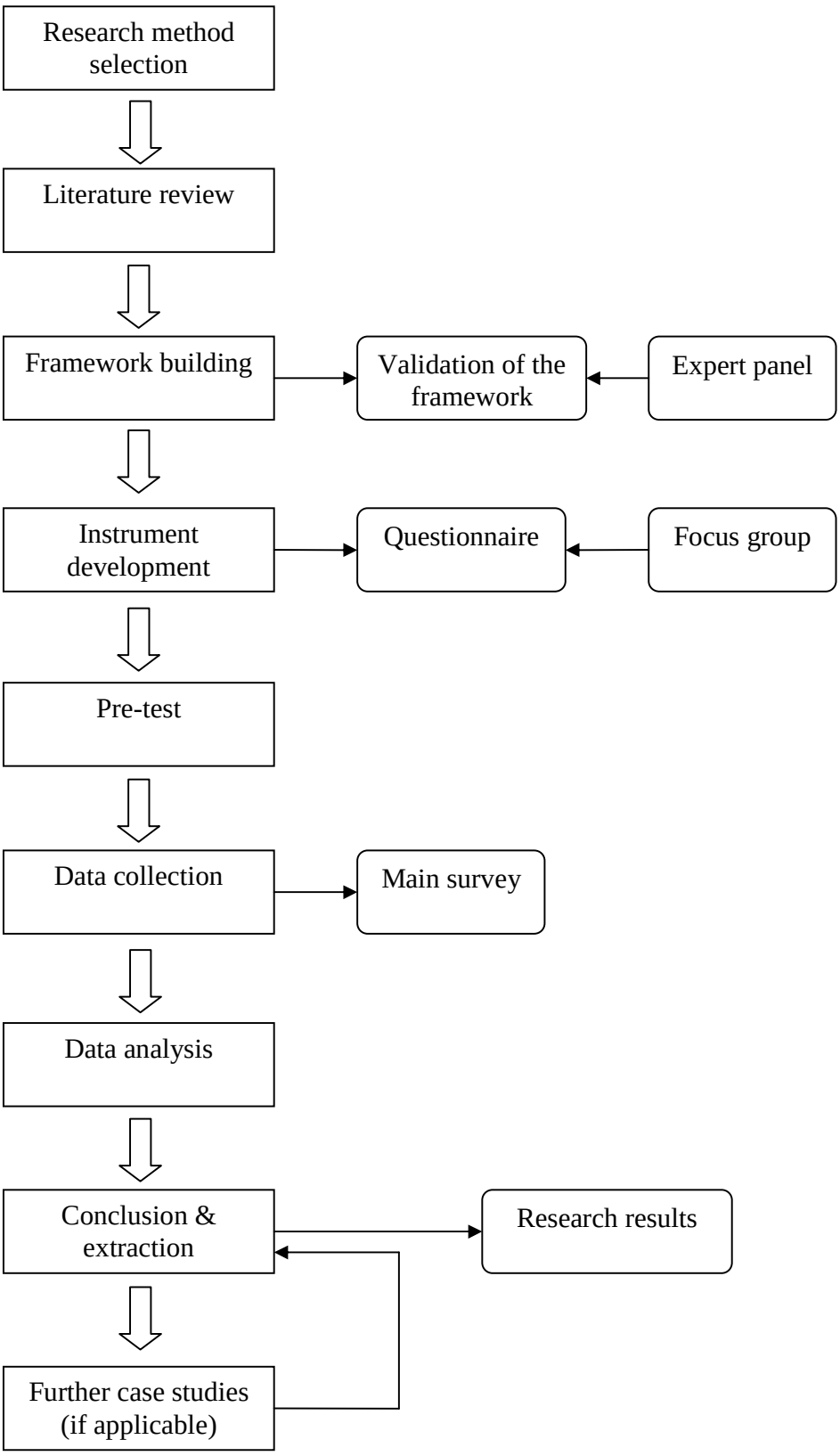

Figure 3. 1 The research procedure

3.4.1 When to use survey research

Empirical research can be used to either build theory or to verify theory (Flynn et al., 1990). Survey research, designated as the most commonly used methodology in empirical OM research, can contribute to theory development in different ways (Babbie, 1990, Forza, 2002, Rungtusanatham et al., 2003).

Survey research can be used in both exploratory and explanatory studies (Kerlinger, 1986, Filippini, 1997, Malhotra and Grover, 1998, Forza, 2002, Rungtusanatham et al., 2003). For exploratory study, survey research is used in the early stages of studying a phenomenon, with the objective of gaining preliminary insight and providing the basis for more in-depth study. For explanatory study, survey research is used in the later stages of research into a phenomenon, with the aim of finding causal relationships among variables. As the research matures, knowledge of a phenomenon is well-developed. The concepts, models and propositions associated with the phenomenon are well-defined. In this case, hypothesized linkages among variables/constructs of the developed conceptual model can be studied by using explanatory surveys. Figure 2 shows the maturity cycle of research, which depicts the relationships between research developing stages and the corresponding types of survey research for use (Malhotra and Grover, 1998).

As discussed in section 3.2, this research is making a further step towards theory building in agility strategy and making an effort to investigate the relationships between key constructs of the research framework. By revisiting the taxonomy developed by Zhang and Sharifi (2007), this research attempted to find the linkages between the choices of agility strategies and the ways of supply chain management. With this purpose, survey research

was carried out in order to ensure that the research was relevant and interesting to OM practitioners and OM researchers.

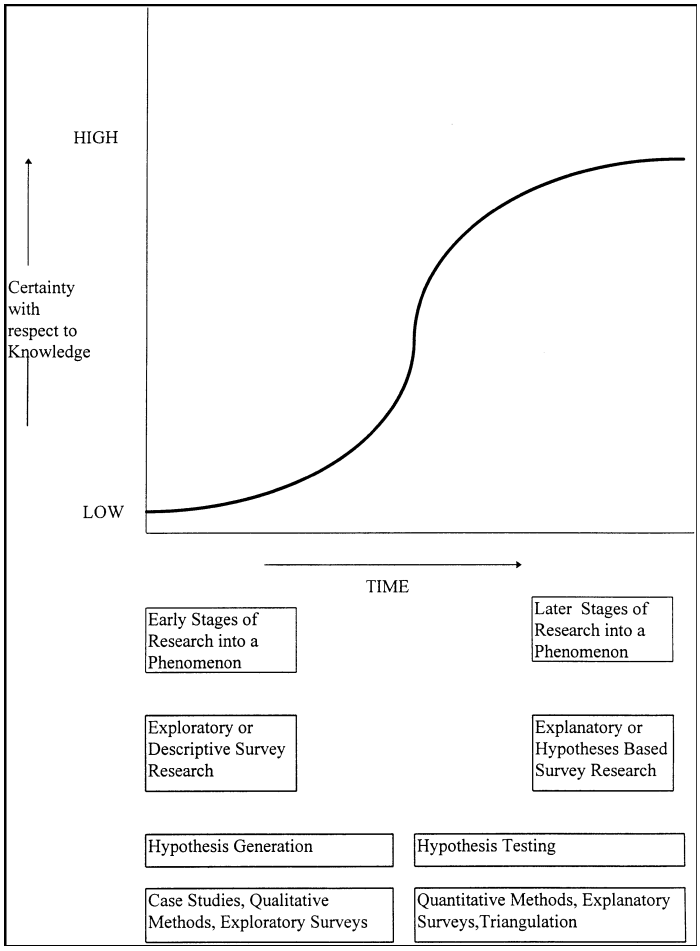

Figure 3. 2 The maturity cycle of research (Malhotra and Grover, 1998)

3.4.2 Literature review

A general literature review was conducted at the beginning of the research (reported in Chapter 2). The reviewed literature mainly covered three areas that included manufacturing strategy, agile manufacturing and supply chain management. The purpose of such literature

review was to learn knowledge about prior relevant works, establish a theoretical foundation and shape the research questions.

A further literature review was done subsequently to generate the theoretical knowledge for research framework development and survey instrument development. This will be reported with details in the following chapters along with the description of the research framework.

3.4.3 Developing the research framework and constructs

This was done during the literature review stage of the research, based on the preliminary investigation of the research area supported by relevant academic works. The constructs, comprising the research framework, were developed on the basis of the literature analysis.

The validation of the framework took place after the framework was developed. An expert panel consisting of senior academic professionals in OM field was organised to validate the framework. The validation was primarily based on the discussions between the author and the experts with regards to the issues identified during the framework development process. It was thought that the research framework and the constructs would become more defined as the validation process was carried out. Detailed description about the research framework and its constructs is provided in Chapter 4.

3.4.4 Developing survey instrument

Questionnaire was used as survey instrument to acquire necessary information from companies. In addition to the ability of producing universal outcomes, it is because that questionnaire can give an authoritative impression to respondents and can reduce

interviewer bias (Forza, 2002). Furthermore, low cost and ease of securing information help questionnaire become a good method for data collection (Miller, 1991, Forza, 2002).

The results of the validation of the research framework and associated constructs were used to develop the survey instrument. The items of the questionnaire were mainly derived from the literature. The structure of the questionnaire was built according to the construction of the framework. Each section involved in the questionnaire corresponds to a core element involved in the framework.

Focus group, which refers to a panel of experts, was used to validate the content of the developed instrument. This is to alleviate confounding effects in determining the true relationship among variables of the instrument (Malhotra and Grover, 1998). All the experts in the panel were from academia, but all of them have been in the operations management field for many years and most of them have worked closely with industries. Some of them have been consultants for industrial companies for a long time. Modifications were made according to the results of the focus group validation in order to ensure that the questionnaire was reasonable on the academic basis and applicable to industrial managers on the practical basis.

3.4.5 Pretesting the instrument

Pretesting of the questionnaire was carried out for further refinement of the developed survey instrument. This echoed the proposition given by Malhotra and Grover (1998) that "careful pretesting of instruments in the field can serve as a reality check indicating to the

researcher how well conceptualizations of the problem match the actual experience of the practitioner."

Specialists in industry were invited to pretest the revised version of the questionnaire after the focus group validation. The specialists were from the companies with which the department has established long term collaborative relationships. They were invited to fill in the questionnaire and make comments on whether the instructions were clear, whether the questions were clear and whether the questionnaire had properly covered the concerned aspects. Necessary modifications were made in accordance with the comments provided. Three purposes were to be fulfilled by the pretesting process: (1) to assess the quality of the instrument (whether the required information can be obtained by the instrument); (2) to ensure the applicability of the questionnaire (whether operations managers can understand questions properly); and (3) to make potential but unaware problems apparent of final revision. Chapter 5 provides more detailed description of the pretesting of the survey instrument.

3.4.6 Implementing main survey

Validated questionnaire was addressed to the targeted informants of selected companies for data collection. Companies were selected from the ranking list of the top 850 UK companies by R&D investment, provided by the Department of Business Innovation & Skills (previously called 'the Department of Trade and Industry database') – a comprehensive source of U.K. business. The reason why the companies for mail survey were chosen from the R&D investment scoreboard was that companies who spent more

efforts on R&D were believed to be more likely to know advanced and relatively new concept and have more potential to be involved in the research.

As the research aimed to investigate issues at the strategic level, senior management officers such as chief executive officer, managing director or other members of executive committee of companies were targeted as the informants. This is due to the common belief that these people are knowledgeable about the company strategies, the overall operational circumstances and other general strategic and managerial issues (Phillips, 1981, Flynn et al., 1990, Miller and Roth, 1994, Forza, 2002, Zhang and Sharifi, 2007).

An explanatory text was provided with the questionnaire together to informants. The text offered the definitions and the explanation of concepts and terminologies that appeared in the questionnaire. The final ready-to-post package included a questionnaire with the explanatory text, an introduction letter about the survey, and a postage-paid return envelope.

To encourage informants to participate in the research, providing research results as a reward to participation was indicated in the introduction letter. Considering that some questions appeared in the questionnaire may be sensitive for some companies, it has been promised that information about the participating companies will be kept strictly confidential. A modified version of Dillman's (1978) survey method was followed to increase the response rate. Two sets of questionnaire mailings were conducted. The first set of survey questionnaire was mailed out to the sampled companies by first-class mail. The due date for reply was specified. One month was given to the informants to complete the questionnaire. The second set of survey questionnaire, one month later, was sent to those who did not respond to the first set. Almost same contents were enclosed in the second set

of mailing. Small modifications were made to the introduction letter. Another month was given to the informants for completing the questionnaires.

3.4.7 Data analysis

Data collected from the questionnaires was typed into electronic database. Double check was performed during data transcribing process to guarantee accuracy of transcribing. SPSS (for Windows) was used as the processing tool for data analysis.

A clustering approach similar to those used by Miller and Roth (1994) and Zhang and Sharifi (2007) was adopted to identify strategic groups. The approach primarily consists of cluster analysis and canonical discriminant analysis. Other statistical techniques for empirical research recommended and commonly used in literature were used as well, including Chi-squared test, Cronbach's alpha, ANOVA and so on. More details about data analysis are offered in Chapter 5, 6 and 7.

3.5 Summary

This chapter presented the research questions formulated based on literature investigation, and described the methodology that would be used to carry out the research in order to answer the research questions. Several propositions were formed based on the proposed research questions.

As an empirical research, survey was found to be an appropriate method for the research to answer the proposed research questions. Questionnaire, as the most commonly used survey instrument, would be used as the means for data collection.

An approach for empirical research proposed by Flynn et al. (Flynn et al., 1990) and a roadmap for conducting survey research provided by Forza (2002) would be followed in order to ensure rigour in the research.

The following chapters detail the processes of the implementation of the research.

Chapter4 Research framework

4.1 Introduction

This chapter presents the research framework and details the main constructs of the framework.

Firstly, a general description of the framework including the interrelationship and linkages between constructs will be given along with literature review. Then, the development of the main constructs and the detailed contents incorporated in the constructs will be narrated with literature support.

4.2 A framework for using SCMPs to support implementation of agility strategies

Zhang and Sharifi (2007) have developed a framework that defines agility as a manufacturing strategy, shown in Figure 4.1. The framework consists of four main elements: agility drivers, manufacturing task, agility capabilities and manufacturing choices. Agility drivers refer to changes and pressures from the business environment. They act as driving forces for considering agility as a manufacturing strategy. Manufacturing task represents a statement of manufacturing objectives which comprise a list of prioritised capabilities that companies tend to focus on in order to positively respond to changes and maintain competitive advantages. Agility capabilities are referred to as a pool of competitive capabilities from which companies' manufacturing task would be formulated by prioritising them in accordance with companies' own business situations. Manufacturing choices are concerned with decisions made by companies with regard to their facilities,

technology, capacity, organisation policies, and other hardware/software resources.

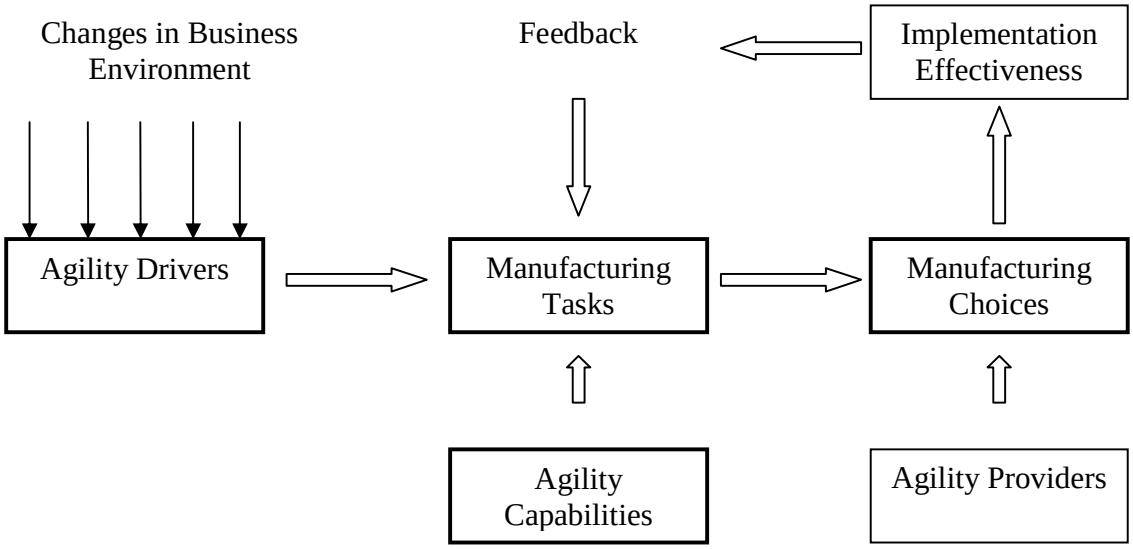

Figure 4.1 The framework for defining agility as a manufacturing strategy (Zhang and Sharifi, 2007)

The framework suggested a way of the formation of manufacturing strategies based around agility. It provides a foundation for applying agility as a manufacturing strategy in practice.

Based on this framework, a more detailed framework for using SCMPs to support implementation of agility strategies has been developed for this study, shown in Figure 4.2. While Figure 4.1 provides a general image of how agility strategy can be formed through the analysis of changes taking place in the business environment, the identification of agility drivers that companies suffered and the need of improvement of agility capabilities in response to the drivers, Figure 4.2 extends Figure 4.1 with detailed agility providers incorporating supply chain design and management practices as enablers to facilitate the conduct of agility strategies.

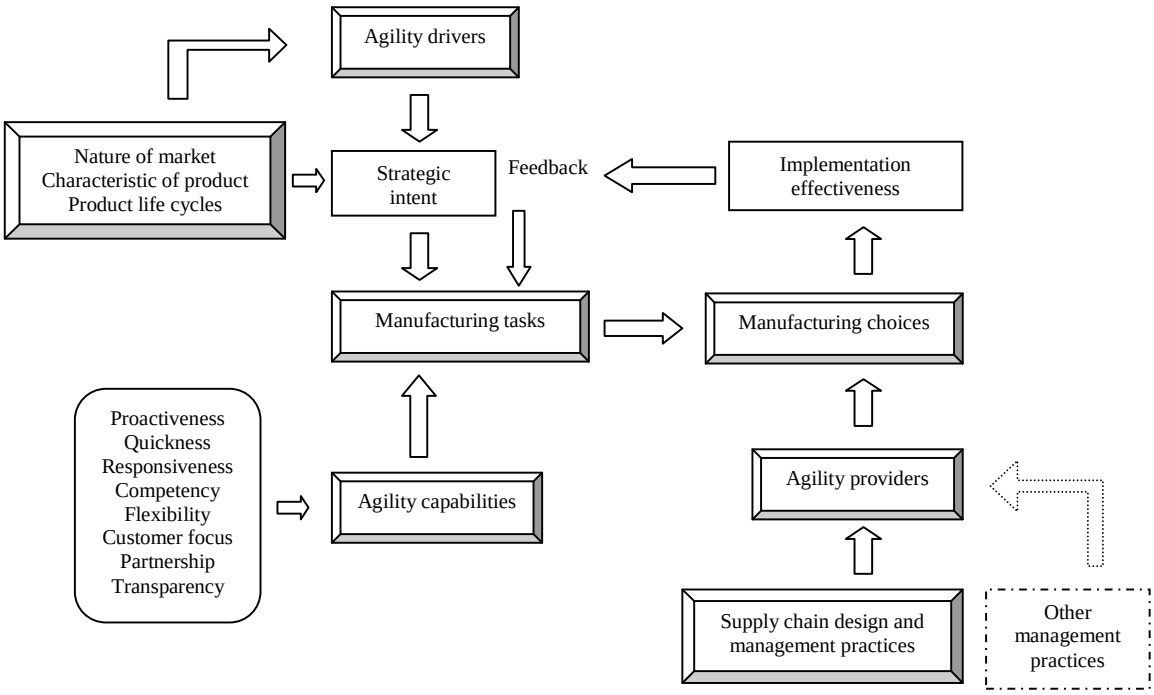

Figure 4. 2 The framework for using SCMPs to support implementation of agility strategies

In Figure 4.2, the framework consists of five main constructs which are “agility drivers,” “manufacturing tasks,” “agility capabilities,” “manufacturing choices” and “agility providers.” “Manufacturing task” and “manufacturing choices” are central to the definition of a manufacturing strategy (Miller and Roth, 1994, Hill, 2000). “Manufacturing task”, which concerns capabilities a manufacturing unit must have in order to compete given the overall business and marketing strategy, corresponds to a list of prioritised capabilities that the company intends to focus on in order to positively respond to and take advantage of changes (Zhang and Sharifi, 2007). “Manufacturing choices” are concerned with decisions a manufacturing unit makes regarding its facilities, technology, ways of integration, capacity, forms of organisation, quality management, workforce policies and information system architectures (Hayes and Wheelwright, 1984). In the case of agility strategies, these decisions correspond to the choices of “agility providers.”

Changes from the business environment play the role of driving forces for considering agility as a manufacturing strategy. They are “agility drivers” and they necessitate a company to seek new ways of running a manufacturing unit in order to maintain its competitive advantage. This search for new ways of working corresponds to a strategic intent, which is an attempt to build a strategy that will enable the company to cope with the changes. Often, companies operating in different types of market, with different product characteristics, and at different stages of product life cycles, may experience different subsets of changes. Their strategic intent may be different. The occurrence of a strategic intent leads to the formulation of a manufacturing task for the company, which leads to the prioritisation of a number of capabilities, in this case “agility capabilities.” The next stage in the strategy building process is the formulation of “manufacturing choices.” The theory in the operations management literature is that good alignment of “manufacturing choices” with “manufacturing task” leads to superior performance (Miller and Roth, 1994, Zhang and Sharifi, 2007). Therefore, making high quality “manufacturing choices” based on “manufacturing task” is crucial to the effective implementation of a manufacturing strategy. In the case of agility strategies, “manufacturing choices” corresponds to the appropriate selection of “agility providers.” Since the focus of this research is to identify how companies with different agility strategies design and manage their supply chains, “agility providers” in the framework mainly comprise generic supply chain design and management practices used by firms to improve supply chain performance. The remaining elements in the framework involve the implementation of “choices,” the assessment of the effectiveness of the implemented choices, and feedbacks from the assessment which provide a basis for the adjustment of “manufacturing task” and “choices.” One point which is worth mentioning is that “agility providers” may include other management practices, such as human resource management practices, knowledge management practices and so forth.

However, due to the scope of this study, they are out of the boundaries, and thus, the attention has not been placed on those factors.

4.2.1 Agility drivers

The main driving force behind agility is change. As many researchers stated, environment turbulence, encapsulating the idea of continuous, uncertain and potentially disruptive change in a variety of factors, both internal and external, is the key driving force for the development of agility (Ismail et al., 2006). Firms that are able to operate successfully in the turbulent environment have to show high level of agility in terms of adaptation of high dynamism (unpredictable changes in the environment), high hostility/competition (high populated, competitive markets with one or more critical and scarce resources), high complexity (close links between firms and their suppliers, customers and other members involved in the supply chain) and high diversity (varied products, production lines, customers or businesses) (Vazquez-Bustelo et al., 2007).

The changes can stem from various aspects such as market, competition and competitors, customer and suppliers, technology, and social factors. These changes drive the organisations to move towards agility to be able to respond appropriately to and take advantage of changes in the business environment.

From the literature review, various changes have been identified that were cited as driving forces for agility. The frequently cited include the increased competition from globalization, fragmenting markets, shortening product life cycles, dynamic changes in demands, faster rate of product introduction, faster pace of innovation, individualizing customer

requirements, the advancement of information technology, and the increasing pressure from environmental legislations (Nagel and Dove, 1991, Kidd, 1994, Dove, 1994-1996, Goldman et al., 1995, Booth, 1996, Dove, 1996, Preiss et al., 1996, Ramasesh et al., 2001, Yusuf and Adeleye, 2002).

The industrial environment and the marketplace have changed dramatically over the last two decades, with technology, market conditions, material and energy costs, customer requirement and product life cycles changing at an unprecedented speed and in directions that have been hard to foresee. Examples found from the literature include the growth of niche markets (Nagel and Dove, 1991), the rapid change of product models in the marketplace, and the shrinkage of product lifetime (Goldman et al., 1995). Changes are also taking place on ways that companies compete, owing to fierce competition among enterprises in cost, quality, technology, time, responsiveness, etc (Zhang and Sharifi, 2000). Pressures from customer, such as increasing demand for individualized products and services, quick delivery time and time to market, higher expectation of product quality, and after sales service, are conspicuous (Yusuf and Adeleye, 2002). Additionally, the rapid pace of technology development, the availability and wide accessibility of new product technology, new manufacturing processes, and new information and communication technology have resulted in threats to businesses (Zhang and Sharifi, 2007). Social factors, in terms of pressures from environmental issues, the workforce, legal/political regulations, culture issues, and the way in which social contract is organised, have big impacts as well (Sharifi and Zhang, 1999, Sharifi and Zhang, 2001).

Drawing on the most cited driving forces discovered from the literature and taking into account the essential feature of each force, five dimensions of agility drivers were formed.

Since the agility drivers summarized in the work of Zhang and Shrifi (2007) were thought to be comprehensive, they were adapted and borrowed for this research. Although some elements, such as climate change, carbon emission, green manufacturing and supply chain and so on, have been frequently mentioned in recent operations management literature as critical pressures for making operations improvements, all these were thought to be covered by the formulated five dimensions.

The detailed list of dimensions and corresponding drivers is shown as follows:

1 – Change in marketplace:

- Growth of the niche market
- Opening of new local or foreign markets or closing of some others because of political change
- Increase rate of change in product models
- Product lifetime shrinkage
- Decreasing cost of entering niche market

2 – Change in competition basis:

- Rapidly changing markets
- Increasing pressures on cost/profitability
- Innovation rate increasing
- Increasing pressure of global market competition
- Decreasing new product time-to-market
- Responsiveness of competitors to changes in marketplace
- Effectiveness of competitors' strategy, marketing, distribution, services, etc.

3 – Change in customers requirements:

- Individualized products and services

- Quicker delivery time and time-to-market
- Quality expectation increasing
- Increasing value of information/services

4 – Social changes:

- Environmental pressures (e.g. climate change)
- Workforce/workplace expectations
- Legal/political pressures
- Cultural pressures
- Social contract change

5 – Internal drivers:

- Strategy of continuous improvement
- Moving towards excellence

To sum up, the drivers derived from the literature are listed in the Table 4.1.

Dimensions	Agility Drivers
Change in marketplace	Growth of the niche market
	Opening of new local or foreign markets or closing of some others because of political change
	Increase rate of change in product models
	Product lifetime shrinkage
	Decreasing cost of entering niche market
Change in competition basis	Rapidly changing markets
	Increasing pressures on cost/profitability
	Innovation rate increasing
	Increasing pressure of global market competition
	Decreasing new product time-to-market
	Responsiveness of competition to changes in marketplace
	Effectiveness of competitions' strategy, marketing, distribution, services, etc.
Change in customers requirements	Individualized products and services
	Quicker delivery time and time-to-market
	Quality expectation increasing
	Increasing value of information/services
Social changes	Environmental pressures (e.g. climate change)
	Workforce/workplace expectations
	Legal/political pressures
	Cultural pressures
	Social contract change
Internal drivers	Strategy of continuous improvement
	Moving towards excellence

Table 4. 1 Agility drivers (adapted from Zhang and Sharifi, 2007)

4.2.2 Agility capabilities

In agile manufacturing strategy, speed is an essential element of agility capabilities. This has been pointed out and stressed in the literature (Nagel and Dove, 1991). In manufacturing strategy, speed is often referred as the capability of quick products delivery (Miller and Roth, 1994). However, the meaning of speed, in agility, has been extended to referring to the capability of quick operations in all aspects of product development and manufacturing process (Gunasekaran, 1999, Sharifi and Zhang, 2001). In this study, two

quick related capabilities have been defined. They are quickness in product development and quickness in product/service delivery.

Flexibility is another frequently cited capability in the agility-related literature. It has been recognized as one of the most important capability for agility (Baker, 1996, Katayama and Bennett, 1999, Das, 2001, Giachetti et al., 2003, Koste et al., 2004). In manufacturing strategy flexibility mainly refers to design and volume flexibility, while in agile manufacturing strategy the meaning of flexibility has also been widened to incorporate not only design and volume, but also people, resources, and organisation flexibility to enable an enterprise to respond to changes (Zhang and Sharifi, 2007).

The most frequently mentioned capability in the agile manufacturing literature is responsiveness to changes. This refers to the capability to identify, respond to and recover from changes. Most of definitions of agility in the literature have included the terms such as "responding to changes" and "exploiting changes as opportunities" (Nagel and Dove, 1991, Kidd, 1994, Goldman et al., 1995, Montgomery and Levine, 1996, Quinn et al., 1997). This demonstrates the significance of responsiveness in agility theory.

Additionally, the literature suggested that an agile competitor must be a competent player who must have the basic business competency in terms of cost, efficiency, quality, and product and delivery performance, and be able to innovate and develop and manage core competency (Nagel and Dove, 1991, Kidd, 1994, Booth, 1996, Dove, 1996, Preiss et al., 1996). Other capabilities emphasised in agility literature include "focusing on customer," "partnership," and "proactiveness." Goldman (1995) has enclosed "enriching customer" and "cooperating to enhance competitiveness" in the proposed dimensions of agility.

Proactiveness is another dimension that has been proposed in most agility definitions. It has been described as the capability to act proactively to create changes and take opportunities of changes as advantages (Nagel and Dove, 1991, Kidd, 1994, Goldman et al., 1995, Montgomery and Levine, 1996, Quinn et al., 1997, Gunasekaran, 1999).

In addition to the capabilities mentioned above, there is another capability that is believed to be critical for agility, especially in the marketplace where competition is carried out between supply chains. This capability concerns gathering and processing, acquiring and conveying information promptly from all aspects with regards to business, in order to form a fluent information flow across the supply chain. The capability is named “transparency” in this research. The importance of visible, available and timely information has been emphasised in many researches (Mentzer et al., 2001, Morash, 2001, Tan et al., 2002). Aviv (2007) suggested that accurate and prompt information sharing can bring benefits on collaborative forecasting. This would result in better decision making and process improvement to the trading partners. Zhou and Benton (2007) demonstrated that effective information sharing can significantly enhance effective practices over supply chains. Also, better information integration can facilitate logistical process linkages (Schonsleben, 2000, Robertson et al., 2002), as well as the whole supply chain integration (Stock et al., 2000, Frohlich and Westbrook, 2001, Gunasekaran and Ngai, 2004). For agile organisations, accurate and prompt information may benefit them in making early preparation to perform quick response to coming changes.

From what has been discussed above, a list of competitive capabilities can be formulated. The list is an extension of the one that was used in the work of Zhang and Shrifi (2007). Nine capabilities are included in this list and used in this research as agility capabilities.

The nine capabilities are defined as follows:

- Flexibility – The capability to perform different tasks and achieve different objective with the same set of resources/facilities.
- Quickness in product development – The capability to innovate at high speed, to develop products rapidly, and to have a short time to market.
- Quickness in product/service delivery – The capability to operate at high speed in products and service delivery.
- Responsiveness to changes – The capability to identify, respond to and recover from changes.
- Competency – The capability to operate efficiently, produce high-quality and high-performance products, deliver on time, innovate, and manage core competency.
- Focusing on customer – The capability to have a strong customer focus.
- Partnership – The capability to form concrete relationship with suppliers and to partner.
- Proactiveness – The capability to act proactively instead of reactively (in attacking threats and opportunities).
- Transparency – The capability to form a transparent, smooth and efficient information stream across supply chain and to acquire prompt information from marketplace and other members involved in the supply chain.

Quite similar capabilities were used in the work of Zhang and Sharifi (2007). They have conducted a comprehensive study of different capabilities proposed in the agility literature and suggested seven capabilities as the essential agility capabilities containing proactiveness, responsiveness to changes, flexibility, quickness, competency, customer focus, and partnership. In this study, while the suggested seven agility capabilities were

borrowed, the “quickness” has been divided into “quickness in product development” and “quickness in product/service delivery.” This is in recognition of two fundamentally different ways in which the quickness is used to address challenges and opportunities in the marketplace. Zhang and Sharifi (2007) did suggest in an initial case study following their early investigation that there appeared to be two sub-categories of quick player, one emphasising product development and the other product/service deliver. Additionally, “transparency” is added to the list of agility capabilities. This attributes to the consideration that visibility and availability of prompt information from trading partners and marketplace have increasing impacts on assisting agile organisations to make quick and proper response to changes as well as proactive attacks to potential changes. Transparency refers to the capability of a firm to form and acquire prompt information across supply chain.

Other similar lists, identified in the literature, have suggested by Dove (1996) who considered modularity, plug compatibility, dynamic relationships, reusability of facilities, and open system framework as capabilities for agile manufacturing, and Reid et al. (1996) who proposed a list of agility attributes including sensing and anticipating changes, adaptability, ability to recover from change, quickness, innovation, flexibility and efficiency.

4.2.3 Agility providers – Supply chain design and management practices

In the literature, various supply chain management (SCM) practices have been proposed from different angles, with a common goal of improving organisational performance, promoting the effective and efficient management of supply chains, and in turn improving

the performance of the whole supply chains. Alvarado and Kotzab (2001) discussed supply chain management practices from aspects of managing transactions and relationships between members within a supply chain. Their list of SCM practice included concentration on core competencies, use of inter-organisational systems such as electronic data interchange (EDI), and postponement of customisation towards the end of the supply chain for eliminating unnecessary inventory levels. Mentzer et al. (2001) proposed a theoretical framework of supply chain management and considered supply chain management activities from integrated behaviour, mutually sharing information, mutually sharing risks and rewards, cooperation, the same goal and the same focus on serving customers, process integration, partners to build and maintain long-term relationships. Tan et al. (2002) identified 24 supply chain management practices and grouped them into six aspects of supply chain management, including supply chain integration, information sharing, supply chain characteristics, customer service management, geographical proximity and JIT capability. By analysis of over 400 articles, Chen and Paulraj (2004) suggested that the efforts to improve supply chain performance ought to be made from the aspects of coping with environmental uncertainty, focusing on customer requirements, improving top management support, developing strategic purchasing, refining competitive priorities, promoting information technology, optimizing supply network structure, improving buyer-supplier relationships and integrating logistics, in order to achieve better supplier and buyer performance which contributes to the overall performance of the entire supply chain. Based on the work of Mentzer et al. (2001), Min and Mentzer (2004) developed measurement scales of supply chain management related concepts which covered aspects of supply chain orientation, supply chain management and business performance. Zhou and Benton (2007) considered supply chain practices from three categories: supply chain planning, just-in-time (JIT) production and delivery practice.

In this study, to ensure that all practices included can be used as generic manufacturing choices in defining manufacturing strategies in different business and supply chain context, rather than as specific techniques for a certain type of business operations or supply chain circumstance, SCM practices were considered from a comprehensive point of view and were collected from various relevant literature. This was making an attempt to take into account all aspects about supply chain management.

As shown in Figure 4.3, in general, there are two crucial flows and three types of activities involved in a supply chain, which are information flow, material/process flow, sourcing activity, delivery activity and relationship management activity.

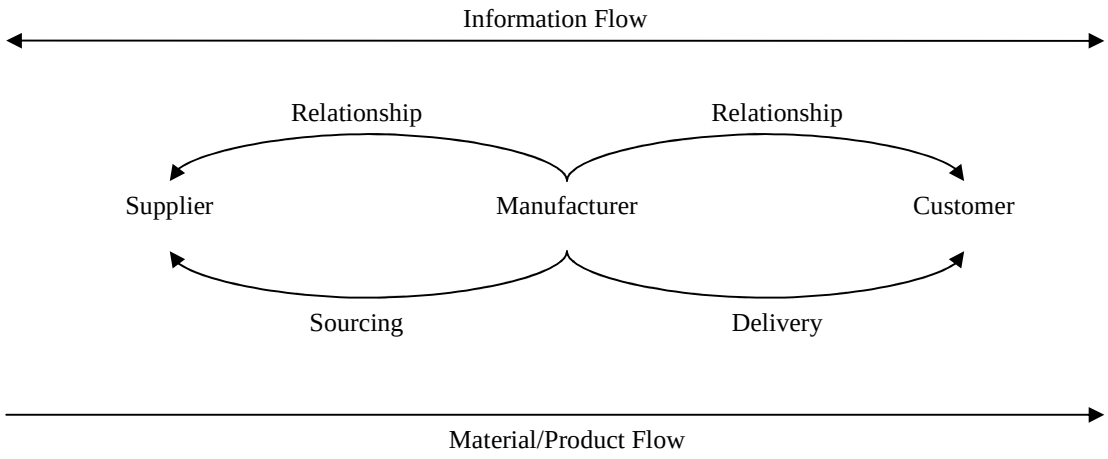

Figure 4. 3 A diagram for supply chain management

Five aspects of practices are thought to be relevant to the management of these flows and activities, which include information integration, process integration, sourcing management, delivery management and relationship management. The five aspects of management practices have covered upstream (sourcing management) and downstream (delivery

management) sides of a supply chain, information flow (information integration) and material/product flow (process integration) across a supply chain, and relationship issues (relationship management) over the entire supply chain.

Apart from these aspects, the importance of supply chain design and supplier selection on supply chain management issue was emphasised in many studies (Fisher, 1997, Mason-Jones et al., 2000, Sharifi et al., 2006, Vonderembse et al., 2006, Selldin and Olhager, 2007, Kehoe et al., 2007, Lee et al., 2001, Baramichai et al., 2006, Huang and Keskar, 2007).

Drawing on what have been discussed above and based on a review and consolidation of literature, four distinct dimensions of SCM are formed (shown in Figure 4.4): (1) strategic design of supply chains; (2) careful selection of suppliers; (3) supply chain integration; and (4) strategic coordination of operations. Two sub-dimensions and three sub-dimensions are under the dimensions of supply chain integration and strategic coordination of operations, respectively: information integration and process integration under the dimension of supply chain integration; strategic sourcing management, strategic delivery management and strategic relationship management under the dimension of strategic coordination of operations.

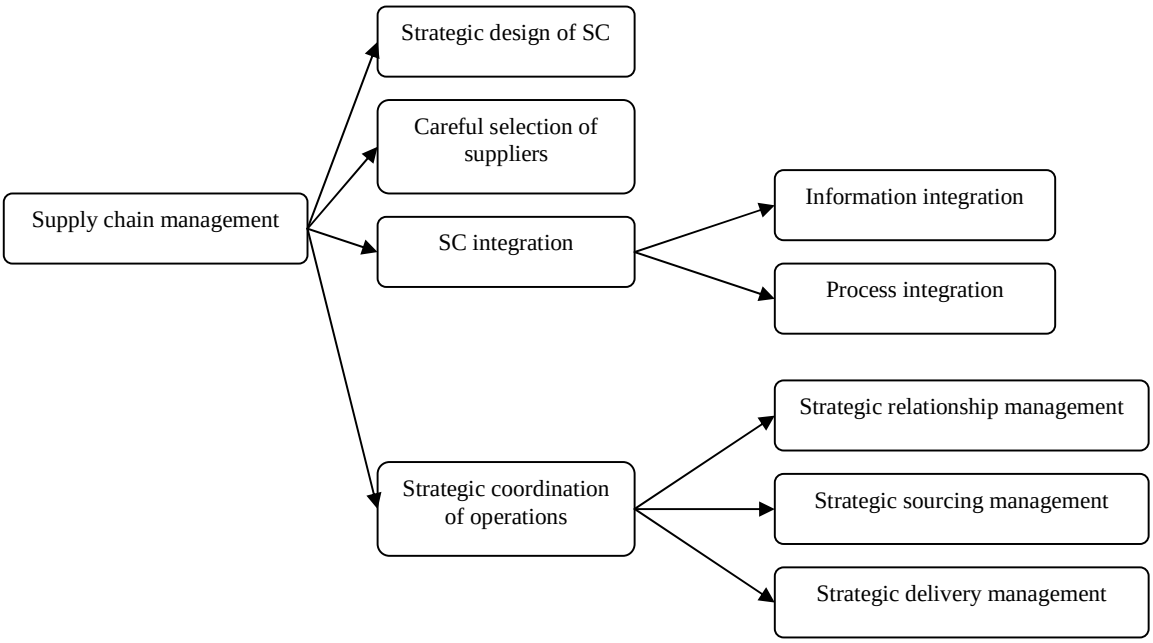

Figure 4. 4 Four dimensions of supply chain management

Strategic design of supply chains - To achieve better alignment of the business strategy and supply chain performance, firms need to design their supply chains strategically at the beginning of supply chain development, taking into consideration the characteristics of products, the business environment, the nature of demand, and other factors that may have influences on the performance of the supply chain (Fisher, 1997, Sharifi et al., 2006, Vonderembse et al., 2006). For instance, it is suggested that products with high profit margins, volatile demand and short product life cycles would require responsive supply chains. In contrast, efficient supply chains may be more suitable for products with relatively stable demand and long product life cycles (Fisher, 1997, Vonderembse et al., 2006). Mason-Jones et al. (2000) claimed that only if the characteristics of the products, marketplace requirements and management challenge are well understood the correct supply chain strategy can be designed, and only when the strategy suits the products and marketplace, optimal performance can be ensured and competitive advantage can be established. Sharifi et al. (2006) discussed the interaction between supply chain design and

design for supply chain, while Vonderembse et al. (2006) through three case studies demonstrated that different types of products should adopt different types of supply chain strategies taking into account product life cycles.

Careful selection of suppliers - Careful selection of suppliers has played a critical role in supply chain management given the significant impacts of suppliers on the performance of supply chains (Lee et al., 2001). This has been the most intensively studied area in the supply chain management literature, and a lot of criteria have been proposed for supplier selection. These include early work of Dickson (1966) which explored a list of 23 supplier selection criteria as a guidance for original equipment manufacturers (OEMs), and later work such as Ghodsypour and O'Brien (1998) which listed cost, quality, on-time delivery, ease of communication, response to changes and process flexibility as main criteria. Recent work has incorporated complex criteria such as quality and cost of support services, problem solving abilities, vendor expertise and experiences (Tam and Tummala, 2001).

Some other works are notable on the supplier selection issue. Narasimhan and Das (1999) considered responsiveness to changes (both in terms of delivery and volume) as a benchmark of supplier selection for agile enterprise. Lee et al. (2001) listed financial status, technological and R&D capability, level of cooperation and information exchange and production capability as conditions of choosing suppliers to establish relationships. Talluri and Narasimhan (2004) proposed a framework and methodology, which utilized both strategic capabilities and performance metrics which include quality, price, delivery and cost reduction performance in evaluating suppliers, to discriminate supplier performance for selecting proper suppliers and in turn facilitating the achievement of strategic outsourcing. Baramichai et al. (2006) suggested that "change response proficiency"

(concerned with the ability of suppliers to respond to specific change) and “agility intangible infrastructure” (including organisational skills, information, knowledge and corporate culture) are the important criteria of selecting and evaluating suppliers. Huang and Keskar (2007) developed configurable metrics for supplier selection, which consist of seven categories including five basic metrics of reliability, responsiveness, flexibility, cost and financial, and assets and infrastructure, and two additional metrics of safety and environment. Lately, Sen et al. (2008) classified 43 supplier selection criteria into six main categories of cost, quality, service, reliability, management and organisation and technology.

Although a large amount of selection criteria were identified from the literature, lots of them share very similar features. Some of them can be considered as the same criterion and others can be regarded as detailed sub-criteria under some representative criteria. For example, level of cooperation and information exchange can be seen as a sub-criterion of ease of communication; quality of support service can be included into the criterion of quality; supplier’s problem solving capability can be regarded as one of change-response capability; supplier’s expertise can be treated as supplier’s technological and R&D capability criterion; vendor’s experience in related products can be seen as an alternative expression of supplier’s performance history; capability in design assistance can be referred to as innovative power.

Drawing on the mentioned research works, through refining the massive criteria gathered from the literature, a list of supplier selection criteria, that is thought to be important for an agile enterprise, has been produced (See Table 4.2).

Quality	Dickson, 1966; Ghodsyopour and O'Brien, 1998; Lee, Ha et al., 2001; Tam and Tummala, 2001; Talluri and Narasimhan, 2004; Baramichai, Zimmers Jr et al., 2006; Li, Ragu-Nathan et al., 2006
Price	Dickson, 1966; Ghodsyopour and O'Brien, 1998; Narasimhan and Das, 1999; Schonsleben, 2000; Lee, Ha et al., 2001; Talluri and Narasimhan, 2004; Huang and Keskar, 2007
Delivery reliability (compliance with due date and quantity)	Ghodsyopour and O'Brien, 1998; Lee, Ha et al., 2001; Tam and Tummala, 2001; Baramichai, Zimmers Jr et al., 2006; Huang and Keskar, 2007
Geographical location	Dickson, 1966
Short lead times	Schonsleben, 2000; Talluri and Narasimhan, 2004; Baramichai, Zimmers Jr et al., 2006; Huang and Keskar, 2007
Change-response capabilities	Ghodsyopour and O'Brien, 1998; Narasimhan and Das, 1999; Tam and Tummala, 2001; Baramichai, Zimmers Jr et al., 2006; Huang and Keskar, 2007
Production capacity	Dickson, 1966; Lee, Ha et al., 2001
Total costs	Schonsleben, 2000; Tam and Tummala, 2001; Baramichai, Zimmers Jr et al., 2006; Huang and Keskar, 2007
Technological and R&D capability	Dickson, 1966; Lee, Ha et al., 2001; Tam and Tummala, 2001
Capability of cost reduction	Lee, Ha et al., 2001; Talluri and Narasimhan, 2004
Innovative power	Schonsleben, 2000; Tam and Tummala, 2001
Flexibility of acting as a partner	Ghodsyopour and O'Brien, 1998; Schonsleben, 2000
Ease of communication	Ghodsyopour and O'Brien, 1998; Lee, Ha et al., 2001
Financial status	Dickson, 1966; Lee, Ha et al., 2001
Reputation	Dickson, 1966; Tam and Tummala, 2001
Performance history	Dickson, 1966; Tam and Tummala, 2001

Table 4. 2 Supplier selection criteria

Supply chain integration – Supply chain integration is concerned with how members in a supply chain are linked together and relate to each other operationally and is the key to successful supply chain management. As shown in Figure 4.5, there are two essential flows along a supply chain. One is information flow which comprises two forms of information: (1) customer order and market information moving from downstream to upstream; (2) order process information moving from upstream to downstream. The other is material/product flow that goes from upstream to downstream. The extent to which the two flows are streamlined influences how well the supply chain is integrated (Robertson et al., 2002, Zhou and Benton, 2007). Therefore, two main categories of practices, one concerned with information integration and the other process integration, are included as constructs for supply chain integration.

A. Information integration

It was found that most of prior studies related to information sharing and integration focused on two main points: (1) information sharing level or scope, which is defined as transparency in this study (Chen and Paulraj, 2004, Min and Mentzer, 2004, Li et al., 2006); (2) information sharing quality (Aviv, 2007, Zhou and Benton, 2007).

Chen and Paulraj (2004) proposed that frequent communication of any event or change that may affect other partners can be adopted as a practice for achieving higher level of information integration. Min and Mentzer (2004) suggested that the results of performance measures should be shared with each other who are involved in the chain, and one should provide its customers with real time information about their orders for improving the availability of information. As the overall performance of the supply chain depends on every member's performance rather than any single unit, sharing business knowledge of

core business processes was thought as a possible means of promoting other partners performance (Li et al., 2006). Creating direct computer-to-computer links via internet and sharing proprietary or even sensitive information (such as financial, production, design, research and/or competition information) with key supply chain trading partners was recommended by some researchers (Frohlich and Westbrook, 2001, Chen and Paulraj, 2004, Zhou and Benton, 2007, Swink et al., 2007). This is due to the belief that high level of information transparency can provide the chance of making forecasting and preparation for possibly forthcoming changes to all the key partners, which will lead to the improvement of responsiveness and quickness in the supply chain management.

In addition to transparency of information sharing, the quality of shared information is the determinant of the eventual effect of information integration. A consistent statement is that timeliness is the top criterion of measurement of information sharing quality (Tan et al., 2002, Chen and Paulraj, 2004, Li et al., 2006, Zhou and Benton, 2007, Swink et al., 2007). Li et al. (2006) considered accuracy, completeness, adequacy and reliability as the measures of the quality of information sharing. Zhou and Benton (2007) incorporated availability, internal and external connectivity, relevance, accessibility and frequency of information updating in their recent study. The study found that effective information integration significantly enhances effectiveness of other supply chain practices. By examining the potential benefits of collaborative forecasting, Aviv (2007) evaluated the significance of information integration and proposed that manufacturers can acquire useful information about future demand from their market-observing supply chain partners via effective information exchange.

B. Process integration

Good processes integration can increase quickness, flexibility and reduce uncertainty (Hammel and Kopczak, 1993, Armistead and Mapes, 1993, Narasimhan and Jayaram, 1998, Towill and McCullen, 1999, Robertson et al., 2002). It is important for companies to integrate all relevant processes across their supply chains by which material/product flow can be streamlined and greater effectiveness and efficiency can be reached.

Bolden et al. (1997) recommended logistics management including both internal and external logistics as a means of process integration. Conformance checks, which refer to testing of the quality of goods inwards and goods outwards continually or randomly in order to guarantee the quality of products through the entire supply chain, is the prerequisite of ideal process integration (Bolden et al., 1997). Stock et al. (2000) presented three logistics-related process integration practices which included (1) integrating logistics activities with suppliers and customers, (2) jointly managing logistics with other members within the supply chain for seamless logistics integration and (3) computer aided logistic communication and support with other supply chain members. Frohlich and Westbrook (2001) and Min and Mentzer (2004) both pointed out the significance of joint management of logistics and inventory with other supply chain members, and proposed postponement of final product assembly activities and development of interlocking programs and activites as means of integrating operations with other supply chain members. Yang et al. (2004) investigated the role of postponement in the management of uncertainty. In their work, all postponement activities identified were able to be affiliated into either time-related or place-related postponement. Both sides of postponement practices were suggested as the effective ways of achieving operations flexibility, reducing uncertainty, and facilitating

process integration. The effects and significance of postponement for process integration in supply chain management were also emphasised in the work of Li et al. (2006).

Strategic coordination of operations – Strategic coordination of operations is concerned with how to make sure members in a supply chain work together to achieve the common goals, and therefore is vital to the success of a supply chain. As shown in Figure 4.4, in addition to the information and materials flows along the supply chain, three main types of activities take place in a supply chain, the "purchasing" types of activities, concerning how to operate with upstream partners, the "delivery" activities, concerning how to operate with downstream partners, and "relationship" management dealing with strategic relations and cross-chain coordination. Practices in this area are therefore grouped into three categories accordingly, "strategic sourcing management," "strategic delivery management," and "strategic relationship management."

A. Strategic relationship management

In the literature, relationship management has been increasingly regarded as a critical part of the entire supply chain management. Quite a few relationship management practices have been identified from the literature. Those practices can be generally classified into two groups from the perspective of relationships with suppliers and customers.

Involvement of key suppliers in "new product design and development processes" and "business planning and goal-setting activities" are the most frequently cited practices regarding supplier relationship management (Narasimhan and Das, 1999, Tan et al., 2002, Min and Mentzer, 2004, Chen et al., 2004, Droge et al., 2004, Li et al., 2006, Swink et al., 2007). This is not only because the ability of supply-base to help design, manufacture and

develop new parts and systems can contribute to modification and delivery flexibilities (Narasimhan and Das, 2000), but also suppliers' participation in early stage of product design can provide more cost-effective design choices, more helps in selection of best components and technologies, and assistances in design assessment (Tan et al., 2002). Narasimhan and Das (1999) demonstrated that "substantive supplier tiering," "financial and technical assistance to suppliers" and "strong supplier partnership programs" can result in reduction in input, work-in-process (WIP) and finished-product inventory levels and production time, as well as improvement in quality level. Maintaining close relationship with a limited pool of key suppliers whilst having a relatively big pool of suppliers as a big supply base for strategic collaborations and responsiveness improvement, treating key suppliers as an extension of the company, and having fewer management levels in the relationship with key suppliers were recommended by Chen et al. (2004) and Min and Mentzer (2004). Other practices suggested by researchers include "sharing a fair profit to key suppliers," "the encouragement of teamwork between the suppliers and the company," (Chen et al., 2004) "jointly solving problems with suppliers," (Li et al., 2006) and "requiring major suppliers to make contributions to cost/quality improvement." (Swink et al., 2007)

On customer relationship management side, giving the priority to customers is undoubtedly the most advocated means of customer relationship improvement (Bolden et al., 1997, Li et al., 2006). Frequent interaction with customers to set reliability, responsiveness and other standards for the firms (Chen et al., 2004), frequent determination of future customer expectations (Tan et al., 2002), and frequent measuring and evaluating customer satisfaction (Swink et al., 2007) were believed to be the effective ways of making reliable and precise prediction of customer future demand, promoting competitiveness in the market,

and acquiring customer feedback in a timely manner. After-sales service and support is an important aspect when customers are thinking about buying a product. Therefore, providing high quality of after-sales service and even facilitating customer's ability to seek assistance from the company can benefit companies in terms of improving the relationships with customers, promoting images of the company, and consolidating competitive advantages of the company (Bolden et al., 1997, Droge et al., 2004, Li et al., 2006). In addition to supplier involvement in product design, customer involvement in product design, including design and tests of new products, is encouraged for better customer requirement fit (Bolden et al., 1997, Droge et al., 2004).

B. Strategic sourcing management

Appropriate sourcing practices can provide manufacturing firms with increasing volume, design and technology flexibilities, as well as reduction of inventory cost and some other competitive advantages. This has been evidenced in the work of Tully and Martin (1994) and Chen et al. (2004).

Gottfredson et al. (2005) indicated that to realize the full potential of sourcing, companies must forget the old peripheral and tactical view and make it a core strategic function. Some researchers, including Poirier and Reiter (1996), Chandra and Kumar (2000) and Gottfredson et al. (2005), suggested that outsourcing non-core competencies/capabilities has critical impact of cost-effectiveness on business. Through auctions-based sourcing and/or splitting contract to multiple suppliers, buyers can acquire great profit (Chen et al., 2008).

In addition, utilization of appropriate measurement and reward system has been proffered as a workable management practice in sourcing process (Narasimhan and Das, 2000). The positive effects of strategic sourcing in fostering close working relationships with a limited number of suppliers, buyer-supplier communication and long-term buyer-supplier relationships were demonstrated by Chen et al. (2004). Chen et al. (2004) also suggested that sourcing should be included in the corporate strategic planning process, and sourcing function's good awareness of the corporate strategic goals should be ensured for better coordination.

C. Strategic delivery management

Delivery plays a critical role in the improvement of the supply chain performance. The performance of delivery is always a key measurement to evaluate the performance of the entire supply chain.

Undoubtedly, good delivery performance can result in reduction of product lead-time, production cost, promotion of customer satisfaction. On-time delivery is the top priority for ensuring high quality performance (Zhou and Benton, 2007). Using common logistical equipment/containers and packaging customisation can increase delivery flexibility and meet customer demand variety (Frohlich and Westbrook, 2001). Cooperating with a third-party logistic specialist to boost delivery effectiveness and improve delivery performance so that firms are able to pay more attention on developing their core competences was proposed by Chandra and Kumar (2000). Zhou and Benton (2007) proffered the utilization of automatic identification to track order status during delivery process, so that delivery reliability and dependability can be improved.

A summarised list of practices collected from the aforementioned literature is provided in Table 4.3.

Strategic design of supply chains ● Consideration of the products characteristics ● Consideration of the product life cycles ● Consideration of the nature of demand ● Integrating vertically/horizontally ● Aligning corporate strategy with supply strategy	**Careful selection of suppliers** ● Quality/price provided ● Delivery reliability (compliance with due date and quantity) ● Globally/locally ● Short lead times ● Change-response capability ● Production capacity ● Total costs ● Technological and R&D capability ● Capability of cost reduction ● Innovative power ● Flexibility of acting as a partner ● Ease of communication ● Financial status ● Reputation ● Performance history
Supply chain integration *Information integration* ● Real time update on order process ● Business knowledge sharing ● Collaborative business planning ● Keep each other informed about events/changes ● Information sharing (e.g. production/financial/design/scheduling information) ● Direct computer-to-computer network links ● Sharing the results of performance measures ● Collecting orders by electronic information systems *Process integration* ● Application of vendor managed inventory (VMI) ● Time/place postponement ● Conformance checks ● Application of computer aided acquisition and logistics support (CALS) ● Application of collaborative planning, forecasting and replenishment (CPFR)	**Strategic coordination of operations** *Strategic relationship management* ● Joint problem solving ● Including trading partners into continuous improvement programs ● Setting planning and goals with key partners ● Including suppliers & customers into product design and development ● Supplier's participation in quality/cost/lead-time improvement ● Close relationship with limited key suppliers ● Treating key suppliers as an extension of the company ● Sharing profits with key suppliers ● Joint team working ● Participation in sourcing decision of suppliers ● Audit suppliers ● Interaction with customers ● Improvement of customer trust ● Periodical measurement of customer satisfaction ● Seeking future customer expectation ● After-sales support and assistance ● Evaluating relationships with customers periodically

Table 4.3 Supply chain design and management practices as agility providers

● Risk sharing programs ● Electronic transfer ● Synchronizing logistics with product demand	*Strategic sourcing management* ● Outsourcing capabilities ● Sourcing by forward/reverse auction ● Sourcing through multiple channels ● Involving sourcing in planning process *Strategic delivery management* ● Third-party logistics management ● Fourth party logistics management ● Customised packaging ● Common logistical equipment/containers ● Application of automatic identification ● Application of advanced information systems

Table 4. 3 Supply chain design and management practices as agility providers (continued)

4.3 Summary

This chapter presented the research framework for studying how to using supply chain management practices to support the implementation of agility strategies.

The framework was developed based on the agile manufacturing strategy framework proposed in the work of Zhang and Sharifi (2007). The details of the main constructs were developed based on literature analysis. The findings accumulated from the literature were structured and articulated into the construct. The interrelationships and linkages between constructs were discussed.

Four dimensions of supply chain management were formed based on analysis of variously relevant supply chain management literature. Each dimension (including sub-dimensions) was discussed with detailed literature support. Summarized lists of agility drivers, agility

capabilities and agility providers consisting of detailed items were formulated. The lists form the basis for the development of a survey instrument to collect data for further studies.

Chapter5 Questionnaire survey

5.1 Introduction

This chapter presents the design and execution of a questionnaire survey for this study. The questionnaire survey is aimed at gathering and analysing data for studying the developed framework discussed in chapter four, investigating the research propositions, and identifying company groups with different agility strategies and the corresponding patterns of choices of supply chain design and management practices, in order to answer the raised research questions.

The development of the survey instrument, including design and validation of the questionnaire is presented. The description of selected companies is provided, and the tools and techniques used for data analysis are described.

General information derived from the preliminary analysis of the surveyed companies, including participating companies' organisational characteristics and product types, as well as various aspects of the companies' business, are discussed.

5.2 Survey design

The developed framework and the constructs were mainly derived from the literature. The theory behind the framework has been articulated in a theoretical form using well-defined concepts, models and propositions proposed in prior relevant works. However, to empirically test the theory and answer the proposed research questions, an empirical survey is necessary for discovering the desired information.

Questionnaire was used as the data collection means, due to its popularity in operations management (OM) research area, ease of administration, and convenience for respondents to answer (e.g. respondents are able to answer the questionnaires at home, during business trip, or even during holiday by using spare time).

5.2.1 Questionnaire development

The ultimate purpose of the questionnaire is to obtain the required information for studying the developed framework and investigating the propositions, by which the changes in the business environment of firms and the ways the firms respond to the changes, as well as the linkages between the constructs, can be examined. To ensure the appropriateness and applicability of the questionnaire, items constituting the questionnaire were mostly adapted from previous research works published on well-reputed OM journals cited in chapter four. The original form of items can be found in chapter four.

The questionnaire was structured by five sections in accordance with the structure of the developed framework and constructs.

Section 1 – 'Company profile and product information' consisted of questions about company's basic information; questions about the company's characteristics such as sector, size, turnover, marketshare, type of production; questions about new product introduction and success rate, R&D expenditure, business priorities; questions about suppliers and customers information; and questions about the level of familiarity of the respondents with the subject.

Section 2 – ‘Agility drivers’ contained items that were concerned with pressures from various aspects (i.e. marketplace, competition, customer requirements, etc.) that force companies to take actions to overcome them for maintaining competitiveness. Respondents were asked to indicate to what extent those pressures affected the company’s business.

Section 3 – ‘Agility strategy’ comprised nine strategic capabilities used to examine the strategies that are of importance in responding to changes. Respondents were asked to choose which of the nine capabilities and indicate to what extent they are emphasised as company’s strategy for future development.

Section 4 – ‘Agility providers’ being a big part of the questionnaire were composed of a number of practices identified from the literature with regard to supply chain design and management. Respondents were asked to rate the practices according to the view of the importance of the practices to the company. This section as the largest category of questions involved in the questionnaire was aimed at probing the practices the respondents and their business units had applied or intended to apply in the future. These questions attempted to tap the patterns of choices of supply chain management practices corresponding to different agility strategies.

Section 5 – ‘General’ was designed to ask for respondents’ comments about either the questionnaire or other information about the company. The company’s will of further involvement in the research was asked in this section as well.

A set of Likert scales were developed to measure items in section 2, section 3 and section 4. Five-point Likert scales were adopted due to its popularity in OM studies (Hensley, 1999,

Stock et al., 2000), as well as the recommendation of Lissitz and Green (1975) that increase in the number of scale points to five or above can result in increase in reliability.

The type of data obtained through Likert scale is an interval scale which can be added or subtracted (Flynn et al., 1990). Because of this, Likert scale responses are frequently added to form a summated scale (Sakakibara et al., 1993). The advantages of utilizing summated scales include permission of averaging of the relationship with other items; allowance of more exact distinctions to be made between respondents; and enhancement of the reliability of the responses (Flynn et al., 1990).

The initially composed questionnaire has been reviewed by the focus group which refers to a panel of four experts. The purpose of doing so is to gain comments about the content validity of the questionnaire, to ensure the wording used in asking the questions is proper, and to clear ambiguity in questions (Flynn et al., 1990, Forza, 2002). All the experts were from academia, but most of them have worked closely with industries. Some of them have been consultants for industrial companies for a long time. Every expert of the focus group was given a copy of the questionnaire. The questions involved in the questionnaire were asked by the facilitator (i.e. the author) one by one to check their wording and appropriateness. Every expert was allowed to express his or her opinion. Discussion was permitted, with the goal of reaching consensus.

Revisions have been made on the initial version of the questionnaire after the focus group review. Some double-barrelled questions in initial version were replaced with several separate questions. Specialists in industry were invited to pretest the revised version of the questionnaire, in order to further improve clarity and identify and resolve any unfamiliar or

unclear wording. Specialists were from three companies with which the department has established long term collaborative relationships. All the specialists are the member of the executive committee of the companies, holding the position of company director. They, therefore, were believed to be well versed with the strategy and management issues, as well as the company's condition.

Comments received from the specialists were positive. No big revision needed to be made further to the questionnaire, since they believed that the questionnaire had been comprehensive for the studied strategy and management issue. This can be demonstrated by the comments the specialists made on the questionnaire. Face-to-face communications with the specialists about the research were conducted, and tours of facilities were carried out. The feasibility of the questionnaire was proved by this specialist involvement process. The potential ambiguity was eliminated, and the appropriateness of the questionnaire was double checked. Content validity, in addition to generating items based on the high quality literature, was justified by specialist pre-test process. Also, as other scholars recommended (Flynn et al., 1994, Flynn et al., 1997), the tours of plants and face-to-face conversation conducted served to refine item representativeness, being a justification for content validity. The careful efforts made during instrument development had also endeavoured to maximize the validity of constructs.

Final version of the questionnaire was confirmed and was used to collect data in the subsequent research phase. A copy of the questionnaire is attached in appendix A.

5.2.2 Execution of the questionnaire survey

The questionnaire was sent to 510 companies in the U.K. A list of 510 companies was extracted from the 2008 R&D Scoreboard, produced by the Department for Business Innovation & Skills (BIS). The BIS database is a public accessible source of U.K. businesses. The Scoreboard provided a comprehensive ranking based on the extent of investment companies made in their R&D. The top 850 U.K. companies by R&D investment were listed in the board.

The reason why the companies for mail survey were chosen from the R&D investment scoreboard was that companies who spent more efforts on R&D were believed to be more likely to know advanced and relatively new concept and have more potential to be involved in the research.

The companies on the list covered a wide range of sectors, such as Aerospace, Automobile & Parts, Chemical, Construction Materials, Electronics & Electricals, Healthcare Equipment & Services, Technology Hardware & Equipment, etc. Excluding those sectors, such as energy, financial services, transportation, insurance, media, and so on, in which manufacturing issues were not involved much (most questions included in the questionnaire may not be applicable to those sectors), 510 companies remained and were selected for questionnaire survey. The surveyed companies can be generally divided into four sectors which are Aerospace, Auto parts, Electronics and Electricals, and Others.

An explanatory text was provided with the questionnaire together to companies. The text offered the definitions and the explanation of concepts and terminologies that appeared in

the questionnaire. The final ready-to-post package included a questionnaire with the explanatory text, an introduction letter about the survey, and a postage-paid return envelope.

As the research aimed to investigate issues at the strategic level, senior management officers such as chief executive officer, managing director or other members of executive committee of companies were targeted as the respondents. This is due to the common belief that these people are knowledgeable about the company strategies, the overall operational circumstances and other general strategic and managerial issues (Phillips, 1981, Flynn et al., 1990, Miller and Roth, 1994, Forza, 2002, Zhang and Sharifi, 2007).

Considering time and finance availability for this research, the questionnaire was addressed to a single informant. As suggested by literature (Miller and Roth, 1994), the problem of involving single informant in questionnaire survey is that strong assessment of convergent or discriminate validity may not be made. However, the cost associated with gaining participation and consensus from several individuals from large numbers of organisations is very high. In this case, the use of high ranking management officers was considered as the means to offset the problem (Phillips, 1981).

Since the length of the questionnaire is relatively long, to encourage participation, providing research results as a reward to participation has been indicated in the introduction letter. It has been promised that the information about the participating companies will be kept strictly confidential.

A modified version of Dillman's (1978) total design method was followed to increase the response rate. The first set of survey questionnaire was mailed out to the sampled

companies by first-class mail. One month were given to respondents to complete the questionnaire. One month after the initial mailing, the second set of survey questionnaire was sent to those who did not respond to the first set of mailings. Almost same contents were enclosed in the second set of mailing (including a questionnaire along with an explanatory text, an introduction letter, and a postage-paid envelope). Small revisions were made to the introduction letter. Another month was given to the respondents for completing the questionnaires.

Out of 510 posted companies, 9 were delivered unsuccessfully because of location change and closing down. 53 refused to participate into the survey within which 34 were due to policy restriction and 19 were due to relocation of manufacturing facilities. A total of 43 responses were received. This has resulted in a response rate of 8.4% (43/510). The response rate is not high but not atypical for industrial research. Other similar works published on well-reputed journals yielded response rate as low as 6.3% (Dwyer and Welsh, 1985), 6.7% (Tan et al., 2002), 7.5% (Nahm et al., 2003a, Nahm et al., 2003b), and 7.9% (Inman et al., 2010).

Some possible reasons have been found to explain this relatively low response rate.

Firstly, this research has been carried out in an economic depression period. It has been believed that financial crisis has big impact on gaining higher response rate. This is because in such special period companies have focused on dealing with more direct business-related issues for getting over the tough time. Thus, much less support can be given to academic research.

Senior management officers are the prime source for strategy and supply chain management related data, and targeted respondents for the research are CEOs or directors within executive committee of companies. However, these senior management officers are often under severe time pressure. Resource constraints make it difficult to achieve high response rate (Inman et al., 2010).

On the other hand, companies have become more sensitive in responding to strategy-related survey in this special time. Out of 53 notifications of refusing to participate, as many as 34 companies were due to policy reasons. This implied that financial crisis increased the difficulties of acquirement of desired information and data.

Given the reasons explained above and the fact that agility as a manufacturing strategy has been still relatively new to the majority of the companies (indicated by the level of familiarity of agility strategy collected from the survey, see later section), as well as the large amount of questions involved in the questionnaire, the number of returns was considered acceptable and may be satisfactory for the purposes of this research.

In order to establish how well the respondents represents the sample nonresponse bias was examined. A common approach to assessment of nonresponse bias is to check the differences of survey variables between the first set of respondents and the later returns (Lambert and Harrington, 1990, Zhao et al., 2006, Inman et al., 2010). Following this common approach, comparisons of the means of the number of employees and the turnovers of respondents were conducted using ANOVA test. The comparisons resulted in statistically non-significant differences at the 0.01 level for the number of employees

(p=0.403) and the turnovers (p=0.314). Thus, nonresponse bias has not negatively impacted the data set.

5.2.3 Data analysis tools and methods

By taking into account the requirements needed for data analysis, the number of responses from the survey and the availability of the data processing software in the university, it was decided to use SPSS (for WINDOWS) as the processing tool for data analysis. SPSS has been known for its easy data entry, strong data handling capability, various statistical test functions, and popularity in academic circles (Black and Porter, 1996, Breu et al., 2001, Frohlich and Dixon, 2001, Cousins et al., 2006, Hult and Chabowski, 2008).

Three basic types of measurement are associated with variables, which are nominal, ordinal and scale. Scale includes two sub-types of measurement referring to interval scale and ratio scale (Pallant, 2007). Most questions involved in the survey questionnaire were in nature covered by two types of measures – nominal and interval scale. Only a few questions were associated with ordinal measure.

There are generally two different types of statistical techniques: parametric and non-parametric. The parametric tests make some assumptions about the population from which the sample has been drawn. For example, a normal distribution is required for the population if the parametric tests are going to be used. On the other hand, non-parametric techniques do not have such stringent requirements. There is no requirement about the underlying population distribution (Pallant, 2007).

Although parametric statistical techniques may be used in the data analysis for this research, the primary statistical techniques utilized are non-parametric, including Chi-square test, t-test, analysis of variables (ANOVA), and so forth. Details about the statistical techniques used in the research are provided in the following sections and subsequent chapter for data analysis.

5.3 Reliability assessment of the instrument

"Reliability measures the extent to which a questionnaire, summated scale or item which is repeatedly administered to the same people will yield the same results." (Flynn et al., 1990) It measures the ability to replicate the study and indicates the dependability, stability, predictability, consistency and accuracy of the developed instrument (Forza, 2002).

There are various means of assessing reliability. The most common methods used to estimate reliability are: test-retest method; alternative forms methods (also referred to as parallel forms method); and internal consistency method (either split-half or Cronbach's alpha) (Flynn et al., 1990, Sakakibara et al., 1993, O'Leary-Kelly and Vokurka, 1998, Forza, 2002). The test-retest method calculates the correlation between responses obtained through the same measure administered to the same respondents at two different points in time. It is one of the traditional measures, estimating the ability of the measure to maintain stability over time. Quite similar to the test-retest method, the alternative forms method calculates the correlation between responses obtained through different measures administered to the same respondents at two different points in time. For practical reasons, these measures have not been used because of time requirements and difficulty of finding subjects who were willing to be involved in a longitudinal study.

Cronbach's alpha (Cronbach, 1951), the other traditional measure of reliability (Churchill, 1979, Hensley, 1999), is the most popular and widely accepted measure for internal consistency (Flynn et al., 1990). As the most used reliability indicator in OM survey research (Forza, 2002), Cronbach's alpha refers to the average of the correlation coefficient of each item with each other item (Nunnally, 1978). It incorporates every possible split of the scale in its calculation rather than one arbitrary split (Flynn et al., 1990). Given the general considerations mentioned above, Cronbach's alpha was adopted as the means of assessing reliability.

Coefficient alpha was calculated for each major construct. Table 5.1 lists the values of alpha calculated for each of the constructs. As suggested by literature (Flynn et al., 1990), the generally accepted alpha value is 0.70. However, many studies in OM area regarded 0.60 as the threshold (Flynn et al., 1994, Black and Porter, 1996). This can be attributed to the recommendation of Nunnally (1978) that a lower threshold (0.60) is acceptable for work involving the use of newly developed measures.

AGILITY DRIVERS, α = 0.839 (0.848)

Change in Marketplace, α = 0.451 (0.486)
- Growth of niche market
- Open of new local of foreign markets/close of some others
- Increasing rate of change in product models
- Product lifetime shrinkage
- Decreasing cost of entering niche market

Change in competition basis, α = 0.756 (0.760)
- Rapidly changing markets
- Increasing pressures on cost/profitability
- Innovation rate increasing
- Increasing pressure of global market competition
- Decreasing new product time-to-market
- Responsiveness of competitors to changes in marketplace
- Effectiveness of competitors' strategy, marketing, distribution, services, etc.

Change in customers requirements, α = 0.720 (0.715)
- Individualised products and services
- Quicker delivery time and time-to-market
- Quality expectation increasing
- Increasing value of information/services

Social changes, α = 0.806 (0.817)
- Environmental pressures (e.g. climate change)
- Workforce/workplace expectations
- Legal/political pressures
- Cultural pressures
- Social contract change

Internal drivers, α = 0.819 (0.822)
- Strategy of continuous improvement
- Moving towards excellence

AGILITY CAPABILITIES, α = 0.642 (0.658)

Flexibility – the capability to perform different tasks and achieve different objective with the same set of resources/facilities.

Quickness in product development – the capability to innovate at high speed in products and service delivery.

Quickness in product/service delivery – the capability to operate at high speed in products and service delivery.

Responsiveness to changes – the capability to identify, respond to and recover from changes.

Competency – the capability to operate efficiently, produce high-quality and high-performance products, deliver on time, innovate, and manage core competency.

Focusing on customer – the capability to have a strong customer focus.

Partnership – the capability to act proactively instead of reactively (in attacking threats and opportunities).

Transparency – the capability to form a transparent, smooth and efficient information stream across supply chain and to acquire prompt information from marketplace and other members involved in the supply chain.

SCM PRACTICES AS AGILITY PROVIDERS, α = 0.944 (0.944)

Strategic design of supply chains, α = 0.707 (0.727)
- Consideration of the products characteristics
- Consideration of the product life cycles
- Consideration of the nature of demand
- Integrating vertically/horizontally
- Aligning corporate strategy with supply strategy

Careful selection of suppliers, α = 0.695 (0.708)
- Quality/price provided
- Delivery reliability (compliance with due date and quantity)
- Globally/locally
- Change-response capability
- Production capacity
- Total costs
- Technological and R&D capability
- Capability of cost reduction
- Innovative power
- Flexibility of acting as a partner
- Ease of communication
- Financial status
- Reputation
- Performance history

Supply chain integration, α = 0.915 (0.918)

Information integration, α = 0.900 (0.904)
- Real time update on order process
- Business knowledge sharing
- Collaborative business planning
- Keep each other informed about events/changes
- Information sharing (e.g. production, financial, design, scheduling information)
- Direct computer-to-computer network links
- Sharing the results of performance measures
- Collecting orders by electronic information systems

Process integration, α = 0.821 (0.823)
- Application of vendor managed inventory (VMI)
- Time/place postponement
- Conformance check
- Application of computer aided acquisition and logistics support (CALS)
- Application of collaborative planning, forecasting and replenishment (CPFR)
- Risk sharing programs
- Electronic transfer
- Synchronizing logistics with product demand

Strategic coordination of operations, α = 0.913 (0.917)

Strategic relationship management, α = 0.910 (0.913)
- Joint problem solving
- Including trading partners into continuous improvement program
- Setting planning and goals with key partners
- Including suppliers & customers into product design and development
- Supplier's participation in quality, cost, lead-time improvement
- Close relationship with limited key suppliers
- Treating key suppliers as an extension of the company
- Sharing profits with key suppliers
- Joint team working
- Participation in sourcing decision of suppliers
- Audit suppliers
- Interaction with customers

Table 5.1 Internal reliability of constructs

	Improvement of customer trust Periodical measurement of customer satisfaction Seeking future customer expectation After-sales support and assistance Evaluating relationships with customers periodically Strategic sourcing management, α = 0.622 (0.638) Outsourcing capabilities Sourcing by forward/reverse auction Sourcing through multiple channels Involving sourcing in planning process Strategic delivery management, α = 0.666 (0.669) Third party logistics management Fourth party logistics management Customised packaging Common logistical equipment/containers Application of automatic identification Application of advanced information systems

Table 5. 1 Internal reliability of constructs (continued)

For the construct of agility drivers, the alpha value for the whole set reached 0.839, with 0.451, 0.756, 0.720, 0.806, and 0.819 for the respective subsets. Although the value for the subset of "change in marketplace" (0.451) was lower than the common threshold (0.6/0.7), it could be argued that this was acceptable, since that all the rest subsets were well above 0.70 and the total set had a very high alpha value. The measure is very reliable with alpha value above 0.80 (Nunnally, 1978, Forza, 2002).

The calculated Cronbach's alpha values for the constructs of agility capabilities and agility providers were all above 0.60 (0.642 for the construct of agility capabilities; 0.944 for the whole set of agility providers). Most of subsets of agility providers had alpha value above 0.70, but "Careful selection of suppliers" (0.695), "Strategic sourcing management" (0.622), and "Strategic delivery management" (0.666). Among these three, "Careful selection of suppliers" was just a little bit lower than 0.70. The latter two were subsets of "Strategic coordination of operations", sub-subsets of agility providers. The subset of "Strategic coordination of operations" was given a high alpha value of 0.913. The results of Cronbach's alpha test have proved the reliability of the instrument.

5.4 The characteristics of samples

This section describes the information collected by the first section of the questionnaire. The preliminary analysis results about the sampled companies are reported.

5.4.1 Sample description

Of 43 responses, three were excluded due to substantial incompleteness. 40 were valid and were used to perform data analysis.

Table 5.2 shows the profile of the respondents. Out of the 40 valid returns, 4 (10%) respondents held the title of Chairman/President, 6 (15%) Strategy/Managing Directors, 17 (42.5%) Operations/Supply chain/Logistics Directors, 2 (5%) HR/Communication Directors, and 11 (27.5%) Managers (Site/General/Business development/Technical).

Respondent titles	NO. of the respondents	Percentage
Chairman/President	4	10.0
Strategy/Managing Director	6	15.0
Operations/Logistics/Supply chain Director	17	42.5
HR/Communication Director	2	5.0
Site/General/Business development/Technical Manager	11	27.5

Table 5. 2 Respondent Profile

5.4.1.1 Studied sectors

The companies involved in the research ranged from Aerospace and Automobile & Parts, through Electronic and Electrical Equipments, to Chemical, Healthcare Equipment &

Service, and Construction, etc. For the convenience purpose and according to the number of companies in each sector, apart from companies belonging to Aerospace, Auto Parts and Electronics and Electrical, all the rest companies were classified into a big category, named "Others," in which all other sectors were included.

Table 5.3 shows the distribution of the surveyed companies among different sectors. The companies belonging to the three major sectors account for 52.5% of the entire sample, while the other 47.5% are occupied by the rest companies. Although the "Other" sector has taken the large portion of the total sample, it consists of various sectors. There are only one or two companies in each of those sectors. Thus, in terms of the number of companies in different sectors, electronic and electrical companies take 1st place. Auto parts and aerospace companies are on 2nd and 3rd places, respectively.

Sectors	Percentage	Cumulative percentage
Aerospace	10.0	10.0
Auto Parts	20.0	30.0
Electronics & Electrical	22.5	52.5
Others	47.5	100.0

Table 5. 3 Distribution of the companies among sectors

5.4.1.2 Size of companies

Two measures were used to classify the size of the surveyed companies. These were number of employees and annual turnover. 'Companies House' (http://ukdata.com/help/credit-reports-documents/accounts-filing-requirements) defines a small sized company as one with no more than 50 employees and an annual turnover of less than £6.5 millions. It defines medium sized companies as having less than 250 employees

and a turnover of less than £25.9 millions. Large companies are defined as having more than 250 employees and a turnover of more than £25.9 millions.

Table 5.4 and table 5.5 show that a majority of the companies involved in the research are large sized companies. Only a small part of the total sample is taken by small sized companies. Among the companies, the minimum number of employees in the company is 21, while the maximum number reaches 40,000. The turnovers of the companies range from £2m per year to £9000m per year. This indicates that the sample has a wide structure range, covering companies from different sectors with different sizes. This combination of companies has been thought to be positive for the research generalisability.

NO. of employees	NO. of companies	Percentage	Cumulative percentage
< =50	2	5.0	5.0
51-250	13	32.5	37.5
>250	25	62.5	100.0

Table 5. 4 Size of companies – Employee number

Annual turnover, £m	NO. of companies	Percentage	Cumulative percentage
<=5.6	3	7.5	7.5
5.7-22.8	7	17.5	25.0
>22.8	30	75.0	100.0

Table 5. 5 Size of companies – Annual turnover in the pass three years

5.4.1.3 Product information

The information, such as the number of finished products, the number of new products introduced in last three years and how successful they were, the portion of exports in the total sales of products, the lead times of products development, and the extent of

innovativeness of new products, was extracted and summarized into several tables shown as follows, in order to provide an overview of product-related information of the companies.

Number of finished products

Table 5.6 shows the ranges of the number of finished products companies provided and the percentage of companies belonging to the ranges. From the table, we can see although a majority of the companies produce no more than 100 types of products (51%), the biggest part of percentage among the five ranges was taken by the companies who produce more than 200 types of products (37.8%). They may be explained by that a large number of objects within the sample are large sized companies. Normally, the bigger the company is the more variety of products it provides.

Number of finished product types	Valid percentage of companies	Cumulative percentage of companies
<=10	16.2	16.2
11-50	27.0	43.2
51-100	8.1	51.4
101-200	10.8	62.2
>200	37.8	100.0

Table 5. 6 Number of finished products types

The results, however, could have been biased. The perceptions of companies about the finished product types may vary, although in this research it refers to all finished products with different product codes (i.e. including products that belong to the same series but with different code number, such as Airbus A320 Family including 4 types of finished products of A318, A319, A320 and A321).

Number of new products

It has been considered that the speed of new product development (NPD) is one of important advantages for companies to outperform competitors in the market. Respondents were asked to report the number of new products their companies introduced to marketplace in the last three years. Table 5.7 shows that most of the companies have introduced no more than 100 new products to the market (88.6%), while about a half of this portion has introduced just no more than 10 new products (42.9%). This indicates a relatively low speed of NPD.

Number of new products	Valid percentage of companies	Cumulative percentage of companies
<=10	42.9	42.9
11-50	31.4	74.3
51-100	14.3	88.6
101-200	2.9	91.4
>200	8.6	100.0

Table 5. 7 Number of new products introduced in the last three years

Nevertheless, the speed of NPD may depend on the nature of products. More often than not, the more sophisticated the product is, the longer period it requires for development. For example, the aviation industries normally require much more time than the textile industries to launch a new product, since a lot of pre-tests are needed for aircraft production to ensure the proper working of the complex structures and systems.

On the other hand, the extent to which a product is manufactured with new elements has impacts on the speed of NPD. A completely innovated product normally takes longer than an improved product to be developed, and in turn to be introduced to the marketplace later.

Table 5.7 also shows that some companies have introduced more than 100 new products in the past three years: 2.9% less than 200; and 8.6% more than 200.

In order to examine the structure of newness of introduced products, the respondents were asked about to what percentage the introduced products were completely innovative, manufactured by new lines, improved products, and/or custom made.

Table 5.8 shows the summarized results. The results show the dominance of improved products and custom made products in the total introduced new products, while the lowest rate is given to complete innovation.

Products newness	Mean (%)	Std. Deviation
Complete innovation	25.13	23.521
New lines	28.90	23.188
Improved products	47.79	26.934
Custom made	40.00	36.218

Table 5. 8 Newness of products introduced by companies

Success rate of new products

The success rate of introduced new products was also investigated. An average of 60% was considered as the acceptable rate of success of new products, and over 80% was considered as great success. Table 5.9 has summarized the companies' conditions with respect to success in new product introduction. Most of the investigated companies (94%) were successful in new product introduction. Furthermore, a great majority of the companies (66.7%) have achieved remarkably over 80% success rate. This, to some extent, indicates support for the good overall performance of the sampled companies.

Percentage of new products success	Valid Percent of companies	Cumulative Percent of companies
<60	6.1	6.1
60-79	27.3	33.3
>80	66.7	100.0

Table 5. 9 Success of new products introduced in the last three years

Ratio of export products

The ratio of export of products was examined, in order to identify to what extent the surveyed companies confront the global competition and challenges. From Table 5.10, we can see a half of the entire sampled companies export more than 50% of their products. 55.9 percent of the companies sell over 30% of their products to overseas markets. This is an indicator of the dramatically increased globalization since the turn of the century.

Percentage of export products	Valid percentage of companies	Cumulative percentage of companies
<=10	20.6	20.6
11-30	23.5	44.1
31-50	5.9	50.0
51-80	23.5	73.5
>81	26.5	100.0

Table 5. 10 Ratio of export of products

Lead time of major products development

The general lead time of major products development for the surveyed companies was moderately short (less than 6 months). Just more than a half of the companies (52.9%) had lead time as short as 6 months (see Table 5.11). Companies with more than 1 year lead time occupied 35.2% of the total companies within which companies with lead time between 1 to 2 years were dominant (23.5%).

Lead time of major products	Valid percentage of companies	Cumulative percentage of companies
<1 month	14.7	14.7
1-6 months	38.2	52.9
7-12 months	11.8	64.7
1-2 years	23.5	88.2
2-3 years	8.8	97.1
>3 years	2.9	100.0

Table 5. 11 Lead time of major products

5.4.1.4 Production mode

Three primary production modes have been identified from the survey, which are manufacture to order (MTO), manufacture to stock (MTS) and assemble to order (ATO). The degree of interaction between the company's production function and the customers of the company is going stronger when moving from an MTS to an MTO situation. The degree of interaction of ATO is in between of MTS and MTO (Wemmerlov, 1984).

Production mode	Valid percentage of companies	Cumulative percentage of companies
Manufacture to order	55.6	55.6
Manufacture to stock	22.2	77.8
Assemble to order	11.1	88.9
Manufacture to order + Manufacture to stock	11.1	100.0

Table 5. 12 Production mode of surveyed companies

Table 5.12 indicates that 55.6 percent of the investigated companies have adopted manufacture to order as their production mode. This implies that a majority of the companies design and produce their products under close collaboration with their customers, at high level of customisation. This identification supports the evolving trend of the dominant production mode from mass production to mass customisation.

However, the results also show that manufacture to stock is still predominant in some companies. This is not surprising, since in those companies standard parts, components, or subassemblies are their major products. Having strong capability of replenishment for their customers is the top priority to them.

11.1% of the total sampled companies have adopted ATO production mode. Through inspecting the questionnaires from these companies, it has been found that postponement of the assembly point to as close to customer orders as it can is the production theory of these companies. Subassemblies are manufactured according to forecasts, while final assembly are not executed until detailed product specifications have been obtained from customer orders.

Wemmerlov (1984) thought that “most companies originate as either MTS or MTO firms and later, if ever, graduate into the ATO stage.” This is because ATO is a kind of hybrid production mode of MTS and MTO from the author’s point of view. A MTS firm, pressured by market considerations, may have gradually broadened its product lines, and in turn becoming an ATO firm. Alternatively, a company, initially as a MTO firm, may transform into ATO mode due to an expanding volume and a strong similarity between some of its products (Wemmerlov, 1984).

Apart from the three main production modes, a combination production mode of MTO and MTS has been also used by some companies which take 11.1 percent of the sample. This is not uncommon that a company apply more than one production modes producing some products to stock and others to order (Wemmerlov, 1984).

5.4.1.5 Investment in Research and Development (R&D)

Research and development has always been considered as an important indicator of improvement in industry. Although the surveyed companies were selected according to scoreboard by R&D investment (the amount of money invested in R&D), to what percentage R&D investment occupy the annual turnover of companies was asked in the questionnaire in order to further examine the R&D situations of the companies.

Based on the results shown in Table 5.13, 65% of companies spend over three percent of their turnover on R&D while 32.5% of companies spend more than 6% of annual turnover on R&D. In comparison with the survey conducted in 1999 (Sharifi, 1999), this shows a big increase in R&D investment of companies. Previous survey reported that about 60% of companies spent over three percent and 26.4% spent more than six percent of their turnover on R&D.

Percentage of annual turnover invested in R&D	Valid percentage of companies	Cumulative percentage of companies
<1%	27.5	27.5
1-3%	17.5	45.0
3-6%	22.5	67.5
6-10%	10.0	77.5
>10%	22.5	100.0

Table 5. 13 Percentage of annual turnover invested in R&D

The result of the increase in R&D investment may be relevant to the position of the surveyed companies in marketplace.

5.4.1.6 Position in marketplace

Market position, 1=Leader, 5=Unsuccessful	Number of companies	Valid percentage of companies	Cumulative percentage of companies
1	18	45.0	45.0
2	18	45.0	90.0
3	3	7.5	97.5
4	1	2.5	100.0

Table 5. 14 Market positions of surveyed companies

In the sample of this research, 90 percent of companies have very high positions in the marketplace. 45% are market leaders, while 45% are at the position of just lower than leaders. Only one company reported its position was lower than the average level of success. By looking at more details about this company, it was found that this company was a subsidiary of a big international company. Its market was mainly located at Asia and North America, rather than Europe. Although the company has established a site in UK, the market share in UK is quite limited. This may be the reason why the company has reported a low market position. The distribution of companies regarding their market position is shown in Table 5.14.

5.4.1.7 Familiarity with agility as strategy

The responds were questioned to what extent they were familiar with agility strategies.

Familiarity with agility strategies 1=Not heard of it 5=Completely familiar	Number of companies	Valid percentage of companies	Cumulative percentage of companies
1	13	32.5	32.5
2	5	12.5	45.0
3	10	25.0	70.0
4	9	22.5	92.5
5	3	7.5	100.0

Table 5. 15 Companies' familiarities with agility strategies

The results (summarized in Table 5.15) shows that quite a few respondents (32.5%) have not heard of it before. However, 55% of respondents rated their familiarity of agility strategies at moderate level (3) and higher. Although the overall statistic results is positive (the majority of respondents are familiar with agility strategies at certain level), a number of companies still do not know about agility strategies much. This reflects that although the agility concept has been developed for several years, as strategies, it is still relatively new to companies. More efforts should be made to develop agility strategies in practical field, rather than just in academic area.

5.5 Summary

This chapter mainly reported three points about the questionnaire survey for the research. First of all, the process of the survey design, including how the survey instrument has been developed, how the questionnaire survey has been carried out and what tools and methods have been used to analyse the collected data, has been described. The reliability of the survey instrument was assessed and reported subsequently. A reliable instrument has been proved by the calculated high Cronbach's alpha coefficient. Thirdly, the characteristics of sample, such as sample profile, products information of the surveyed companies, production modes of the companies and so on, have been provided.

In summary:

1. A postal questionnaire has been developed with five sections to collect desired information and data from companies, in order to study research propositions, verify the validity of the research framework, and identify the taxonomy of agility strategies and the corresponding patterns of the choices of supply chain management practices.

2. Questionnaires were posted to 510 UK companies selected from the top 850 UK companies by R&D investment on 2008 R&D Scoreboard. A response rate of 8.4% was received of which 40 responses were valid.
3. SPSS for Windows has been used to analyse the collected data, due to its popularity in OM research area and availability in the University.
4. Various aspects of the surveyed sample were examined. The sample covered a wide range of small, medium and large sized companies, and 90 percent of the sample has very high position in the marketplace. Although 55% of the respondents rated their familiarity with agility strategies at moderate or higher level reflecting their knowledge about agility to a certain extent, however, agility as strategies is still relatively new to quite a few companies.

More indepth data analysis is carried out and reported in the following chapter.

Chapter6 Cluster and discriminant analysis

6.1 Introduction

This chapter provides a description of the cluster analysis and canonical discriminant analysis that have been carried out to identify existing agility strategy types in today's marketplace. The nine capabilities, defined in Chapter 4, are used as taxons to classify respondent companies. The respondents were formed into groups depending on the emphases they placed on the nine agility capabilities.

Canonical discriminant analysis was conducted in order to explore underlying dimensions which separate strategic groups from each other. A comparison will be drawn between the resulting types of agility strategies in this study and that discovered in Zhang and Sharifi's taxonomy work in which the validity of previous taxonomy in today's market conditions is examined.

6.2 Identifying agility strategy types

6.2.1 Cluster analysis

Cluster analysis was employed to develop the taxonomy and identify agility strategy types from respondents' capabilities profiles. The 9 agility capabilities (identified in Chapter 4) were used as taxons. There are two basic types of clustering algorithms that are commonly used in cluster analysis: hierarchical and non-hierarchical. Hierarchical algorithms through a series of steps build a tree-like structure by either adding individual elements to or deleting them from clusters. Non-hierarchical algorithms partition a data set into a

prespecified number of clusters (Ketchen and Shook, 1996). Solely using either one of them can be problematic. On one hand, with hierarchical algorithms, it is difficult for researchers to select the 'correct' algorithm since they often do not know the underlying structure of a sample in advance. Additionally, all hierarchical algorithms make only one pass through a data set, thus poor cluster assignments cannot be modified. Finally, solutions are volatile when cases are dropped, especially when sample size is small (Ketchen and Shook, 1996). This is troublesome for strategy research where sample sizes are often small (Dess and Davis, 1984, Lewis and Thomas, 1990). Therefore, the validity of a solution obtained by using only hierarchical methods is questionable.

On the other hand, although non-hierarchical methods are less impacted by outlier cases as they allow observations to be conducted to switch cluster membership and they make multiple passes through the data set optimizing within-cluster homogeneity and between-cluster heterogeneity, obtaining this improvement requires the predetermination of the number of clusters. This is problematic in the strategic management research field in which cluster analyses are often exploratory.

Miller and Roth (1994) and Kathuria (2000) explain that the greatest challenge in cluster analysis is the determination of the most appropriate number of clusters. The most influential taxonomy work of Miller and Roth (1994) relied on only a non-hierarchical algorithm (also know as the K-Means method) for their cluster analysis. However, due to the aforementioned shortcomings of using single type of clustering methods, recently, experts have strongly advocated the use of a two-stage clustering procedure (Ketchen and Shook, 1996): firstly a hierarchical method helps determine the number of clusters; and

then the non-hierarchical method performs the actual clustering (Frohlich and Dixon, 2001, Zhao et al., 2006, Zhang and Sharifi, 2007).

This study followed the two-stage approach. At the first stage, hierarchical clustering was carried out to generate a hierarchical dendogram (see Figure 6.1) and an agglomeration schedule table (see Table 6.1). Ward's partitioning and squared Euclidean distance were used for the hierarchical cluster analysis. This was due to the established robustness and ability of Ward's method to maximize within-cluster homogeneity and between-cluster heterogeneity (Aldenderfer and Blashfield, 1984). The squared Euclidean distance measure is recommended for use with Ward's method together because it leads to clusters with the smallest sum of squares error (Arabie and Huber, 1994).

The dendogram was visually inspected for relatively dense branches to confirm the number of major groups formed (Aldenderfer and Blashfield, 1984). The incremental changes in the agglomeration coefficient, shown in the generated agglomeration schedule table, were observed as an indication of whether dissimilar clusters had been merged (Ketchen and Shook, 1996, Frohlich and Dixon, 2001). During cluster combination stages, hierarchical cluster analysis builds a decision tree by adding individual elements one at a time. Relatively large changes in the agglomeration coefficient signify important increases in cluster homogeneity implying that dissimilar clusters have been merged together at that step. Thus, the most appropriate number of clusters should be just before the merger (Ketchen and Shook, 1996). By examining the dendogram and the agglomeration schedule table, a five cluster model appeared to be the most appropriate (stop combing around 10 of rescaled distance).

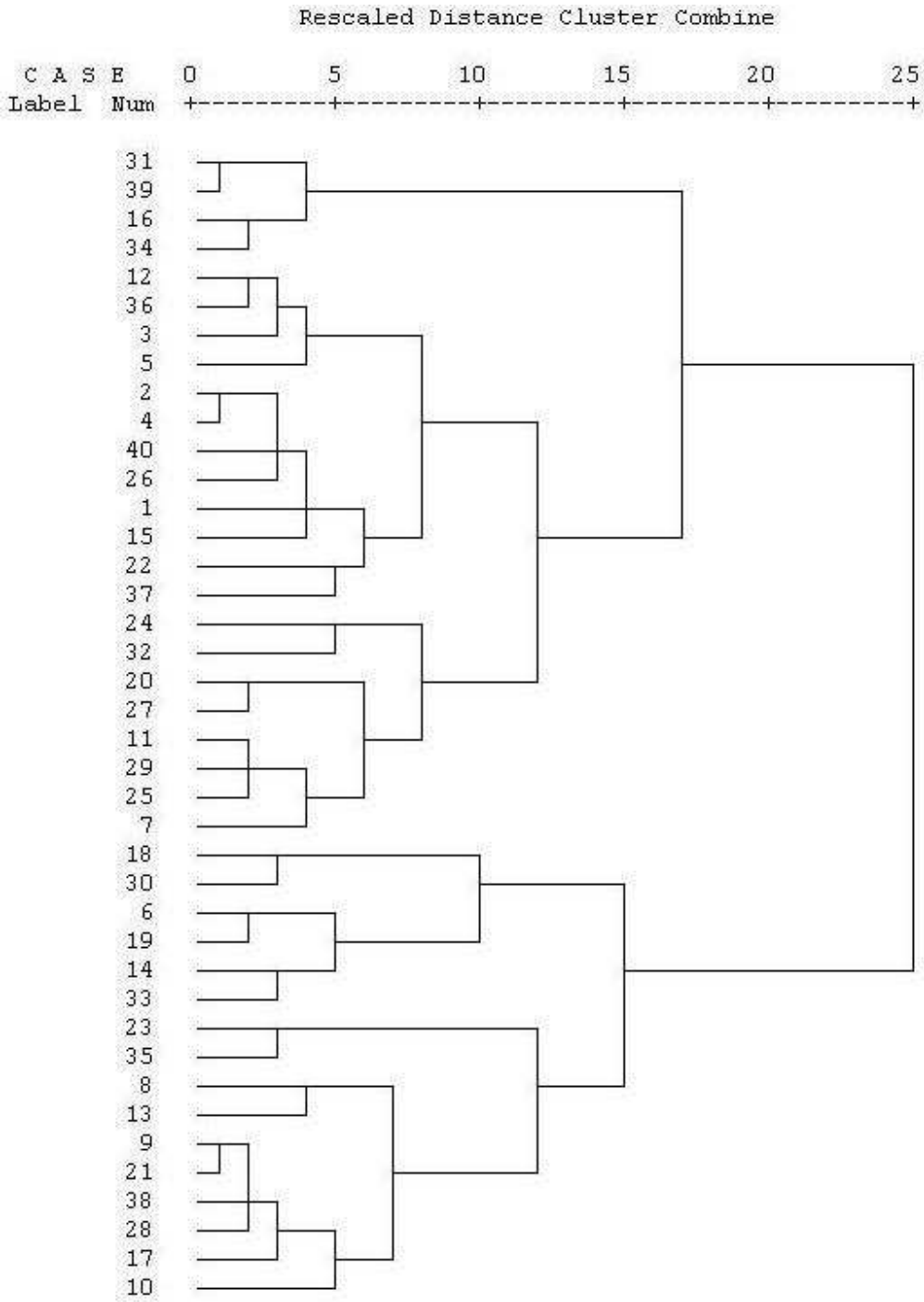

Figure 6. 1 Dendogram

Table 6. 1 Agglomeration schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	31	39	.500	0	0	20
2	9	21	1.000	0	0	6
3	2	4	1.500	0	0	12
4	12	36	2.366	0	0	18
5	11	29	3.232	0	0	8
6	9	38	4.114	2	0	7
7	9	28	5.055	6	0	13
8	11	25	6.011	5	0	24
9	16	34	7.011	0	0	20
10	20	27	8.011	0	0	30
11	6	19	9.011	0	0	28
12	2	40	10.088	3	0	14
13	9	17	11.170	7	0	27
14	2	26	12.267	12	0	21
15	14	33	13.385	0	0	28
16	18	30	14.503	0	0	34
17	23	35	15.728	0	0	35
18	3	12	16.960	0	4	23
19	8	13	18.283	0	0	31
20	16	31	19.623	9	1	38
21	1	2	21.030	0	14	22
22	1	15	22.452	21	0	29
23	3	5	24.003	18	0	32
24	7	11	25.571	0	8	30
25	22	37	27.230	0	0	29
26	24	32	28.888	0	0	33
27	9	10	30.546	13	0	31
28	6	14	32.386	11	15	34
29	1	22	34.389	22	25	32
30	7	20	36.472	24	10	33
31	8	9	38.753	19	27	35
32	1	3	41.173	29	23	36
33	7	24	43.832	30	26	36
34	6	18	46.782	28	16	37
35	8	23	50.401	31	17	37
36	1	7	54.117	32	33	38
37	6	8	58.620	34	35	39
38	1	16	63.678	36	20	39
39	1	6	70.949	38	37	0

At the second stage, K-means (i.e. non-hierarchical clustering) was conducted to perform the actual clustering. Given the suggestion from the inspection of the dendogram of the hierarchical cluster analysis, five clusters were generated.

ANOVA and pairwise comparison tests of mean differences (Harrigan, 1985) were used to examine cross-cluster heterogeneity of the resulting 5-cluster solution on the defining 9 capabilities, in order to seek managerial interpretability of the clusters. An overall multivariate test was conducted (see Table 6.2). The significance using Wilk's Lambda criterion and the associated F statistics indicated that the null hypothesis that the five clusters are equal across all defining variables could be rejected ($p < 0.000$).

Table 6. 2 Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.995	5.668E2	9.000	27.000	.000
	Wilks' Lambda	.005	5.668E2	9.000	27.000	.000
	Hotelling's Trace	188.950	5.668E2	9.000	27.000	.000
	Roy's Largest Root	188.950	5.668E2	9.000	27.000	.000
Clusters	Pillai's Trace	2.430	5.159	36.000	120.000	.000
	Wilks' Lambda	.011	6.590	36.000	102.919	.000
	Hotelling's Trace	10.938	7.748	36.000	102.000	.000
	Roy's Largest Root	6.300	20.999[b]	9.000	30.000	.000

a. Exact statistic
b. The statistic is an upper bound on F that yields a lower bound on the significance level.
c. Design: Intercept + Clusters

The five resultant clusters are described in Table 6.3 in terms of their respective group centroid (mean) scores and relative ranking in the set of nine agility capability variables. The probability that one or more of the cluster means differed from another is also depicted for each capability. The F values indicate that the clusters differed from each other on seven of the nine capability variables at the 0.05 level of significance or less.

Table 6. 3 Agility capabilities by group – 5 clusters

Agility capabilities	Responsive Players Group 1 (n=9)	Quick Operators Group 2 (n=5)	Quick Innovators Group 3 (n=3)	Proactive Players 1 Group 4 (n=9)	Proactive Players 2 Group 5 (n=14)	F Values Significance
Proactiveness						
Mean*	4.33	2.60	**5.00**	4.78	3.57	15.667
Std. Error**	0.167	0.400	0.000	0.147	0.173	0.000
Rank***	1 (2)	8 (1, 3, 4)	1 (2, 5)	2 (2, 5)	7 (3, 4)	
Responsiveness						
Mean	4.00	2.80	**5.00**	4.00	4.00	6.819
Std. Error	0.236	0.200	0.000	0.289	0.105	0.000
Rank	3 (2)	6 (1, 3, 4, 5)	1 (2)	6 (2)	4 (2)	
Flexibility						
Mean	3.22	3.60	2.33	3.44	**4.07**	5.600
Std. Error	0.222	0.245	0.333	0.294	0.127	0.001
Rank	7 (3)	4 (3)	7 (1, 2, 4, 5)	9 (3)	3 (3)	
Quick Innovation						
Mean	2.67	2.00	4.33	**4.44**	3.50	28.382
Std. Error	0.167	0.000	0.333	0.176	0.139	0.000
Rank	9 (3, 4, 5)	9 (3, 4, 5)	3 (1, 2, 5)	4 (1, 2, 5)	8 (1, 2, 3, 4)	
Quick Operations						
Mean	3.00	4.40	3.00	**4.56**	4.14	9.040
Std. Error	0.289	0.245	0.577	0.176	0.143	0.000
Rank	8 (2, 4, 5)	1 (1, 3)	6 (2, 4, 5)	3 (1, 3)	2 (1, 3)	
Customer Focusing						
Mean	4.22	3.80	3.67	**5.00**	4.29	6.107
Std. Error	0.222	0.374	0.333	0.000	0.125	0.001
Rank	2 (4)	3 (4)	4 (4)	1 (1, 2, 3, 5)	1 (4)	
Competency						
Mean	3.78	**4.20**	3.33	3.67	**3.93**	0.470
Std. Error	0.278	0.374	0.667	0.373	0.267	*0.757*
Rank	5	2	5	8	5	
Partnership						
Mean	3.89	3.60	1.67	**4.11**	3.71	5.550
Std. Error	0.200	0.510	0.333	0.309	0.194	0.001
Rank	4 (3)	4 (3)	9 (1, 2, 4, 5)	5 (3)	6 (3)	
Transparency						
Mean	3.33	2.80	2.33	**4.00**	3.43	2.256
Std. Error	0.333	0.583	0.333	0.289	0.251	*0.083*
Rank	6	6	7	6	9	

* Represents the average degree of importance attached to each agility capability by cluster. Based on five point Likert scale (1=not important, 5=highly important).
** The standard error of the estimates of the mean of the group.
*** The rank order of importance of this agility capability within the group.
Note. The numbers in parentheses indicate the group numbers from which this group was significantly different at the 0.05 level as indicated by the Scheffe pairwise comparison procedure. Numbers in bold indicate the highest group centroid for that measure. Group 1 = Responsive Players, Group 2 = Quick Operator, Group 3 = Quick Innovator, 4 = Proactive Players 1, 5 = Proactive Players 2. The observed F-statistics were derived from one-way ANOVA and the p-values are associated with the observed F-statistics.

6.2.2 Labelling the clusters

The interpretation of the groups is given below. The interpretations are predicated upon: (1) whether there are significant differences on the cluster means of the capability variables at 0.05 level or less; (2) relative ranking of the importance of a capability within a cluster. It is possible that a high ranking capability within a cluster may actually exhibit a relatively low numerical score.

Cluster 1 – Responsive Players

Cluster 1 is labelled "Responsive Players." According to the ranking of the agility capabilities within the cluster, proactiveness, customer focusing and responsiveness to changes are ranked top three, followed by partnership, competency, transparency, flexibility, quick operations/delivery and quick innovation. Although responsiveness to changes is not ranked the highest, its mean value (as well as the mean values of proactiveness and customer focusing) is much larger than the other six capabilities. This cluster is fundamentally similar to the "Responsive Players" strategic group in Zhang and Sharifi's (2007) work. In their work, "Responsive Players" placed high emphasis on the capability of responsiveness to changes with support of the capability of flexibility. They competed along the "change proficiency" dimension which mainly consisted of the capabilities of proactiveness, partnership and responsiveness to changes (Zhang and Sharifi, 2007). In this study, cluster 1 places high emphasis on responsiveness to changes and proactiveness. The members of this cluster seem to compete along the "change proficiency" dimension as well, but moving along further to the high end of the dimension (i.e. proactiveness and responsiveness to changes). Due to the fundamental similarity and for the purpose of continuity, it was decided to succeed the label of "Responsive Players" and use

it for cluster 1 in this study. It appears that cluster 1 members intend to compete by rapidly respond to changes through constantly focusing on customer requirement updates and acting proactively as well as reactively. They do not place high emphases on quick innovation and quick operations/delivery in comparison to other clusters.

Cluster 2 – Quick Operators

The members of this cluster distinguish themselves from their counterparts of other clusters by ranking quick operations/delivery as the top priority in business competition. Competency is ranked at the second highest place, and then customer focusing, flexibility, partnership, responsiveness to changes, transparency, proactiveness and quick innovation. The cluster ascribes significantly less importance to quick innovation, proactiveness and responsiveness to changes when compared with the other clusters. The scores given to these three capabilities are the lowest. In contrast, the score for quick operations/delivery is significantly higher than that given in the responsive players cluster, the quick innovators cluster and the proactive players 2 cluster and is similar to that given by proactive players 1 cluster. Flexibility and partnership are both ranked at 4th places, but the scores for them are only significantly higher than that given by quick innovators cluster. In addition to quick operations/delivery, customer focusing is emphasised by this cluster. It appears that the members of this cluster intend to compete by high speed of operations and product delivery. This cluster focuses on developing the competence of offering quick operations and product delivery with customer focus. They do not emphasise responsiveness to changes and they give the lowest scores and rankings to proactiveness and quick innovation.

Cluster 3 – Quick Innovators

Labelled "Quick Innovators," this cluster is differentiated from other clusters by the relative emphasis placed on the ability to innovate and introduce new products quickly. Proactiveness, responsiveness to changes and quick innovation are ranked at the top, followed by customer focusing, competency, quick operations/delivery, flexibility, transparency and partnership. Although the score given to quick innovation is not the highest across clusters, it is the only capability that is significantly higher than the counterpart scores given by responsive players cluster, quick operators cluster and proactive players 2 cluster. The score is statistically similar to that given by proactive players 1. For customer focusing, the score is significantly lower than that given by proactive players 1 cluster and is similar to the other clusters. However, across clusters, the score is the lowest, though customer focusing is ranked at 4th place within the cluster. The score for quick operations/delivery is also the lowest. The cluster gives significantly lower scores to flexibility and partnership. The emphases of this cluster seem to be quick innovation. It appears that the members of this cluster plan to compete by high speed of innovation and new product introduction. Additionally, the cluster put high emphases on proactiveness and responsiveness to changes. This may be interpreted as that they use high speed of innovation as a way to react passively and proactively to changes in market. Furthermore, in order to make successful innovative products, companies within this cluster may not only react to changes in the market and but also proactively explore new potential markets and customers. They have to be able to identify existing or emerging changes in market needs and respond to them quickly so that the innovative products can be successfully launched.

Cluster 4 – Proactive players 1

This cluster ranks customer focusing and proactiveness first, followed by quick operations/delivery, quick innovation, partnership, responsiveness to changes, transparency, competency and flexibility. Across clusters, quick operations/delivery, quick innovation, partnership and transparency are given the highest scores by this cluster. Almost all capabilities are given very high scores, over 4.00, with exception of competency and flexibility which have scores of 3.67 and 3.44 respectively.

The characteristic of this cluster is very similar to the "Proactive Players" group in Zhang and Sharifi's (2007) taxonomy work. "Proactive Players" in their work placed very high emphases on all capabilities with special focus on customer focusing and proactiveness. Whilst the "Responsive Players" and the "Quick Players" in their work competed along the dimension of "change proficiency" and the dimension of "speed to customers" respectively, "Proactive Players" competed along both dimensions (Zhang and Sharifi, 2007). It seems that, in this study, members of this cluster plan to compete by developing all capabilities whilst paying special attention to customer focusing and proactiveness. Because of this fundamental similarity, cluster 4 in this study was labelled "Proactive Players 1." It may be logically interpreted that in order to be fully proactive in the marketplace the members of this cluster have to be quick, responsive and flexible, as well as partnering with suppliers/customers. The way they deal with changes is more proactive.

Cluster 5 – Proactive Players 2

Similar to proactive players 1 cluster, this cluster places relatively high emphases on all capabilities. No capability is given score under 3. Due to this, the cluster is labelled "Proactive Players 2." In the same was as with Proactive Players 1 customer focusing is

ranked first. However, different from proactive players 1 cluster, whilst this cluster place emphases on all capabilities, it pays special attention to quick operations/delivery and flexibility. Flexibility earns the highest score across clusters. Proactiveness is ranked relatively low. In comparison to the proactive players 1 cluster, flexibility and quick operations/delivery is more important to this cluster, while quick innovation is less important. According to the relative ranking, it seems that the members of this cluster intend to compete by developing all capabilities. They do this with special focus on quick operation and product delivery in a flexible manner in order to rapid respond to changes in the market. The way they deal with changes is more reactive.

It is noticeable that while there are no statistically significant differences between the five groups on the capabilities of competency and transparency, the discrepancies of the mean values of flexibility given by the five clusters are comparatively small. This may be interpreted that flexibility is more like a supportive capability to all types of agility strategies. To companies on different types of strategies, it might not be as important as some other agility capabilities, but it is necessary for all types of companies to possess in order to cope with changes caused in today's dynamic business environment. On the other hand, all the five groups gave relatively high scores to the capability of customer focusing. This may imply that customer focusing has become an essential capability to all types of companies. In the customer-oriented market, focus on customer is the prerequisite for business success (White, 1996, Yusuf et al., 1999, Breu et al., 2001, Vonderembse et al., 2006).

6.3 Identifying underlying dimensions

Similar to other taxonomy studies (Miller and Roth, 1994, Frohlich and Dixon, 2001, Zhao et al., 2006, Zhang and Sharifi, 2007), a multi-group discriminant analysis was used to identify underlying dimensions that separated the clusters from each other. As a more general approach to discriminant analysis, canonical discriminant analysis is a dimension-reduction technique related to principal component analysis and canonical correlation (Fornell, 1978, Green, 1978, Dillon and Goldstein, 1984). According to Johnson and Wichern (1998), canonical correlation analysis identifies and quantifies the associations between two sets of variables. These associations are based on the relationships between a linear combination of the variables in one set and a linear combination of the variables in another set.

In this 5-cluster solution, canonical discriminant analysis was carried out, with each of the taxonomic groups as criterion variables coded into four (number of clusters – 1) dummies and with the nine agility taxons comprising the predictor set. Standardized estimates for both canonical structure loadings and canonical coefficients were obtained. The canonical loadings represent the correlations of the original variables in the predictor set with an underlying unobserved dimension (each dummy discriminant function). So the loading can be useful as indicators of which original variables are most correlated with each canonical function. The standardized canonical coefficients are analogous to beta weights in regression and can be used to predict cluster membership. Based on this, multiple group discriminant classification was also used to cross-validate this 5-cluster solution resulted from clustering stage.

Table 6. 4 Results of canonical discriminant analysis

Canonical Functions	Eigenvalue	Percentage of Variance	Cumulative % of Variance	Canonical Correlation
1	6.300	57.6	57.6	0.929
2	3.197	29.2	86.8	0.873
3	1.005	9.2	96.0	0.708
4	0.437	4.0	100	0.551
Test of Canonical Functions	Wilks' Lambda	Chi-square	Df	Sig.
1 through 2	0.011	143.361	36	0.000
2 through 3	0.083	79.750	24	0.000
3 through 4	0.347	33.852	14	0.002
4	0.696	11.595	6	0.072

Table 6.4 lists the results of the canonical discriminant analysis used to investigate the relationship between the nine taxons and cluster membership. Four canonical functions were resulted from five clusters. Function 1, with an Eigen value of 6.300, represented 57.6% of total variance in the data and had a canonical correlation of 0.929. The canonical correlation is a measure of the relative strength of the relationship between predictor variables and the group membership (Fornell, 1978). Function 2, with an Eigen value of 3.197, represented 29.2% of total variance in the data and had a canonical correlation of 0.873. The remaining 13.2% of total variance in the data was shared by Function 3 and Function 4, 9.2% and 4% respectively. Three out of four correlations were significant except the correlation of Function 4. A multivariate test of the relationships between the functions and the predictor set gave Wilks' Lambda of 0.011, 0.083, 0.347 and 0.696 and the corresponding significance levels of 0.000, 0.000, 0.002 and 0.072 to the four canonical functions. Function1, 2 and 3 together explained cumulative 96% of total variance, and were assigned very high significance levels. Although Function 4 had less significance,

since it explained only 4% of total variance, it would not affect much the overall significance. Thus, significant overall relationships between the discriminant functions and predictor variables do exist.

Table 6.5 shows the values of the centroids for the five groups given by the four canonical functions. According to the table, Function 1 discriminated cluster 3 and cluster 4 from other clusters, while Function 2 separated cluster 2 and cluster5 from cluster 1. Then, cluster 3 and cluster 4 was distinguished from each other by Function 3. Function 4 separated cluster 5 from cluster 2.

Table 6. 5 Functions at group centroids

Cluster Number of Case	Function			
	1	2	3	4
1 (Responsive Players)	-.502	-1.813	1.386	.122
2 (Quick Operators)	-4.327	.262	-.552	-1.112
3 (Quick Innovators)	4.953	-3.223	-1.518	-.769
4 (Proactive Players 1)	2.245	2.355	.524	-.299
5 (Proactive Players 2)	-.637	.249	-.706	.676

Table 6. 6 Canonical loadings and coefficients

Predict Set	Structure Matrix				Standardized Canonical Coefficients			
	Function 1	Function 2	Function 3	Function 4	Function 1	Function 2	Function 3	Function 4
QuickInnovation	**0.627**	0.431	-0.325	0.395	0.818	0.351	-0.448	0.121
Competency	**-0.089**	0.027	-0.033	0.027	-0.210	0.296	-0.035	-0.165
QuickOperation	-0.062	**0.527**	-0.338	-0.115	-0.100	0.826	-0.230	-0.457
CustomerFocusing	0.137	**0.362**	0.361	0.263	-0.044	0.491	0.472	0.089
Proactiveness	0.486	-0.030	**0.548**	-0.034	0.514	0.235	0.557	-0.280
Partnership	-0.117	0.281	**0.486**	0.366	-0.153	0.231	0.466	0.367
Flexibility	-0.172	0.232	-0.191	**0.749**	-0.508	0.218	-0.133	0.670
Responsiveness	0.306	-0.166	-0.059	**0.472**	0.395	-0.833	-0.153	0.543
Transparency	0.044	0.216	0.241	**0.295**	-0.167	-0.091	0.163	-0.072
Bold numbers indicate largest absolute correlation between each variable and any discriminant function								

Table 6.6 lists structure loadings and standardized canonical coefficients. According to the loadings, across the four discriminant functions, Function 1 has larger absolute correlation with quick innovation and competency; Function 2 has larger absolute correlation with quick operations/delivery and customer focusing; Function 3 with proactiveness and partnership; and Function 4 with flexibility, responsiveness to changes and transparency. For the two variables in Function 1, quick innovation is positively correlated with the function, while competency is negatively correlated. The two variables in Function 2 and Function 3, and the three variables in Function 4, are all positively correlated. The large canonical coefficient with quick innovation in Function 1 (> 0.4, Miller and Roth, 1994) indicates that quick innovation contributed the most to Function 1. Likewise, quick operations/delivery contributed the most to Function 2, proactivenss and partnership to Function 3, and flexibility and responsiveness to changes to Function 4. It is noticeable that although the largest absolute correlation of proactiveness across the clusters is in Function 3, the correlation value of proactiveness in Function 1 is as large as 0.486.

It is interesting that function 3 characterized by proactiveness and partnership is very similar to the “change proficiency” dimension identified in Zhang and Sharifi’s (2007) work. The other dimension in their work was “speed to customers” dimension which was characterized by quickness and customer focus. Due to the similarity between the Function 3 dimension in this study and the “change proficiency” dimension in the work of Zhang and Sharifi (2007) and for continuity purpose, Function 3 is labelled as “change proficiency” dimension. Function 1 is labelled as “quick innovation” dimension and Function 2 is labelled as “quick operations/delivery” dimension. Function 4 is labelled as “flexibility” dimension.

Drawing on the indications from Table 6.6 and by taking into consideration Table 6.5, it can be derived that quick innovation representing Function 1 dimension separated quick innovators and proactive players 1 from the other three groups. Quick operations/delivery representing Function 2 dimension distinguished quick operators and proactive players 2 from responsive players. Quick innovators and proactive players 1 were further discriminated from each other by proactiveness and partnership from Function 3 dimension, while quick operators and proactive players 2 by flexibility and responsiveness to changes from Function 4 dimension.

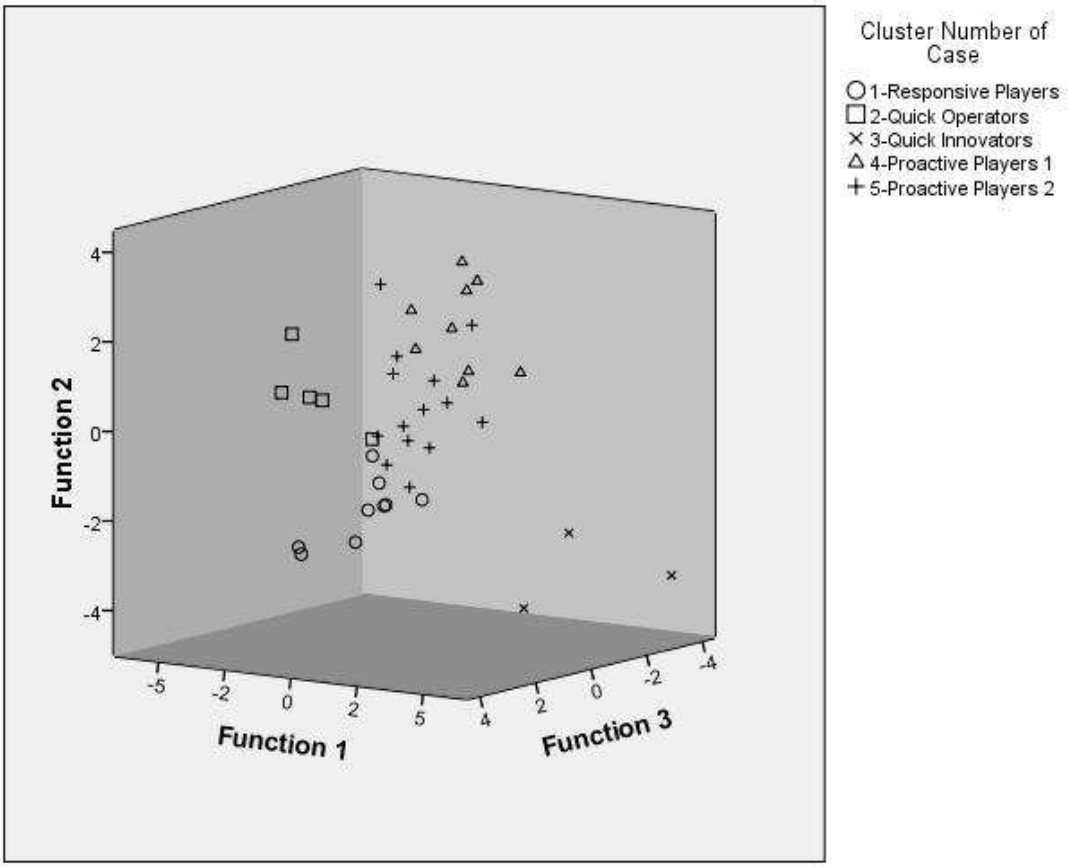

Figure 6. 2 Plot of respondent business units

In order to visually show the distribution of respondent business units, a 3-dimensional diagram was drawn based on the canonical discriminant function 1, 2 and 3 (see Figure 6.2).

This is due to the fact that these three functions together explained cumulative 96% of total variance in the data and their canonical correlations were significant. For Function 1 dimension, the large positive canonical loadings with quick innovation and proactiveness suggest that companies placing high emphases on these two capabilities will fall at the high end of this dimension. The smaller positive canonical loading with responsiveness to changes suggests that companies who emphasise this capability will appear somewhere in the middle of this dimension. Those placing low emphases on quick innovation and proactiveness will appear at the low end of the dimension. For Function 2 dimension, the large positive canonical loading with quick operations/delivery suggests that companies placing high emphases on this capability will be assigned to the high end of the spectrum. The smaller positive canonical loading with customer focusing implies that those who put high emphases on this capability will be assigned somewhere in the middle. For Function 3 dimension, the large positive canonical loadings with proactiveness and partnership suggest that companies placing high emphases on these two capabilities will fall at the high end of this dimension.

Figure 6.2 shows the plot of respondent business units on a 3D space. Figure 6.3 is a 2D projection of Figure 6.2 where Function 1 represents horizontal (X) and Function 2 represents vertical (Y) axes.

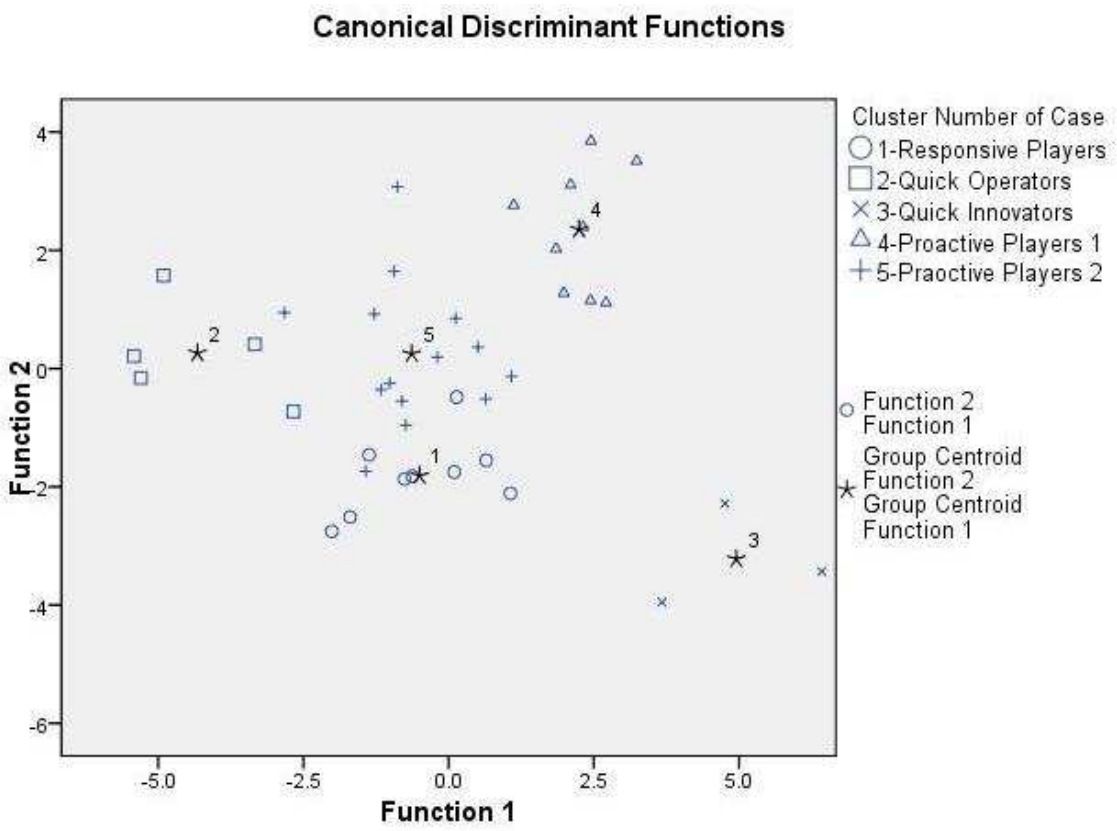

Figure 6. 3 Plot of respondent business units

As shown in Figure 6.3, cluster 3 (quick innovators) and cluster 4 (proactive players 1) giving the highest scores to quick innovation and proactiveness across clusters appear at the high end of horizontal axis. Cluster 1 (responsive players) with high emphasis on responsiveness to changes and cluster 5 (proactive players 2) with less quick innovation and proactiveness but relatively high responsiveness shows in the middle, and cluster 2 (quick operators) with lowest scores on quick innovation and proactiveness stays at the low end of the horizontal dimension. On the other hand, since cluster 2, cluster 4 and cluster 5 have given high scores to quick operations/delivery, they appear at the high end of the vertical dimension. Cluster 1 and cluster 3 giving low scores to quick operations/delivery show at the low end of the vertical dimension. Taking into consideration the two dimensions together, quick operators (cluster 2) occupy the upper left corner of the space

which means that they mainly compete by offering quick operations and product delivery. Quick innovators (cluster 3) occupy the bottom right corner of the space, indicating that they primarily compete by proactive quick innovation. Proactive players 1 (cluster 4) occupy the upper mid-right of the space, suggesting that they compete along all dimensions by developing capabilities of proactive quick innovation and quick operations/delivery, as well as rapid response to changes. Proactive players 2 (cluster 5), emphasising less on all quick innovation, proactiveness, quick operations/delivery and customer focusing in comparison to proactive players 1, occupy the space where it is both horizontally and vertically lower than that occupied by proactive players 1. Responsive players (cluster 1), emphasising less on quick operations/delivery and quick innovation but more on proactiveness and responsiveness to changes, occupy the low middle of the space. Broadly speaking, no group occupies extremely low end of the vertical dimension. This may be because that the scores given to quick operations/delivery and customer focusing by all cluster are generally high. Cluster 3 with lowest scores on both quick operations/delivery and customer focusing is located at the low end of the vertical dimension. The bottom left corner is unoccupied, where it represents a combination of slow innovation, low proactiveness and slow operations. The absence of companies in this area may imply that such a company implementing such a strategy would not survive for long.

Figure 6.3 visually shows the characteristics of the clusters. On this Function 1 (Quick innovation) versus Function 2 (Quick operations/delivery) diagram, the quick operators on the upper left corner compete along quick operations/delivery dimension, whilst the quick innovators on the bottom right corner compete along quick innovation dimension. Proactive players 1 compete along both quick innovation and quick operations/delivery dimensions, whilst proactive players 2 also compete along both dimensions but with emphases on quick

operations/delivery. Responsive players do not show a strong focus in either dimension. This is logical, as the dimension that responsive players compete is not shown in this view of the 3D space. In order to better show the characteristics of the responsive players group, the 3D diagram has been rotated. The rotated diagram is shown in Figure 6.4.

Figure 6.4 is a 2D projection of Figure 6.2 in which Function 3 and Function 2 represent horizontal (Z) and vertical (Y) axes respectively. This Figure clearly shows that responsive players on the bottom left corner compete along change proficiency dimension.

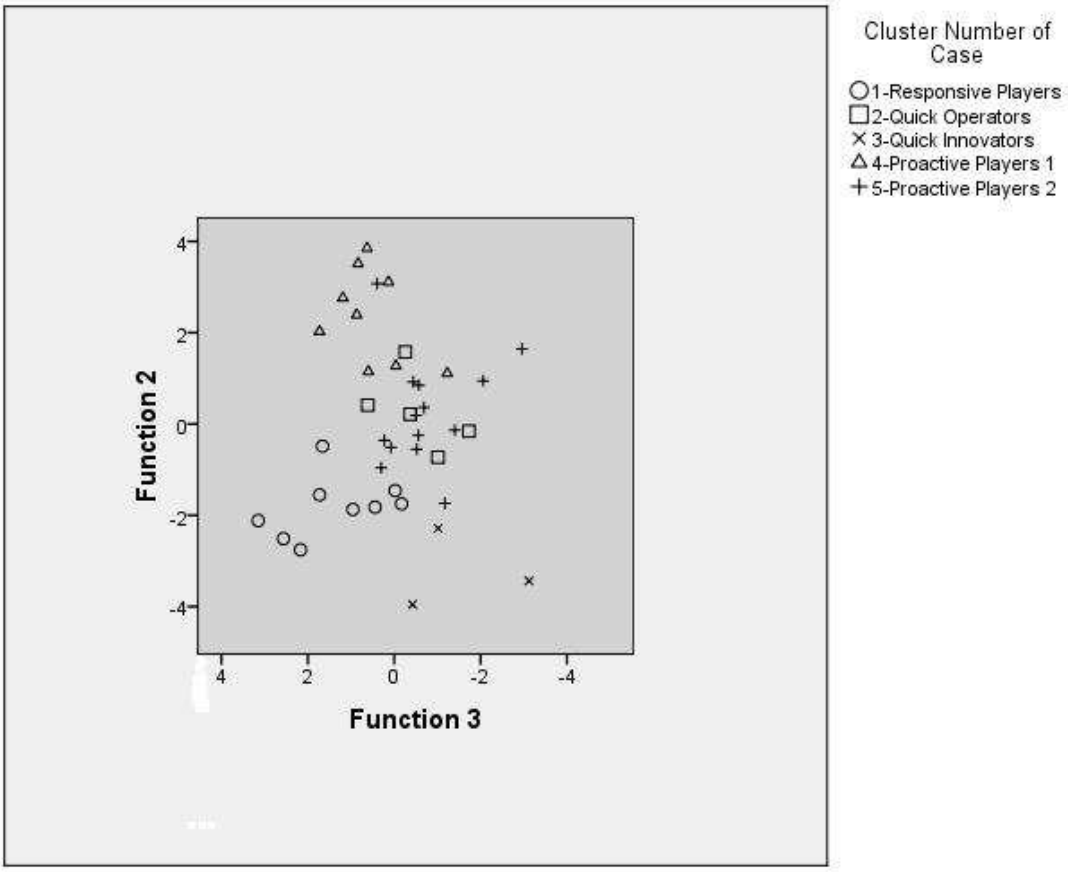

Figure 6. 4 Plot of respondent business units

To determine the stability of estimates of the clusters, a cross validation test was carried out. The probability of misclassification was estimated by cross-validation. During the procedure, a discriminant function with the nine taxons of agility capabilities as predictors was computed for 39 out of 40 cases. This function was used to classify the one observation held out. The process was iterated for each of the 40 cases and the proportion of hold-out observations assigned to each group was determined. As shown in Table 6.7, the classification results of the repeated process indicate that all the five clusters are hundred percent correctly classified. The overall probability of correct classification is 100%.

Table 6. 7 Classification results

Cluster Number of Case			Predicted Group Membership					
			1	2	3	4	5	Total
Original	Cluster	1	9	0	0	0	0	9
		2	0	5	0	0	0	5
		3	0	0	3	0	0	3
		4	0	0	0	9	0	9
		5	0	0	0	0	14	14
	%	1	100.0	.0	.0	.0	.0	100.0
		2	.0	100.0	.0	.0	.0	100.0
		3	.0	.0	100.0	.0	.0	100.0
		4	.0	.0	.0	100.0	.0	100.0
		5	.0	.0	.0	.0	100.0	100.0

a. 100.0% of original grouped cases correctly classified.

6.4 Analysis and discussion against the taxonomy of Zhang and Sharifi (2007)

In Zhang and Sharifi's taxonomy work, three strategic agility groups were discovered that were named "Responsive Players," "Quick Players" and "Proactive Players." However, in the subsequent case studies, they found two types of action plans corresponding to quick

strategy and two types corresponding to proactive strategy. Therefore, they suspected that two types of quick players and two types of proactive players may exist. These two strategies have strong similarities to the quick operators and quick innovators and proactive players 1 and 2 identified in this study.

In order to check this, the five strategic groups were merged into three groups. In the new three groups, quick players group was comprised of quick operators and quick innovators. Proactive players group consisted of proactive players 1 and 2, and responsive players group remained on its own.

Canonical discriminant analysis was carried out to investigate if the three groups compete along dimensions in the same way as those in the work of Zhang and Sharifi (2007).

Table 6. 8 Results of canonical discriminant analysis

Canonical Functions	Eigenvalue	Percentage of Variance	Cumulative % of Variance	Canonical Correlation
1	1.699	80.5	80.5	0.793
2	0.411	19.5	100.0	0.540
Test of Canonical Functions	Wilks' Lambda	Chi-square	Df	Sig.
1 through 2	0.263	46.127	12	0.000
2	0.709	11.868	5	0.037

Two canonical functions resulted from the three groups. Table 6.8 lists the results of the canonical discriminant analysis. Function 1, with an Eigen value of 1.699, represented 80.5% of total variance in the data and had a canonical correlation of 0.793. Function 2, with an Eigen value of 0.411, represented the remaining 19.5% of total variance in the data

and had a canonical correlation of 0.540. Both correlations were significant, this was shown through a multivariate test of significance using Wilks' Lambda. The significance levels of 0.000 and 0.037 indicate that significant overall relationships between the discriminant functions and predictor variables exist.

Table 6.9 lists structure loadings and standardized canonical coefficients. According to the loadings, Function 1 has larger absolute correlation with quick operations/delivery, quick innovation and flexibility, while Function 2 with customer focusing, proactiveness, responsiveness to changes, partnership, competency and transparency. The three variables in Function 1 and the six variables in Function 2 were all positively correlated.

The large canonical loadings with quick operations/delivery and quick innovation (> 0.4) in Function 1 suggest that companies placing high emphases on these capabilities will fall at the high end of this dimension. In contrast, the companies who place high emphases on customer focusing and proactiveness will fall at the high end of the Function 2 dimension. This is due to the large canonical loadings with customer focusing and proactiveness. The smaller positive canonical loadings with responsiveness to changes suggest that companies putting high emphases on this capability may appear somewhere in the middle of the dimension.

It was found that the two dimensions described above are very similar to the two dimensions identified in Zhang and Sharifi's (2007) work. In Zhang and Sharifi's taxonomy, quickness was used as a broad agility capability. However, in this study, two more specific quick related capabilities – quick operations/delivery and quick innovation – were used to replace the broader term. Since quick operations/delivery and quick

innovation appeared at the same dimension and were the dominant capabilities along the dimension, it can be considered that Function 1 dimension here is similar to “speed to customers” dimension in their work. Likewise, with high canonical loadings with proactiveness and responsiveness, Function 2 dimension here is similar to “change proficiency” dimension in their work.

Table 6. 9 Canonical loadings and coefficients

Predict Set	Structure Matrix		Standardized Canonical Coefficients	
	Function 1	Function 2	Function 1	Function 2
Quick Operations	0.553*	-0.306	0.545	-0.442
Quick Innovation	0.542*	0.205	1.002	-0.267
Flexibility	0.324*	0.283	0.398	0.558
Customer Focusing	0.299	0.640*	0.102	0.733
Proactiveness	-0.030	0.486*	-0.287	0.538
Responsiveness	0.048	0.301*	-0.257	0.105
Partnership	0.257	0.286*	0.097	0.241
Competency	0.174	0.191*	-0.105	0.270
Transparency	0.063	0.125*	0.142	-0.170
*. Largest absolute correlation between each variable and any discriminant function				

Companies belonging to the five strategic groups identified in this study are plotted on a space formed from the two dimensions (shown in Figure 6.5), where dimension 1 and 2 represent vertical and horizontal axes respectively. According to the plot, proactive players 1 and 2 occupy the upper right corner of the space, indicating that they compete along both dimensions. However, proactive players 1 seem to be even more upper right. This may reflect that proactive players 1 are relatively more proactive and quicker in terms of both operations/delivery and innovation than proactive players 2. Quick operators and quick innovators occupy upper left of the space which means that they mainly compete along quick related dimension. Responsive players occupy the mid-right bottom of the space,

implying that they compete along proactive/responsive related dimension. The distributions of the strategic groups are synergy of the counterpart in the work of Zhang and Sharifi (2007) in which proactive players correspond to proactive players 1 and 2, and quick players to quick operators and quick innovators.

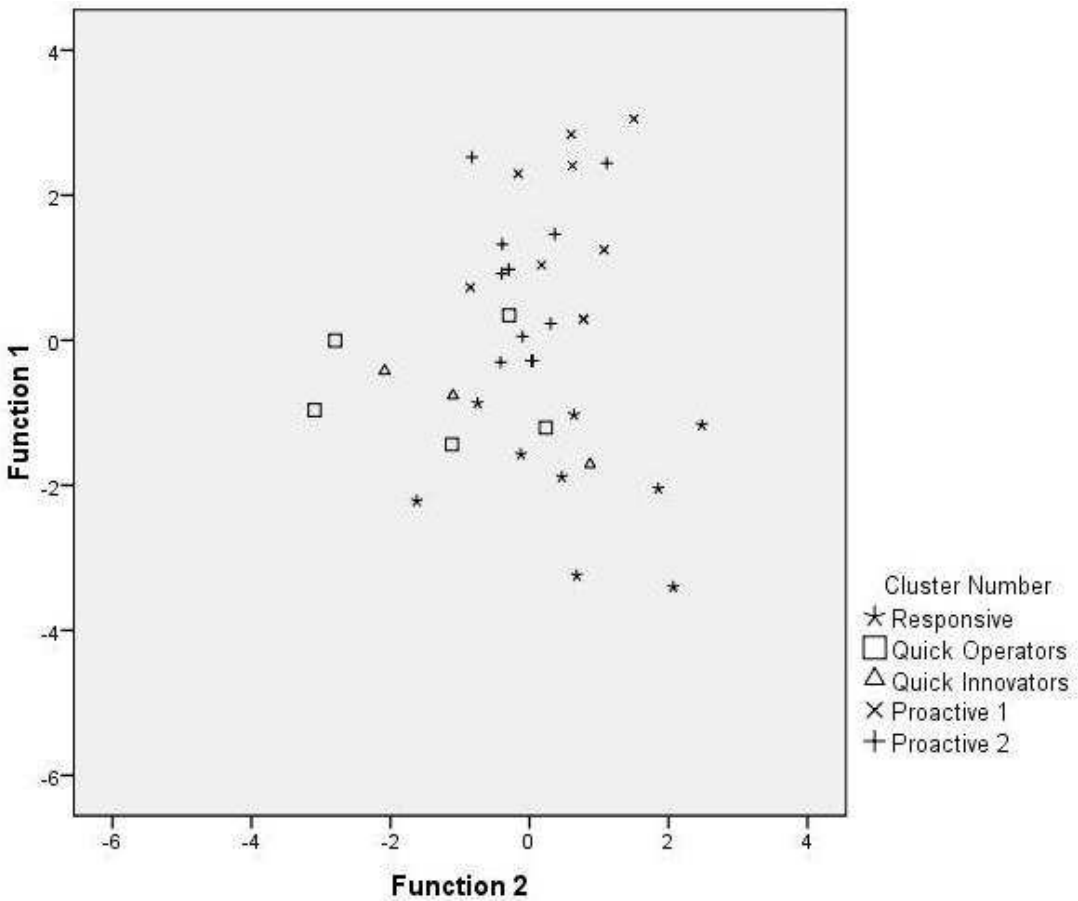

Figure 6. 5 Plot of the five groups on two canonical functions

While the regions occupied by the strategic groups are clear, it is found that the borders between the regions become blurred. Compared to the quick players in the previous work (Zhang and Sharifi, 2007), quick operators and quick innovators are towards the high end of proactive/responsive dimension. The overlaps between quick players (both operators and innovators), responsive player and proactive players indicate the tendency of moving towards being more proactive and responsive of quick players. This is understandable.

While the business environment is increasingly dynamic and the requirements in the marketplace become more unpredictable than ever before, being purely quick may be no longer sufficient for companies to survive for long. The ability of dealing with changes either reactively or proactively is becoming more and more important to those companies who want to compete in today's highly competitive global business environment.

The plot shows that three broad types of agility strategies still exist as were identified by Zhang and Sharifi (2007). However, two sub types of quick strategic groups and two sub types of proactive strategic groups were identified. Zhang and Sharifi had suspected the existence of such types of strategic groups. This study has statistically proved their existence.

6.5 Summary

This chapter described the conduct process of cluster analysis and canonical discriminant analysis. As a result of this analysis, 5 types of strategic groups were identified based on the emphases respondent companies placed on the nine agility capabilities that were defined in Chapter 4. The five strategic groups are responsive players, quick operators, quick innovators, proactive players 1 and proactive players 2.

Canonical discriminant analysis was conducted to identify underlying dimensions that separated the five strategic groups from each other. Respondents were plotted on a 3D space. Each axis of the 3D space represents a strategic dimension derived from a significant canonical discriminant function. The types of strategic groups identified in this study were then compared with the types of strategic groups identified by Zhang and Sharifi (2007).

This was done by plotting the five groups on the two dimensions that separated the three types of agility strategy groups identified in their study.

By comparing to the three types of agility strategy groups in Zhang and Sharifi's taxonomy work, it was found that quick operators and quick innovators groups discovered in this study are two sub types of quick players in that work, and proactive players 1 and proactive players 2 are sub types of the proactive players. While the continuity of the previous taxonomy has been demonstrated the borders between quick players, responsive players and proactive players can become blurred. Quick players (corresponding to quick operators and quick innovators in this study) are moving towards being more proactive and responsive.

The primary findings of this work can be summarized as follows:

Firstly, it has demonstrated the continuity of the taxonomy developed by Zhang and Sharifi (2007). It concludes that three broad types of agility strategies do still exist in today's marketplace.

Secondly, while the three broad types of agility strategies have remained, two sub types of quick strategies and two sub types of proactive strategies have also been identified. Previous work had suspected the existence of such sub types of agility strategies and this study has statistically proved their existence.

Thirdly, while the plot showed the clear regions along two dimensions that the strategic groups compete, the borders between the regions become blurred. A tendency that two

types of quick players are moving towards being more proactive and responsive has been identified.

Chapter7 Analysis and discussion

7.1 Introduction

This chapter provides an analysis of the contextual variables, agility drivers and agility providers associated with the five resultant agility strategic groups developed in Chapter 6.

The different ways of supply chain management associated with the five strategic groups are examined. The linkages between the pressures exerted on the different groups and the supply chain management practices they chosen will be investigated. The nature of the market, the product life cycles and the product characteristics related to the five strategic groups will be investigated, and the associations between them and the different ways of supply chain management of the strategic groups will be examined.

7.2 Industrial mix and contextual variables

The relationships between clustered agility group memberships and industrial sector memberships were studied. The results by cross-tabulation are shown in Table 7.1. A chi-square test indicates that there is no significant association between cluster membership and industry sector ($p = 0.741$, see Table 7.2). This leads to the conclusion that all sectors had members that compete within each of the different agility strategies. The differences between industry sectors are not statistically significant. Thus, sector bias is rejected.

Table 7. 1 Industry representation by strategic groups

			Strategic Group					Total
			Responsive Players	Quick Operators	Quick Innovators	Proactive Players 1	Proactive Players 2	
Sector	Aerospace	Count	0	0	0	0	2	2
		% within Sector	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
	Auto Parts	Count	2	0	1	2	2	7
		% within Sector	28.6%	0.0%	14.3%	28.6%	28.6%	100.0%
	Electronics	Count	2	1	0	3	5	11
		% within Sector	18.2%	9.1%	0.0%	27.3%	45.5%	100.0%
	Other	Count	5	4	2	4	5	20
		% within Sector	25.0%	20.0%	10.0%	20.0%	25.0%	100.0%
	Total	Count	9	5	3	9	14	40
		% within Sector	22.5%	12.5%	7.5%	22.5%	35.0%	100.0%

Table 7. 2 Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.554[a]	12	.741
Likelihood Ratio	10.523	12	.570
Linear-by-Linear Association	2.023	1	.155
Number of Valid Cases	40		

a. 19 cells (95.0%) have expected count less than 5. The minimum expected count is .15.

The differences between the five strategic groups and several contextual variables were examined by using ANOVA and Scheffe pairwise comparison tests of mean differences. This was done in order to identify how each strategic group differs across the contextual variables. The results are shown in Table 7.3. The F value and p value that were found do not show significant differences among the five groups in terms of the listed contextual variables. It is thought that this may be due to the limited size of dataset available for this study. However, the mean scores given to each contextual variable across the five strategic groups show that different competing dimensions possessed by the groups led to different patterns of the contextual variables.

Table 7. 3 Contextual variables by strategic group

	Strategic Group					F Value Sig.
	Responsive Players	Quick Operators	Quick Innovators	Proactive Players 1	Proactive Players 2	
% of new product success						
Mean	77.14	80.00	**93.33**	90.67	82.50	0.768
Std. Error	9.184	10.000	6.667	5.800	4.827	0.555
Average lead time for major product (month)						
Mean	**4.1000**	7.7500	16.1667	18.2500	15.5000	1.083
Std. Error	1.77294	5.43714	7.83333	4.51881	5.92440	0.383
% of turnover in R&D investment						
Mean	2.1667	1.5000	5.6667	**12.4278**	6.9286	0.861
Std. Error	1.14261	.92195	4.25572	8.50717	2.10824	0.497
% of complete innovation in NPI						
Mean	6.67	5.50	26.67	**40.22**	18.57	2.300
Std. Error	1.667	4.500	12.019	8.947	6.701	0.096
% of new assembled lines in NPI						
Mean	**36.00**	30.00	25.00	28.00	25.62	0.144
Std. Error	16.912	10.000	15.000	11.321	6.644	0.963
% of improvement in NPI						
Mean	35.00	51.67	**53.33**	49.75	48.50	0.254
Std. Error	6.455	27.437	8.819	7.468	10.621	0,904
% of customization in NPI						
Mean	48.75	**50.00**	3.33	11.67	42.22	1.255
Std. Error	21.830	10.00	3.333	1.667	11.369	0.328

Quick innovators, which compete along quick innovation dimension, have the highest percentage of new product success. They also show a higher percentage of complete innovation in their new product development than all of the other groups with the exception of proactive players 1. In addition to this the percentage of annual turnover they put into R&D investment is relatively high in comparison to the other groups. This appears to indicate that quick innovators derive business success from a high ratio of successful new product development and introduction. They strive to develop their innovation capabilities and produce highly innovative products to make high margins in the early stage of product development. They regularly invest a high proportion of their annual turnover into R&D in

order to enhance and update their innovation capabilities in order to maintain their competitiveness.

In contrast, quick operators and responsive players are much quicker than the other three groups at developing new products. As quick operators compete along quick operations/delivery dimension, they may place low emphases on the aspect of R&D. This may result in a low rate of complete innovation in their new products. Table 7.3 shows that quick operators have the lowest percentages of R&D investment and complete innovation in new product development. Quick operators have the highest percentage of custom made products in new product introduction. These appear to suggest that with short lead times for product development and production, quick operators try to achieve business success by providing quick product tailoring and customization. Although they have lower percentage of complete innovation than other groups, their new product success rate is still high.

In contrast to quick operators, responsive players have the highest proportion of new assembled lines in the new product introductions as well as shortest lead time of product development. In other words, responsive players have the largest number of new products made by new assembled production lines compared to the other groups. This corresponds to the change proficiency dimension that responsive players compete within. They use even shorter lead times to make faster responses to changes in the marketplace by creating new lines to fulfil customer requirements. These changes can be either volume changes or product model changes. According to their feature of developing new lines with shortest lead time, it may suggest that they achieve the speed of new lines development by making good use of existing facilities/resources.

Proactive players 1 emphasise their investment into R&D more than any of the other groups and have highest proportion of complete innovation in new product introduction but with the longest lead time. They also have average proportions of improvement and new lines in the introduction of new products. This is understandable, since proactive players 1 that compete along all the dimensions intended to develop all capabilities as they desire to excel in all aspects. A higher proportion of R&D investment results in a higher percentage of complete innovation in new product development and introduction. However, this may compromise the lead time for new product development. Compared to proactive players 1, proactive players 2 stand in the middle of all of the contextual variables listed in Table 7.3. This is consistent with the situation of their competing dimensions. While proactive players 2 intend to compete along all dimensions, they place less emphasis on quick operations/delivery, quick innovation and proactiveness than proactive players 1. Their proportion of R&D investment is smaller and the new products they make are less innovative than those made by proactive players 1. However, this makes them spend shorter lead time to develop products. The proportion of custom made goods in their new products is higher than their counterparts in proactive players 1. Although proactive players 2 do not have an outstanding advantage amongst all contextual variables and are generally average in terms of all aspects, they still perform well in the market. They do have higher new product success rate than responsive players and quick operators.

7.3 Business environment

The twenty-two agility drivers discussed in Chapter 4 were used to investigate the business environment around the five types of agility companies identified in Chapter 6. The drivers represent the changes and pressures that exist in the marketplace. Respondents were asked

to rate influence of these changes and pressures on their companies using a five-point Likert scale, where 1=not important and 5=highly influential.

Responses from the five strategic groups were compared in order to find out if and how their strategies were shaped by changes and pressures from the business environment. ANOVA and Duncan's pairwise comparison tests were performed to calculate the mean differences of the responses from the five strategic groups.

Duncan's pairwise test is a stepwise test that does not provide confidence intervals. It just divides pairwise differences into possibly overlapping groups. Means within the same group are not significantly different, while those from different groups are significantly different at an assumed significance level (Hochberg and Tamhane, 1987, Zhao et al., 2006). By conducting Duncan's pairwise tests, it was found that the strategic groups differed in 13 agility drivers. The results are shown in Table 7.4.

All strategic groups gave high mean values to the two internal drivers – "continuous improvement" and "moving towards excellence." This may imply that all types of companies suffer high pressures from increasingly fierce competition in the business environment and from the need to be able to achieve sustainable growth. This echoes the literature that business environment is increasingly dynamic and unpredictable. Companies have to continuously improve their competences in order to maintain competitive edges so that they can survive and prosper in such business environment (Cho et al., 1996, Gunasekaran, 1998, McAdam and McCormack, 2001, Robertson et al., 2002, Gunasekaran et al., 2008).

Table 7. 4 Agility drivers by strategic group

	Responsive Players	Quick Operators	Quick Innovators	Proactive Players 1	Proactive Players 2	F Value Sig.
	Group 1	Group 2	Group 3	Group 4	Group 5	
Change in marketplace						
Growth of the niche market						
Mean*	3.11	1.80 (4, 5)	3.00	**3.56** (2)	3.29 (2)	1.613
Std. Error**	0.351	0.374	1.155	0.377	0.398	0.193
Increasing rate of change in product models						
Mean	3.00	2.20 (3)	**4.00** (2)	3.22	3.07	1.175
Std. Error	0.333	0.374	0.577	0.324	0.399	0.339
Product lifetime shrinkage						
Mean	1.89 (3)	2.20 (3)	**3.67** (1,2,4,5)	2.56 (3)	2.36 (3)	1.854
Std. Error	0.261	0.490	0.667	0.294	0.308	0.141
Change in competition basis						
Rapidly changing markets						
Mean	**4.00** (2)	2.40 (1, 3)	**4.00** (2)	3.56	3.21	1.911
Std. Error	0.289	0.510	0.577	0.530	0.261	0.131
Innovation rate increasing						
Mean	2.78	2.00 (3, 4)	3.33 (2)	**3.44** (2)	2.86	2.159
Std. Error	0.364	0.316	0.882	0.338	0.177	0.094
Increasing pressure of global market competition						
Mean	3.33	2.40 (4)	2.67	**3.89** (2)	3.43	1.387
Std. Error	0.500	0.600	0.333	0.351	0.327	0.258
Decreasing new product time-to-market						
Mean	2.67	1.80 (4)	2.67	**3.11** (2)	2.93	1.150
Std. Error	0.471	0.374	1.202	0.309	0.267	0.349
Responsiveness of competitors to changes in marketplace						
Mean	3.44 (3)	2.80 (4)	2.33 (1, 4)	**3.78** (2, 3)	3.14	2.123
Std. Error	0.294	0.490	0.667	0.278	0.206	0.099
Change in customer requirements						
Individualized products and services						
Mean	3.89 (2)	2.80 (1, 3)	**4.33** (2)	3.22	3.36	2.035
Std. Error	0.200	0.583	0.667	0.324	0.225	0,111
Social changes						
Environmental pressures						
Mean	3.78 (3, 4)	**4.60** (3, 4)	2.00 (1, 2)	3.00 (1, 2)	3.21	2.185
Std. Error	0.364	0.400	0.577	0.527	0.408	0.091
Workforce/workplace expectation						
Mean	**3.33** (3)	3.20 (3)	2.00 (1, 2, 4)	3.00 (3)	2.71	1.745
Std. Error	0.236	0.200	0.000	0.373	0.244	0.162
Internal drivers						
Strategy of continuous improvement						
Mean	4.11	4.20	**4.67** (5)	4.22	3.71 (3)	1.460
Std. Error	0.200	0.200	0.333	0.364	0.163	0.235
Moving towards excellence						
Mean	3.89	4.00	**4.67** (5)	4.44	3.71 (3)	1.678
Std. Error	0.309	0.316	0.333	0.294	0.194	0.177

* Represents the average degree of influence each driver had on the cluster. Influence is measured on a five-point Likert scale (1=not important, 5=highly influential). ** The standard error of the estimates of the mean for the group.

Note: The number in parentheses indicate the group numbers from which this group was significantly different as indicated by Duncan pairwise comparison procedure. Numbers in bold indicate the highest group centroid for that measure. The observed F-statistics were derived from one-way ANOVA and the p values are associated with the observed F-statistics.

Responsive players experienced the highest pressures on “rapidly changing markets” and “workforce/workplace expectation,” and relatively high pressures on “global market competition,” “responsiveness of competitors to changes in marketplace,” “individualized products and services,” and “environmental pressures” across the groups. It appears that high pressures from changes in market and demands for individualized product as well as competitors’ improvement may have led companies within this group to be more responsive and proactive. This may explain why responsive players intend to overcome these pressures by competing along the change proficiency dimension. Low pressures on these aspects gave quick operators little motivation to do the same as responsive players.

Quick operators experienced the highest pressures on environmental pressures and the relatively high pressures on increasing workforce/workplace expectation across the groups. Based on the statistics, it indicated that quick operators experienced much higher pressures than other groups from environmental issues. This may be due to the fact that most of the sampled companies within this group were chemical suppliers (semiconductor industry) or electronics producers, which commonly suffer from high pressures in dealing with contamination from production processes. Quick operators, with the lowest pressures on almost all drivers except internal drivers, had chosen to compete along the quick operations/delivery dimension. They intend to increase market share by offering high speed of operations and product delivery to customers.

In contrast, quick innovators suffered from the highest pressures on “increasing rate of changes in product models,” “product lifetime shrinkage,” “rapidly changing markets” and “individualized products and services.” They also suffered from higher pressure on “increasing innovation rate” than most of the other groups, except proactive players 1 and

high pressure on “growth of the niche market.” It appears that high pressures from shortening product life cycles along with increasing rate of innovation and change in product models may have forced quick innovators to have high speed of innovation and to be responsive. This corresponds to the dimension within which quick innovators compete.

Proactive players 1 and 2 suffer from relatively high pressures on almost all drivers. This may be the reason why proactive players 1 and 2 placed such a relatively high emphases on all agility capabilities and intended to compete along all dimensions. Generally, proactive players 1 suffered from higher pressures on most of drivers than proactive players 2. In comparison to proactive players 1, “increasing innovation rate” does not affect proactive players 2 much. This appears to be in line with the emphases proactive players 2 placed on agility capabilities. While proactive players 2 intend to compete by developing all capabilities they put more emphases on quick operations/delivery and flexibility. It appears that in order to increase market share, proactive players 2 focus more on providing a high speed of operations and product delivery to customers in a flexible manner rather than high speed of product innovation.

7.4 Supply chain management practices

Similar methods to previous business environment analysis were used to examine if the five agility strategic groups adopted different practices to manage their supply chains.

In the survey, a list of seventy-eight supply chain management practices (agility providers) were given to the respondents, and the respondents were asked to rate the importance they attach to each practice on a five-point Likert scale (where 1=not applicable and 5=highly

important). This was done in order to indicate to what extent these practices are important to them. These practices, also known as ‘action programs’ by (Miller and Roth, 1994, Zhang and Sharifi, 2007), indicate that “the intended emphasis on manufacturing choices and tap important underlying structural and infrastructural directions in a manufacturing strategy.” (Zhang and Sharifi, 2007)

The results of the ANOVA and Duncan’s pairwise comparison tests showed that significant differences existed among 36 out of 78 practices. The distinguishable 36 practices resulted from the Duncan’s pairwise comparison are shown in Table 7.5.

Table 7. 5 Supply chain management practices by strategic group

	Responsive Players	Quick Operators	Quick Innovators	Proactive Players 1	Proactive Players 2	F Value Sig.
	Group 1	Group 2	Group 3	Group 4	Group 5	
Strategic design of SC						
Consideration of the products characteristics						
Mean*	3.00	2.80 (4)	2.67 (4)	**4.00** (2, 3)	3.79	2.214
Std. Error**	0.408	0.583	0.333	0.236	0.300	0.088
Consideration of the product life cycles						
Mean	2.56 (4)	2.20 (4)	3.00	**3.89** (1, 2)	3.29	2.212
Std. Error	0.377	0.735	0.577	0.351	0.322	0.088
Consideration of the nature of demand						
Mean	3.00 (4)	2.40 (4, 5)	3.00 (4)	**4.33** (1,2,3)	3.71 (2)	3.312
Std. Error	0.441	0.678	0.577	0.167	0.286	0.021
Integrating vertically						
Mean	2.44 (3)	2.40 (3)	**3.67** (1,2,4,5)	2.44 (3)	2.64 (3)	2.60
Std. Error	0.444	0.678	0.882	0.412	0.427	0.223
Integrating horizontally						
Mean	3.22	3.40	2.67 (4)	**4.33** (3)	3.57	1.424
Std. Error	0.521	0.678	0.667	0.333	0.291	0.247
Careful selection of suppliers						
Quality provided						
Mean	**4.56** (2)	3.20 (1,3,4)	4.33 (2)	**4.56** (2)	3.64	2.846
Std. Error	0.242	0.490	0.667	0.242	0.308	0.038
Short lead times						
Mean	**3.11** (2)	2.00 (1)	3.00	2.67	2.86	1.173
Std. Error	0.200	0.548	1.000	0.167	0.294	0.339
Total costs						
Mean	3.89 (3)	3.80 (3)	2.67 (1,2,4,5)	**4.00** (3)	3.71 (3)	0.957
Std. Error	0.200	0.583	0.667	0.373	0.304	0.443
Technological and R&D capability						
Mean	3.78 (2)	2.40 (1,4,5)	3.33	3.56 (2)	**3.86** (2)	1.648
Std. Error	0.222	0.678	0.667	0.475	0.275	0.184
Capability of cost reduction						
Mean	**4.22** (2,3)	3.00 (1)	3.00 (1)	3.67	3.64	2.069
Std. Error	0.147	0.447	0.577	0.373	0.225	0.106
Innovative power						
Mean	**3.56** (2,3)	2.40 (1)	2.00 (1)	3.00	3.14	2.354
Std. Error	0.176	0.510	0.577	0.441	0.177	0.073
Flexibility of acting as a partner						
Mean	3.56	3.00 (4, 5)	2.67 (4, 5)	**3.89** (2, 3)	3.86 (2, 3)	2.487
Std. Error	0.176	0.447	0.333	0.261	0.231	0.061
Ease of communication						
Mean	**3.67** (2, 3)	2.60 (1)	2.67 (1)	3.22	3.43	1.453
Std. Error	0.289	0.245	0.333	0.434	0.228	0.237
Supply chain integration						
Business knowledge sharing						
Mean	2.22 (3)	2.20 (3)	**3.33** (1, 2)	2.89	2.93	1.482
Std. Error	0.324	0.374	0.667	0.389	0.221	0.229
Keep informed about events/changes						
Mean	2.44 (4)	2.80	3.00	**3.78** (1)	3.50	2.254
Std. Error	0.377	0.583	0.577	0.364	0.251	0.083

Table 7.5 Supply chain management practices by strategic group (continued)

Products information sharing with key suppliers						
Mean	3.44 (2, 3)	2.20 (1, 4, 5)	2.33 (1, 4, 5)	**3.89** (2, 3)	3.50 (2, 3)	2.219
Std. Error	0.338	0.583	0.667	0.351	0.359	0.087
Financial information sharing with key customers						
Mean	2.56	1.60 (4)	2.33	**3.44** (2)	3.00	1.723
Std. Error	0.444	0.400	0.882	0.503	0.363	0.167
Scheduling information sharing with key customers						
Mean	3.11	2.20 (3,5)	**3.67** (2)	3.11	3.57 (2)	1.152
Std. Error	0.484	0.583	0.333	0.484	0.309	0.348
Time postponement						
Mean	2.11 (3)	2.00 (3)	**4.33** (1,2,4,5)	2.33 (3)	2.57 (3)	1.370
Std. Error	0.512	0.775	0.333	0.553	0.402	0.264
Risk sharing programs						
Mean	2.44	1.40 (4)	2.00	**2.78** (2)	2.57	1.201
Std. Error	0.412	0.245	0.000	0.434	0.374	0.328
Strategic coordination of operations						
Strategic relationship management						
Including suppliers into product design and development						
Mean	2.67 (4)	3.40	3.33	**3.89** (1)	3.29	1.499
Std. Error	0.289	0.510	0.667	0.351	0.304	0.224
Supplier's participation in lead-time improvement						
Mean	3.67	2.80 (3, 4)	**4.33** (2)	4.00 (2)	3.36	1.605
Std. Error	0.408	0.374	0.333	0.333	0.289	0.195
Joint team working						
Mean	2.78	1.60 (4)	2.00	**2.89** (2)	2.21	1.511
Std. Error	0.401	0.245	0.577	0.423	0.300	0.220
Improvement of customer trust						
Mean	3.44	2.80 (3, 4, 5)	4.00 (2)	4.00 (2)	**4.07** (2)	1.837
Std. Error	0.503	0.490	0.577	0.289	0.165	0.144
Seeking future customer expectation						
Mean	2.89 (3)	2.80 (3)	**4.67** (1, 2)	4.00	3.86	2.039
Std. Error	0.539	0.490	0.333	0.500	0.275	0.110
After-sales support and assistance						
Mean	3.33 (3, 4, 5)	3.00 (3, 4, 5)	4.33 (1, 2)	4.56 (1, 2)	**4.64** (1, 2)	3.471
Std. Error	0.527	0.707	0.667	0.338	0.133	0.017
Evaluating relationships with customers periodically						
Mean	3.22	2.80 (3, 5)	4.00 (2)	3.67	**4.21** (2)	1.969
Std. Error	0.494	0.583	0.577	0.471	0.114	0.121
Involvement of customers in the design and test of new products						
Mean	2.89 (4, 5)	2.60 (4, 5)	3.67	4.00 (1, 2)	**4.21** (1, 2)	2.582
Std. Error	0.564	0.510	0.667	0.441	0.239	0.054
Involvement of customers in strategic planning activities						
Mean	2.67	1.60 (4, 5)	2.33	**3.11** (2)	2.93 (2)	1.535
Std. Error	0.500	0.245	0.667	0.484	0.245	0.213

Table 7.5 Supply chain management practices by strategic group (continued)

Strategic sourcing management						
Outsource capabilities						
Mean	2.67 (3)	3.20	**3.67** (1)	3.33	2.93	0.391
Std. Error	0.527	0.583	0.333	0.553	0.399	0.814
Sourcing by forward auction						
Mean	2.11	**2.60** (4)	2.00	1.67 (2)	1.86	0.664
Std. Error	0.261	0.812	0.577	0.373	0.254	0.621
Sourcing through multiple channels						
Mean	3.00	**3.40** (4, 5)	2.67	2.00 (2)	2.21 (2)	2.232
Std. Error	0.408	0.510	0.882	0.236	0.261	0.085
Involving sourcing in planning process						
Mean	3.11	3.20	2.67 (4)	**3.78** (3)	2.79	0.858
Std. Error	0.423	0.800	0.882	0.434	0.318	0.499
Strategic delivery management						
Third party logistics management						
Mean	3.44 (3, 4)	3.80	**5.00** (1)	4.78 (1)	3.93	1.657
Std. Error	0.580	0.800	0.000	0.147	0.339	0.182
Customized packaging						
Mean	2.11 (4)	2.40	3.00	**3.11** (1)	3.07	1.032
Std. Error	0.351	0.600	1.155	0.455	0.339	0.404
Application of advanced information systems						
Mean	2.78 (3)	2.60 (3)	**4.00** (1,2,4,5)	2.67 (3)	2.71 (3)	0.585
Std. Error	0.465	0.678	0.577	0.500	0.384	0.676

* Represents the average degree of importance attached to each practice by the cluster. Importance is measured on a five-point Likert scale (1=not important, 5=highly influential). ** The standard error of the estimates of the mean for the group.
Note: The number in parentheses indicate the group numbers from which this group was significantly different as indicated by Duncan pairwise comparison procedure. Numbers in bold indicate the highest group centroid for that measure. The observed F-statistics were derived from one-way ANOVA and the p values are associated with the observed F-statistics.

Table 7.5 shows that, broadly speaking, across clusters, responsive players placed a high emphasis on supplier selection related practices; quick operators placed a high emphasis on sourcing management related practices; quick innovators placed a high emphasis on relationship management related practices; and proactive players 1 and 2 placed high emphases on almost all practices.

The 36 distinguishable practices were ranked within each strategic group based on the calculated mean scores. The ranked 36 practices were divided into 3 sets. Each set contains 12 practices. The top 12 practices was assigned to the top set; the following 12 practices was assigned to the middle set; and the rest 12 practices was assigned to the low set. It was

found that, for responsive players, 7 out of 8 supplier selection practices were included in their top set. For quick operators, 3 out of 4 sourcing management practices were incorporated in their top set. For quick innovators, 6 out of 9 relationship management practices were included in their top set, and the majority of the practices in quick innovators' top set are closely related to customer. Only proactive players 1 and proactive players 2 incorporated practices about strategic design of supply chain in their top sets whilst both of them gave relatively high scores to almost all the practices.

Out of all of the groups responsive players placed the highest emphases on "select suppliers based on the quality they provided," "select suppliers based on their short lead times," "taking into consideration supplier's capability of cost reduction in selection process," "consider suppliers' innovative power as an important criterion in supplier selection" and "consider ease of communication as an important criterion in supplier selection." Additionally, responsive players also placed high emphases on "select suppliers based on the view of total costs," "select suppliers based on their technological and R&D capability," "consider flexibility as an important criterion in supplier selection," "share products information with key suppliers," "sourcing through multiple channels" and "including sourcing in the firm's strategic planning process." This may suggest that, in addition to developing their own capability of quick response to changes, responsive players also require their suppliers to be able to make short production lead times. In addition to this they require them to communicate well and have high flexibility in order to facilitate/ensure their speed of response to various changes. Although responsive players do not place high emphases on quick innovation, they have a high requirement of innovative power and R&D capability for their suppliers. It is possible that they rely on suppliers' innovation power and R&D capability in order to meet requirement of new innovative products of customers

since they do not have strong capability of innovation themselves. By focusing on developing their core capabilities of responsiveness to changes and proactiveness, responsive players compete along the change proficiency dimension. They do not place focus on the development of innovation capability themselves, but they make use of suppliers' innovative power to respond to the requirements for innovative products from the market.

Quick operators had a low emphasis on a majority of the providers. However, they placed high emphases on "including suppliers into product design and development," "outsourcing capability," "sourcing by forward auction," "sourcing through multiple channels" and "including sourcing in planning process." Most of the providers they emphasised are associated with sourcing management, which indicates that they intend to make use of sourcing practices to improve the capabilities they emphasised. This finding provides support for the theory that "increased use of purchasing practices lead to improved agile manufacturing capabilities."(Inman et al., 2010) The choices of these practices may imply that quick operators try to ensure their high speed of operation by achieving high performance on the sourcing function in order to compete along the quick operations/delivery dimension. They may outsource some capabilities and focus on their core capability of high speed operation. By multiple channel sourcing and strategic sourcing planning, quick operators may be able to minimize the possibility of delay or slow speed caused by shortage of materials. In addition to this sourcing from multiple channels may also be helpful to cost control and to increase reliability of delivery.

The quick innovators group is the only strategic group that showed a high emphasis on "vertical integration of supply chain" rather than "horizontal integration." This could be

interpreted as follows. By competing along the quick innovation dimension quick innovators intend to design and manufacture components of products in house as much as possible. The main reasons for doing this may be attributed to the concern of patent security for innovative technologies and products. This is logical since the confidentiality of innovative technologies is critical to the business success of companies who compete by offering creative and innovative products to market in short time. In order to minimize the risk of leaking business confidentiality these companies minimise the sharing of product information with others.

Generally, quick innovators placed high emphases on relationship management related practices. Quick innovators placed higher emphases on “sharing business knowledge of core business processes between trading partners and us,” “keep each other informed about events or changes that may affect the other partners,” “sharing scheduling information with key customers,” “delay final product assembly activities until customer orders have actually been received,” “suppliers participation in lead-time improvement,” “improvement of customer trust,” “seeking future customer expectation,” “after-sales support and assistance,” “evaluating relationships with customer periodically,” “involvement of customers in the design and test of new products,” “outsource capabilities,” “using third party logistics management,” “using customized packaging” and “application of advanced information systems to track/expedite order” than responsive players and quick operators. Given the practices they emphasised, it appears that quick innovators have a strong focus on interaction and communication with customers. This may due to the fact that quick innovators compete by high speed of innovation and new product introduction. In order to do this they need to have very good knowledge about what customers expect from the new product. This enables them to develop innovative products that meet the expectations of

their customers. This method has the potential to minimize the risk of developing unwanted products. By establishing an effective management of the relationship with customers, the success rate of new product introduction can be increased. Quick innovators also placed a high emphasis on “select suppliers based on their short lead times.” This indicates that quick innovators also require their suppliers to have the capability of production in short lead times in order to reach and ensure the high speed of new product introduction to marketplace. However, it is noticeable that quick innovators placed a low emphasis on supplier’s capability of total costs control. This can be logically explained as follows. As quick innovators compete by providing innovative products as fast as the first to market, they derive high margins from the early stage of product life cycles. At this stage they may have power to set prices for products. This has led them to take less care of costs.

Across groups proactive players 1 and 2 placed high emphases on almost all providers. This is in line with capabilities they emphasise and dimensions within which they compete. Both of the groups gave high emphases to all capabilities and intend to compete along all dimensions.

Proactive players 1 gave higher scores than proactive players 2 to the majority of providers. This is consistent with the finding that proactive players 1 have had stronger emphases than proactive players 2 on almost all of the capabilities.

Across clusters, proactive players 1 have given the highest scores to “consideration of the products characteristics,” “consideration of the product life cycles” and “considerations of the nature of demand in strategic design of supply chain.” Proactive players 2 have also placed relatively high emphases on these practices. This suggests that proactive players 1

and proactive players 2 tend to focus strongly on supply chain design related practices when compared with the other strategic groups.

Proactive players 2 placed higher emphasis on “selecting suppliers based on short lead time,” “selecting suppliers based on their technological and R&D capability,” “consider suppliers’ innovative power as an important criterion in supplier selection,” “consider ease of communication as an important criterion in supplier selection,” “sharing scheduling information with key customers,” “delay final product assembly activities until customer orders have actually been received,” “evaluating relationships with customers periodically” and “involvement of customers in the design and test of new products” than proactive players 1. It appears that proactive players 2 rely more on suppliers’ innovative power and R&D capability than proactive players 1. Proactive players 2 also had a higher requirement for short production lead times and good communications with their suppliers. This may suggest that while both proactive players 1 and 2 intend to compete along all dimensions, proactive players 2 placed a high requirement of innovative power and R&D capability on their suppliers. It appears that proactive players 2 intend to derive more innovation and R&D power from their suppliers in order to enhance their competitivity in terms of product innovation. In the same way as proactive players 2 emphasised less on the development of quick operations/delivery capability than proactive players 1, proactive players 2 asked for more from their suppliers’ capability of production in short lead times and ease of communication. This is in order to ensure quick production operations and rapid response to customer demand changes. This corresponds to the idea that while both proactive players 1 and 2 compete along all dimensions, proactive players 2 places less emphases on the capabilities associated with each dimension than proactive players 1.

A summary of SCM practices emphasised by strategic groups is provided in Table 7.6.

Table 7. 6 Summary of emphases on SCM practices by strategic groups

SCM Practices	Responsive Players	Quick Operators	Quick Innovators	Proactive Players 1	Proactive Players 2
Strategic design of SC	Integrating horizontally	Integrating horizontally	Integrating vertically	Integrating horizontally; Consideration of the products characteristics; Consideration of the product life cycles; Consideration of the nature of demand	Integrating horizontally; Consideration of the products characteristics; Consideration of the product life cycles; Consideration of the nature of demand
Careful selection of suppliers	Quality provided; Short lead times; Capability of cost reduction; Innovative power; Ease of communication; Total costs; Technological and R&D capability; Flexibility of acting as a partner			Quality provided; Total costs; Capability of cost reduction; Flexibility of acting as partner; Ease of communication	Technological and R&D capability; Capability of cost reduction; Innovative power; Flexibility of acting as partner; Ease of communication
Supply chain integration	Products information sharing with key suppliers		Business knowledge sharing; Keep informed about events/changes; Scheduling information sharing with key customers; Time postponement	Keep informed about events/changes; Products information sharing with key suppliers; Financial information sharing with key customers; Risk sharing programs	Keep informed about events/changes; Products information sharing with key suppliers; Financial information sharing with key customers; Scheduling information sharing with key customers
Strategic coordination of operations	Sourcing through multiple channels; Involving sourcing in planning process	Including suppliers into product design and development; Outsourcing capabilities; Sourcing by forward auction; Sourcing through multiple channels; Involving sourcing in planning process	Supplier's participation in lead-time improvement; Improvement of customer trust; Seeking future customer expectation; After-sales support and assistance; Evaluating relationships with customers periodically; Involvement of customers in the design and test of new products; Outsourcing capabilities; Using third party logistics management; Using customized packaging Application of advanced information systems	Including suppliers into product design and development; Supplier's participation in lead-time improvement; Improvement of customer trust; Seeking future customer expectation; After-sales support and assistance; Involvement of customers in the design and test of new products; Involvement of customers in strategic planning activities; Outsourcing capabilities; Involving sourcing in planning; Third party logistics management; Customized packaging	Improvement of customer trust; After-sales support and assistance; Evaluating relationships with customers periodically; Involvement of customers in the design and test of new products; Customized packaging

7.5 Linking up agility strategies, corresponding agility providers and agility drivers.

To investigate if and how well their choices were aligned with tasks in their agility strategies, a comparison between agility drivers and agility practices was carried out.

It was found that proactive players 1 and 2 suffered from high pressures on most of the drivers. This might explain why proactive player 1 and 2 emphasised most of the providers in order to compete along all dimensions.

Responsive players gave high priority to supplier's short lead-time, technological and R&D capability, cost reduction capability, innovative power, ease of communication as well as other key supply chain management practices. Their use of these practices may correspond to the pressures they suffered including growth of the niche market, rapidly changing markets, increasing pressure of global market competition, responsiveness of competitors to changes in the marketplace, individualized products and services. Responsive players had a high requirement of supplier selection. This is consistent with the findings of the work of Miemczyk and Howard (2008) that suppliers are a key element of a responsive supply strategy. Miemczyk and Howard (2008) pointed out that close connection with suppliers and the management of planning and forecast information is important in a responsive supply strategy. Yet, failure in effective communication about the market requirement with suppliers leads to problems. This may explain why responsive players in this study also place a high emphasis on products information sharing with key suppliers.

While quick operators suffered from high environmental pressure and the pressure of increasing workforce/workplace expectation, they are the one group that gave the lowest mean values to most of the drivers. The providers they emphasised were related to sourcing management. The correspondence relationships between the pressures they suffered and the providers they emphasised are not strong. Based on the information derived from the survey, quick operators are often contract manufacturers working for other companies. They mainly produce intermediate products. This is potentially why they suffered less pressure from most of drivers. They had chosen to compete by increasing market share through high speed of operations and product delivery. Their emphases on sourcing management related practices may be interpreted as follows. While they outsource capabilities to maintain their central focus on their core competence, through multiple channels sourcing and auction, they are able to avoid unexpected delays in their production processes. This may help them to ensure high speed production and operations, and in turn ensure the quickness of product delivery to customers.

Quick innovators suffered most from the pressures of increasing rate of product model change, product lifetime shrinkage, rapidly changing markets and individualized products and services. The pressures they faced are essentially about rapid changes to products. To deal with the pressures about the product variations, quick innovators placed a strong emphasis on the practices that improve the interaction and communication with customers. This is understandable, as products are valuable only when customers acknowledge their value. While quick innovators compete by quick introduction of new innovative products and derive revenues from the early stages of product life cycles (Zhang and Sharifi, 2007), they need to ensure a high success rate of the new products they introduce. Close interaction and frequent communication with customers may provide quick innovators with

crucial information about future customer expectations and ensure that the new products are able to meet customers' expectations. Effective customer relationship management may help quick innovators set up an appropriate orientation for product development towards customer and market expectations. In turn their market share can be increased. This is consistent with the statement that quick players (referred to quick innovators in this work) intended to increase their market share through customer focus and high speed of operation (referred to high speed of innovation in this work) (Zhang and Sharifi, 2007). Customer focus is found to be highly emphasised by all types of agility strategic groups in this study.

Based on what has been discussed in this chapter, it is noticeable that while proactive players 1 and proactive players 2 emphasised practices on all dimensions of supply chain management, responsive players, quick operators and quick innovators put emphases on supplier selection related practices, sourcing management related practices and customer relationship management related practices, respectively. This suggests that differences exist between the strategic groups in terms of their choices of supply chain management practices. While proactive players experience pressures on almost all drivers and intend to compete by developing all capabilities and emphasised practices on all aspects of supply chain management, different patterns of the choices of supply chain management practices were identified among responsive players, quick operators and quick innovators.

Table 7. 7 Linkages between agility drivers, agility strategies and agility providers

Agility drivers	Agility strategies	Choices of SCM practices as agility providers	Interpretation of linkages
Growth of the niche market, rapidly changing markets, increasing pressure of global market competition, responsiveness of competitors to changes in the marketplace, individualised products and services, etc.	Responsive Players	Supplier selection related practices, e.g. supplier's short lead times, technological and R&D capability, cost reduction capability, innovative power, ease of communication, etc.	Suppliers are a key element of a responsive strategy. Close connection with suppliers and the management of planning and forecast information is important in a responsive supply strategy (Miemczyk and Howard, 2008).
Suffered from the least pressures on almost all of drivers. For this study, quick operators suffered from high environmental pressure and the pressure of increasing workforce / workplace expectation.	Quick Operators	Sourcing management related practices, e.g. outsourcing capabilities, sourcing by forward auction, sourcing through multiple channels, including sourcing in planning process, etc.	No strong linkages between drivers and practices were found. However, a logic interpretation of the linkage between the choice of the strategy and the choices of the SCM practices is that while quick operators outsource capabilities to maintain their central focus on their core competence, through multiple channels sourcing and auction they are able to avoid unexpected delays in production processes.
Increasing rate of product model change, product lifetime shrinkage, rapidly changing markets and individualised products and services, etc.	Quick Innovators	Relationship management related practices (especially on customer side), e.g. sharing business knowledge of core business processes between trading partners and us, keep each other informed about events or changes that may affect the other partners, sharing scheduling information with key customers, suppliers participation in lead-time improvement, improvement of customer trust, seeking future customer expectation, after-sales support and assistance, evaluating relationships with customer periodically, involvement of customers in the design and test of new products, etc.	To deal with the pressures about the product variations, quick innovators placed a strong emphasis on the practices that improve the interaction and communication with customers. Products are valuable only when customers acknowledge their value. While quick innovators compete by quick introduction of new innovative products and derive revenues from the early stages of product life cycles, they need to ensure a high success rate of the new products. Close interaction and frequent communication with customers may be able to provide quick innovators with crucial information about future customer expectations and ensure that the new products are able to meet customers' expectations.
Suffered from high pressures on most of the drivers.	Proactive Players 1	Almost all aspects of SCM practices	As suffered from pressures on almost all drivers, proactive players 1 by developing all agility capabilities emphasise all aspects of supply chain management practices.
Suffered from high pressures on most of the drivers.	Proactive Players 2	Almost all aspects of SCM practices	Similar to proactive players 1, proactive players 2 suffered from pressures on almost all drivers. They intend to develop almost all agility capabilities with special attention on flexibility. The emphases they put on capabilities development are not as high as proactive players 1. The SCM practices they choose are comprehensive covering almost all aspects of SCM.

The linkages between the agility capabilities emphasised, the supply chain management practices chosen and the drivers suffered by the five resultant agility strategic groups were examined. It was found that with the exception of quick operators, all other groups suffered from pressure due to the growth of niche markets within their respective industries. This was based on the extent indicated by the five groups that quick operators experienced the least pressure from the driver of individualized products and services while all of the other groups experienced relatively high pressure from this driver.

Depending on the extent of the pressure each strategic group experienced from increasing innovation rate, it appears that quick innovators produce more innovative products while quick operators produce more functional products. Responsive players were observed to produce both functional and innovative products. Quick innovators, while providing more innovative products, focus on the customer requirements and future expectations of their customers. Quick operators, while providing more functional products, focus on physically efficient operations of sourcing management. From this it appears that innovative products are more customer/market needs oriented while functional products are more cost and operations speed oriented.

Interestingly, the findings above correspond well to the Fisher's (1997) model of the match between supply chains and products. Quick operators providing functional products intend to develop physically efficient supply chains through focusing on sourcing management related practices, corresponding to the upper left square of the Fisher's model (see Figure 7.1). Quick innovators which provide innovative products intend to develop market responsive supply chains through focusing on customer relationship management practices. This corresponds to the bottom right square of Fisher's model.

Physically Efficient Supply Chains	Match	Mismatch
Market Responsive Supply Chains	Mismatch	Match
	Functional products	Innovative products

Figure 7. 1 Matching supply chains with products (Fisher, 1997)

Selldin and Olhager (2007) recently retested Fisher's model using an empirical survey and confirmed the classification scheme for distinguishing between product types and supply chain design types. Additionally, they found that instead of either/or choices of supply chain characteristics associated with different supply chain types, some companies select properties from both supply chain types in order to obtain additional benefits. This led to the creation of a supply chain frontier of physical efficiency and market responsiveness. This finding corresponds well to the agility strategic type of proactive players in this study. While proactive players 1 gave a high score to the driver of increasing innovation rate implying more innovative products, proactive players 2 gave a moderate score to the driver indicating less innovative products. However, since both of them compete by developing all capabilities and emphasising almost all supply chain management practices, they are very much likely to be attempting to use some of the advantages from both types of supply chain.

Responsive players seem to intend to develop market responsive supply chains. This is due to their suffering from the pressure on increasing innovation rate in between quick innovators and quick operators and suffering the most from the pressure on rapidly changing markets. Unlike quick operators and quick innovators, responsive players may not have clear definitions about the characteristics of their products. By competing along the change proficiency dimension, the strategy of responsive players is to respond to changes of market demand rapidly. In this case, they may produce both functional and innovative products. Since they place a low emphasis on developing the capability of quick innovation, they rely on suppliers' R&D capability and innovative power in order to achieve their aims. They enrich the responsiveness of their operation to deal with market changes by deliberately choosing key suppliers and closely integrating with them in terms of products information. This echoed the findings in the work of Miemczyk and Howard (2008) that suppliers are a crucial part of a responsive supply strategy.

7.6 Summary

This chapter has described the analysis of practices chosen by the resultant five agility strategic groups to manage their supply chains. In addition to the inspection of industrial mix across the five groups, a number of key contextual variables were analysed according to the agility strategies the five groups have chosen. The pressures faced by different strategic groups were examined through the analysis of agility drivers. The linkages between the choices of supply chain management practices of different agility strategic groups and the pressures the groups suffered were investigated.

By analysing the supply chain management practices emphasised by the strategic groups, it was found that proactive types of agility players emphasise almost all practices along all dimensions of supply chain management. In addition to this it was found that responsive players placed a strong emphasis on supplier selection related practices, quick operators placed a strong emphasis on sourcing management related practices, and quick innovators placed a strong emphasis on customer relationship management related practices. This answered the second research question that different agility strategies manage their supply chains in different ways by emphasising relevant practices on the different dimensions of supply chain management.

The supply chain management practices the strategic groups emphasised in accordance with the agility drivers they experienced were examined. The possible linkages between the choices of agility strategies and the way of supply chain management and the pressures the agility strategic groups experienced were investigated. This answered the third research question that companies which use different agility strategies emphasise on different aspects of supply chain management practices, and this may relate to the agility drivers companies suffered. The attempts were made to link up the emphases of the five strategic groups on the capabilities and the choices of supply chain management practices with the pressures companies suffered. It was found that the relation between the emphases of quick operators on the capabilities and the pressures they suffered are not strong.

The possible product characteristics associated with different strategic groups based on the emphases placed by the groups on the driver of innovation rate increasing were analysed. It was found that quick innovators with more innovative products tend to take advantages of a market responsive supply chain while quick operators with more functional products tend

to take advantages of a physically efficient supply chain. Responsive players tend to take advantages of a market responsive supply chain by competing along the change proficiency dimension. It was observed that proactive players tend to take advantages of both supply chain types. This corresponds to the classification scheme for product types and corresponding supply chain types developed by Fisher (1997) and Selldin and Olhager (2007).

Chapter8 Conclusions

8.1 Introduction

This chapter concludes the research discussed in this thesis. A brief discussion will be made on the research objectives, the research questions and the research results. It draws conclusions about the effectiveness of the research along the contributions to the existing literature and the limitations of the study. Additional studies that will take this research work further are discussed at the end.

8.2 Research questions, propositions and the answers

The popularity of agility-based manufacturing strategies and the considerably increasing attention received on supply chain management in the past decade motivated this research project for exploring the linkages between agility strategies and supply chain management. Although some efforts have been made in the literature attempting to relate agility to supply chain, rare work has considered the multidimensional nature of agility strategies in the supply chain context. Prior relevant works either limited research scales in the internally organisational operations or presented only very general ideas about supply chain management from an agility point of view. How to develop a manufacturing strategy based on agility and how to design and manage supply chain networks effectively to implement the strategy is not fully understood.

Three primary objectives were set at the beginning of the research. They are:

- To develop a taxonomy of agility strategies for manufacturing industry and to compare the ways of supply chain design and management conducted by members of different strategic groups.
- To examine the most significant differences between agility strategies with respect to supply chain design and management practices.
- To find the relationships among agility strategies, agility providers of supply chain management practices and agility drivers.

Following the findings of Zhang and Sharifi's (2007) empirical research and based on the objectives, the research questions were formulated as below:

1. Are the basic types of agility strategies as identified in Zhang and Sharifi's taxonomic theory still valid in the changing situation? If not, what are the changes to the strategy types?
2. How companies on different agility strategies design and manage their supply chain? Are there clearly identifiable patterns of choices of supply chain design and management practices corresponding to each type of agility strategies? If yes, what are the patterns?
3. Do the choices of agility strategies and ways of supply chain design and management relate to agility drivers companies suffered? How about the nature of market, characteristics of products, and product life cycles? If yes, how are they related?

Several propositions were formed for the research to help answer the research questions.

Proposition 1 – There has been changes on the types of agility strategies discovered in Zhang and Sharifi's work.

Proposition 2 – Different types of agility strategies will have different patterns of choices of supply chain design and management practices.

Proposition 3 – The pressures companies suffered from on agility drivers will have an impact on the choices of agility strategies.

Proposition 4 – The pressures companies suffered from on agility drivers will have an impact on the ways of supply chain design and management.

Proposition 5 – The nature of market, characteristics of products and product life cycles have impacts on the choices of agility strategies and the corresponding ways of supply chain design and management.

Based on the research carried out, some findings have been identified. Firstly, while the basic types of agility strategies identified in Zhang and Sharifi's taxonomy work are still generally valid, two sub types of quick players and two sub types of proactive players are identified. While clear differences in the emphases of agility capabilities still exist between the five resultant groups, a tendency of moving towards becoming more proactive are recognized from quick types of agility players and responsive types of agility players. This has answered the first research question and proposition 1 can be confirmed.

Secondly, while proactive types of agility players emphasise almost all practices along all dimensions of supply chain management, responsive players place a strong emphasis on supplier selection related practices, quick operators place a strong emphasis on sourcing management related practices, and quick innovators place a strong emphasis on customer relationship management related practices. This has answered the second research question and proposition 2 can be confirmed.

Thirdly, proactive players compete by developing capabilities on all dimensions and emphasise practices on all dimensions of supply chain management. This may be because that they suffered from high pressures on almost all drivers presented. Responsive players compete by developing the capabilities of responsiveness along with proactiveness and intend to achieve the objectives through deliberately choosing key suppliers to enrich the responsiveness of their operation over supply chains. This may be due to the pressures they suffered from competitors' increasing responsiveness to market changes, increasing global market competition, rapidly changing markets, etc. Quick innovators compete by developing high speed of operations and intend to fulfil the objectives through effective sourcing management to maintain sufficient and flexible replenishment of materials/resources, avoiding unexpected delay of stops during the production processes that could impede the speed of operations. While they suffered from high pressures on environment issue and workforce/workplace expectation that do not show strong evidence that the emphases on capabilities and the choices of practices are related to the pressures they suffered, the possible reasons why they suffered from such pressures and why they emphasised sourcing management related practices were discussed. Quick innovators compete by developing high speed of innovation along with proactiveness and responsiveness and intend to achieve business success through effectively strong interaction and communication with customers. By choosing to emphasise customer relationship management related practices, accurate information about future customer expectation and requirement of new products may be obtained. Based on this, better orientation/direction of new product development may be well established. The drivers/pressures they suffered most are rapid changes to customers and market expectation. This may be the reason why quick innovators place a strong emphasis on customer relationship management related

practices while developing the capability of high speed of innovation. This has answered the third research question and proposition 3 and proposition 4 can be generally confirmed.

Additionally, by investigating further the drivers of growth of the niche market, product lifetime shrinkage and increasing innovation rate, it has been found that except quick operators all other strategic groups suffered from pressure on the growth of the niche market. This corresponds to the situation that all other groups expect quick operators suffered from pressure on the driver of individualized products and services. This implies that companies positioned in different markets may employ different agility strategies and associated practices to manage their supply chains. On the other hand, it has also been found that only quick innovators suffered from very high pressure on product lifetime shrinkage. Besides, quick innovators suffered from high pressure on increasing innovation rate while quick operators suffered from much less pressure on it. This may indicate that quick innovators make more innovative products which have short product life cycles while quick operators produce more functional products which have long product life cycles. Based on these, it is proposed that differences in the nature of market, characteristics of products and product life cycles may lead to the differences in the choices of agility strategies and the associated practices of supply chain management. Proposition 5 has been confirmed on this basis.

8.3 Research contributions

The research questions developed at the beginning of the research have been answered. Although more in depth empirical research is needed, this research provides an insight about the connections between the different types of agility strategies and the

corresponding manners of supply chain management. Several original contributions have been made through the conduct of the research, and they are summarized as follows:

1. This study revisited the taxonomy developed by Zhang and Sharifi (2007). It has confirmed that the three basic types of agility strategies – responsive type, quick types and proactive types – still exist.
2. While the validity of the basic types of agility strategies were demonstrated, two sub types of quick players and two sub types of proactive players were identified. Although the existence of such sub types of agility strategies has been suspected in the work of Zhang and Sharifi, this study is the first work that has statistically proved it. In addition, a tendency of moving towards being more proactive has been recognized from responsive players and the two types of quick players.
3. While the two types of proactive players compete by developing all the agility capabilities and place high emphases on almost all practices of all dimensions of supply chain management, distinct patterns of the choices of supply chain management practices have been identified among responsive players, quick operators and quick innovators.
4. The possible linkages between the choices of agility strategies and the way of supply chain management and the pressures the agility strategic groups suffered were attempted to present. While the emphases of responsive players and quick innovators on the capabilities and the supply chain management practices and the pressures responsive players and quick innovators suffered were tried to link up, the correlation between the emphases of quick operators on the capability and the practices and the pressures they suffered are not strong.

8.4 Research implications and limitations

In addition to contributions to theory development of agility strategy this research can provide companies with a managerial guide to improve their operations management based on agility.

Most of prior agility related work regarded agility as a holistic concept. The findings of this research further demonstrated the multidimensional nature of agility concept. On the other hand, while some of previous works have considered some management practices in the development of agility strategy, almost all of them only focused on internally organisational management practices. This research bridged the development of agility strategy and supply chain management practices. By assessing the pressures companies suffered from the marketplace and the capabilities they required to achieve the agility objectives, companies can recognise which agility strategy they need to employ and what supply chain management practices can be used to support the implementation of such agility strategy.

While the research questions were answered, the propositions were confirmed and the objectives of the study were successfully accomplished, limitations of the study should be explicit. In general, the limitations inherited in the survey population and the chosen research methodology imposed restriction in the extent of the research horizon and the details. In particular, the strategy related research theme which requires the involvement of top senior executives/managers make the study difficult to obtain high response rate, especially in the depressed economic period caused financial crisis. Although the number

of returned responses provided the required information and was thought to be sufficient to draw conclusions for this study, the response rate was lower than expected.

On the other hand, companies involved in this research are all in U.K. This is due to the time limit and budget consideration. As a result, there is a risk to generalise the results to other geographical regions. Also, caution should be exercised when generalising the results to non-manufacturing industry, such as service and governmental sectors.

8.5 Further work

This research, in addition to developing a taxonomy for agility strategies to revisit the prior relevant work, has discovered distinct patterns of the choices of supply chain management practices corresponding to different agility strategies. The linkages between the choices of agility strategies, the way of supply chain management and the pressures companies suffered have been examined. Additional research aimed at verifying these results is necessary.

In depth case studies will be advantageous to further validate the research results and enhance the results with more details. Larger sample population and sample frames that focus on more varieties of manufacturing companies are necessary to facilitate generalisation of the results. Using data collected recently from manufacturing companies in United Kingdom, changes to the prior taxonomy work (Zhang and Sharifi, 2007) have been identified, although the general continuity of the prior work has been confirmed. This offers further evidence that the testing and replication of taxonomies is an important

element of taxonomic research. Further international studies are needed to challenge and validate the results in different regions.

Appendix A

Agility in Manufacturing Enterprises

Rundong Wang, Exeter Manufacturing Enterprise Centre (XMEC)
School of Engineering, Room 204, Harrison Building, North Park Road, Exeter, EX4 4QF
Tel.: 07825161113, Email: rw271@ex.ac.uk

Please tick or circle the appropriate response(s) or write in the provided spaces.

1- Company profile and product information.

1-1- Name of respondent ----------Job Title ----------

Name of company ----------

Address of company ----------

Postcode ---------- Tel. No. ---------- Fax No. ---------- Email ----------

1-2- To what industry sector does your company belong? ----------

1-3- Is the company: 1) UK owned 2) Non UK owned 3) Subsidiary 4) Independent

1-4- How many on site employees are there? ----------APPROX.

1-5- What was the average level of on site annual turnover in the last THREE years? £m ----------APPROX.

1-6- Do you produce mainly: 1) Raw material 2) Finished marketable products
3) Intermediate products (Components need further assembly)

1-7- How many different types of finished products does the company manufacture? ----------APPROX.

1-8- How many new products has your company introduced to market in the last THREE years? ------APPROX.

1-9- What percentage of these products have been successful (as defined by the company)? ---------% APPROX.

1-10- What percentage of your products is exported? ----------% APPROX

1-11- Which of the following best describe the company's production type?

1) Engineering to order 3) Manufacture to order 5) Manufacture to stock (Mass production)
2) Assemble to order 4) Mass customisation 6) Other (Please specify) ----------

1-12- What is the average lead time for your major product (From concept to cash (sale))?------Month APPROX.

1-13- How new are your products usually? (Please indicate an approximate percentage)

1- Complete Innovation ----------% 3- Improved Products ---------- %
2- New lines (not new to market) ----------% 4- Custom made (Tailored) ----------%

1-14- What percent of turnover is being invested in R&D programmes? ----------% APPROX.

1-15- What are the real priorities of the company's business?

(please rank in order from 1to 6, **1=The most important**, **6=NOT important at all**)

1- Quality( ) 2- Low cost( ) 3- Flexibility( )

4- Time( ) 5- Profit( ) 6- Sales volume( )

1-16- What sort of manufacturing control system is being utilised in the company? For how many years?

1- Mainly manual for ---------years 2- MRPI/MRPII for ---------years

3- JIT/Kanban for ---------years 4- Optimised Production Technology (OPT) based for ------years

5- Other (please specify) ----------for ---------years

1-17- Is the company? (Please tick both if applicable)

1- ISO 9000 (or equivalent) accredited 2- TQM company

1-18- How many companies are in the supply chain of the company? ---------APPROX.

1-19- How many of them are main suppliers? ---------APPROX.

1-20- How many of these are chosen as partners? ---------APPROX.

1-21- How many customers does the company have? ---------APPROX.

1-22- How many of them are your main customers? ---------APPROX.

1-23- How do you evaluate your company's position in the marketplace?

1 = Leader 5 = Not successful

1 2 3 4 5

1-24- How familiar are you with the concept/strategy of AGILITY?

1 = Not heard of it 5 = Completely Familiar

1 2 3 4 5

1-25- What would you consider on a scale of 1 to 5, as the degree of your company's capability in agility components, according to the definition given in the attached explanatory text? (1=Not at all, 5=Highly)

PROACTIVENESS	1	2	3	4	5
RESPONSIVENESS	1	2	3	4	5
COMPETENCY	1	2	3	4	5
FLEXIBILITY	1	2	3	4	5
QUICKNESS IN PRODUCT DEVELOPMENT	1	2	3	4	5
QUICKNESS IN PRODUCT/SERVICE DELIVERY	1	2	3	4	5
CUSTOMER FOCUS	1	2	3	4	5
PARTNERSHIP	1	2	3	4	5
TRANSPARANCY	1	2	3	4	5

2- Agility Drivers

2-1- Is the company being affected by CHANGE in the business environment factors? ☐YES ☐NO

2-2- If yes, then to what extent?

Slightly				Highly
1	2	3	4	5

Some external and probably some internal factors are the cause of being agile, or agility drivers

In questions 2-3 to 2-7, please specify to what extent each of the suggested drivers have influenced your company's business in recent years.

PLEASE CIRCLE THE APPROPRIATE RESPONSE

1 = NOT IMPORTANT 5 = HIGHLY INFLUENTIAL (VITAL)

2-3: Change in marketplace:

1- Growth of the niche market	1	2	3	4	5
2- Opening of new local or foreign markets or closing of some others because of political change	1	2	3	4	5
3- Increasing rate of change in product models	1	2	3	4	5
4- Product lifetime shrinkage	1	2	3	4	5
5- Decreasing cost of entering niche market	1	2	3	4	5

2-4: Change in competition basis:

1- Rapidly changing markets	1	2	3	4	5
2- Increasing pressures on cost/profitability	1	2	3	4	5
3- Innovation rate increasing	1	2	3	4	5
4- Increasing pressure of global market competition	1	2	3	4	5
5- Decreasing new product time-to-market	1	2	3	4	5
6- Responsiveness of competitors to changes in marketplace	1	2	3	4	5
7- Effectiveness of competitors' strategy, marketing, distribution, services, etc.	1	2	3	4	5

2-5: Change in customers requirements:

1- Individualised products and services	1	2	3	4	5
2- Quicker delivery time and time-to-market	1	2	3	4	5
3- Quality expectation increasing	1	2	3	4	5
4- Increasing value of information/services	1	2	3	4	5

2-6: Social changes:

1- Environmental pressures (e.g. climate change)	1	2	3	4	5
2- Workforce/workplace expectations	1	2	3	4	5
3- Legal/political pressures	1	2	3	4	5
4- Cultural pressures	1	2	3	4	5
5- Social contract change	1	2	3	4	5

2-**7**: Internal drivers:

1- Strategy of continuous improvement	1	2	3	4	5
2- Moving towards excellence	1	2	3	4	5

3- Agility strategy : In response to change, in order to survive, prosper, and take competitive advantage, which of the following are being considered as the strategy for the company **(please tick in the left box)**.

Also please indicate degree of importance from 1 to 5 in the right side: **1= not important 5=very important**

☐	1- Acting **proactively** instead of reactively (attacking threats and opportunities)	1	2	3	4	5
☐	2- Increasing **responsiveness** to change	1	2	3	4	5
☐	3- Increasing total **competency** of the co. and organizing around core competency	1	2	3	4	5
☐	4- Increasing **flexibility**	1	2	3	4	5
☐	5- Increasing **quickness (speed)**	1	2	3	4	5
	☐ 5-1 of innovation, new product introduction and first to market	1	2	3	4	5
	☐ 5-2 of operations and product delivery	1	2	3	4	5
☐	6- **Focusing on customer**	1	2	3	4	5
☐	7- Concrete relationship with suppliers and moving towards **partnership**	1	2	3	4	5
☐	8- Increasing **transparency** of information across the supply chain	1	2	3	4	5

4- Supply chain management as agility provider

In questions 4-1 to 4-4, please specify to what extend you think each of the following practices is important to your company.

4-1: **Strategic design of supply chains**

1=Not applicable 2=Less important 3=Moderately important
4=Important 5=Highly important

- We consider the characteristics of products in supply chain design process.	1	2	3	4	5
- We consider the product life cycles in supply chain design process.	1	2	3	4	5
- We consider the nature of demand for the products in supply chain design process.	1	2	3	4	5

- Our supply chain is designed to be vertically integrated (We design and manufacture components in house where possible).	1 2 3 4 5
- Our supply chain is designed to be distributed horizontally (We work on our core competency and outsource non-core capabilities).	1 2 3 4 5
- We consider the alignment of corporate strategy and supply strategy in supply chain design process.	1 2 3 4 5

4-2: **Careful selection of suppliers**

- We select our suppliers based on the quality they provided.	1 2 3 4 5
- We select our suppliers based on the price they provided.	1 2 3 4 5
- We consider delivery reliability (compliance with due date and compliance with quantity) as an importance criterion of supplier selection.	1 2 3 4 5
- We choose our suppliers globally.	1 2 3 4 5
- We choose our suppliers locally.	1 2 3 4 5
- We select our suppliers based on their short lead times.	1 2 3 4 5
- We place a high weight on change-response capabilities in supplier selection (including both order delivery changes responsiveness and order volume changes responsiveness).	1 2 3 4 5
- We take into account suppliers' manufacturing production capacity in selection process.	1 2 3 4 5
- We select our suppliers based on the view of total costs (i.e. taking all opportunity costs and maintenance cost into consideration).	1 2 3 4 5
- We care about supplier's technological and R&D capability.	1 2 3 4 5
- We take into account supplier's capability of cost reduction in selection process.	1 2 3 4 5
- We consider innovative power as an important criterion of supplier selection.	1 2 3 4 5
- We consider flexibility as an important criterion of supplier selection.	1 2 3 4 5
- We consider ease of communication as an important criterion of supplier selection.	1 2 3 4 5
- We consider supplier's financial status in selection process.	1 2 3 4 5
- We consider supplier's reputation as one of criteria in selection process.	1 2 3 4 5
- We consider supplier's performance history in selection process.	1 2 3 4 5
- We select supplier based on the IT/software compatibility.	1 2 3 4 5

4-3: **Supply chain integration**

4-3-1: ***Information integration***

- We provide our customers with real time update on order process.	1 2 3 4 5
- Our trading partner share business knowledge of core business processes with us.	1 2 3 4 5

- We and our trading partners exchange information that helps establishment of business planning.	1 2 3 4 5
- We and our trading partners keep each other informed about events or changes that may affect the other partners.	1 2 3 4 5
- We share financial information with key suppliers.	1 2 3 4 5
- We share production information with key suppliers.	1 2 3 4 5
- We share design information with key suppliers.	1 2 3 4 5
- We share financial information with key customers.	1 2 3 4 5
- We share production information with key customers.	1 2 3 4 5
- We share design information with key customers.	1 2 3 4 5
- We use direct computer-to-computer network links (i.e. EDI) with key suppliers.	1 2 3 4 5
- We and our key suppliers share the results of performance measures with each other to improve the efficiency and effectiveness of the supply chain processes.	1 2 3 4 5
- We collect customer orders by our electronic information system (e.g. email, company's on-line shop).	1 2 3 4 5
- Our key customers share scheduling information with us.	1 2 3 4 5

4-3-2: ***Process integration***

- We use vendor managed inventory (VMI).	1 2 3 4 5
- We delay final product assembly activities until customer orders have actually been received (time postponement).	1 2 3 4 5
- We delay final product assembly activities until the last possible position (nearest to customers) in the supply chain (place postponement).	1 2 3 4 5
- We conduct conformance checks (continual or random testing of the quality of goods inwards and goods outwards).	1 2 3 4 5
- We use computer aided acquisition and logistics support (CALS) to manage our internal and external logistics.	1 2 3 4 5
- We conduct collaborative planning, forecasting and replenishment (CPFR) to ensure process integration.	1 2 3 4 5
- We develop risk sharing programs and activities to integrate operations with other supply chain members.	1 2 3 4 5
- We use electronic transfer of purchase orders, invoices and/or funds.	1 2 3 4 5
- We synchronize logistics with product demand patterns.	1 2 3 4 5

4-4: **Strategic coordination of operations**

4-4-1: ***Strategic relationship management***

- We attempt to solve problems jointly with suppliers.	1 2 3 4 5
- We have continuous improvement programs that include key suppliers.	1 2 3 4 5
- We include key suppliers in planning and goal-setting activities.	1 2 3 4 5
- We involve key suppliers in new product design and development processes.	1 2 3 4 5
- We require major suppliers to participate into quality improvement.	1 2 3 4 5
- We require major suppliers to participate into cost improvement.	1 2 3 4 5
- We require major suppliers to participate into lead-time improvement.	1 2 3 4 5
- We maintain close relationship with selected suppliers from our supplier pool.	1 2 3 4 5
- We view our key suppliers as an extension of our company.	1 2 3 4 5
- We share profits with our key suppliers.	1 2 3 4 5
- We design project teams that include supplier's staff.	1 2 3 4 5
- We participate in the material sourcing decisions of our suppliers.	1 2 3 4 5
- We audit our suppliers.	1 2 3 4 5
- We interact with customers to set reliability, responsiveness and other targets for us.	1 2 3 4 5
- We show our desire for future dealings with our customers to improve their trust.	1 2 3 4 5
- We measure and evaluate customer satisfaction.	1 2 3 4 5
- We seek to future customer expectations.	1 2 3 4 5
- We provide after-sales support and assistance to customers and facilitate customer's ability to seek assistance from us.	1 2 3 4 5
- We periodically evaluate the importance of our relationships with our customers and prioritise them.	1 2 3 4 5
- We involve customers in the design and test of new products.	1 2 3 4 5
- We involve customers in strategic planning activities.	1 2 3 4 5

4-4-2: ***Strategic sourcing management***

- We outsource capabilities.	1 2 3 4 5
- We conduct sourcing through forward auction (we bid for seller's goods).	1 2 3 4 5
- We conduct sourcing through reverse auction (sellers bid for our order).	1 2 3 4 5
- We split the supply contract to multiple suppliers, sourcing through multiple channels.	1 2 3 4 5
- We include sourcing in the firm's strategic planning process.	1 2 3 4 5

4-4-3: ***Strategic delivery management***

- We utilize third-party logistics to deliver our products.	1 2 3 4 5
- We use fourth party logistics to manage our delivery.	1 2 3 4 5
- We customize packaging for our customers.	1 2 3 4 5
- We use common logistical equipment/containers.	1 2 3 4 5
- We use automatic identification (e.g. RFID or bar code) during the delivery process to track order status.	1 2 3 4 5
- We use advanced information systems to track and/or expedite order.	1 2 3 4 5

5- General

5-1- Please feel free to add any comments or details here. (PLEASE CONTINUE ON THE REVERSE SIDE OF THIS PAGE IF NECESSARY)

_____

_____

_____

_____

_____

5-2- The next stage of the research will involve semi-structured interviews and/or case studies. Would your company be willing to take part in this second phase?

Interview	YES ☐	NO ☐
Case Study	YES ☐	NO ☐

5-3- Would you like to receive a copy of the results? YES ☐ NO ☐

Thank you again for your invaluable assistance

Explanatory Text

Explanation for some terms appeared in the questionnaire:

Capability of cost reduction – the ability of fulfilment of operations with less cost by continuous improvement.

Collaborative planning, forecasting, and replenishment (CPFR) – Both buyer and supplier share internal information to integrate their plans, forecasts, and delivery schedule to ensure a smooth flow of goods and services as they are needed.

Competency – The capability to operate efficiently, produce high-quality and high-performance products, deliver on time, innovate, and manage core competency.

Computer aided acquisition and logistics support (CALS) – Close integration among buyers and vendors or the different units of an enterprise, created and sustained through application of standard technologies (such as electronic data interchange-EDI), streamlining of business processes, and effective use of business and technical information.

Flexibility – the capability to perform different tasks and achieve different objectives with the same set of resources/facilities.

Focusing on customer – The capability to operate at high speed in products and service delivery.

Fourth party logistics – Arrangement in which a firm outsources its logistical operations to two or more specialist firms (the third party logistics) and hires another specialist firm (the fourth party) to coordinate the activities of the third parties.

Information system – Combination of hardware, software, infrastructure and trained personnel organised to facilitate planning, control, coordination and decision making.

Key suppliers – Those who possess long-term contract with us.

Partnership – The capability to form concrete relationship with suppliers and to partner.

Proactiveness – The capability to act proactively instead of reactively (in attacking threats and opportunities).

Production capacity – Volume of products that can be generated by a production plant or enterprise in a given period by using current resources.

Quickness in product development – The capability to innovate at high speed, to develop products rapidly, and to have a short time to market.

Quickness in product/service delivery – The capability to operate at high speed in products and service delivery.

Responsiveness – The capability to identify, respond to and recover from changes.

Synchronisation of logistics – The manufacturing and logistics are aligned to the product demand by synchronising operations and supply.

Third party logistics – Arrangement in which a firm with long and varied supply chains outsources its logistical operations to one or more specialist firms, the third party logistics providers.

Transparency – The capability to form a transparent, smooth and efficient information stream across supply chain and to acquire prompt information from marketplace and other members involved in the supply chain.

Vendor managed inventory (VMI) – Inventory replenishment arrangement whereby the supplier either monitors the customer's inventory with own employees or receives stock information from the customer. The vendor then refills the stock automatically, without the customer initiating purchase order.

References

ADAM, E. E. & SWAMIDASS, P. M. 1989. Assessing operations management from a strategic perspective. *Journal of Management,* 15**,** 181-203.

AGARWAL, A., SHANKAR, R. & TIWARI, M. K. 2006. Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach. *European Journal of Operational Research,* 173**,** 211-225.

AGARWAL, A., SHANKAR, R. & TIWARI, M. K. 2007. Modeling agility of supply. *Industrial Marketing Management,* 36**,** 443-457.

ALDENDERFER, M. S. & BLASHFIELD, R. K. 1984. *Cluster analysis,* London, U.K., Sage.

ALLEN, B. & HAMILTON, I. 1982. *Manufacturing strategy: concepts and application*.

ALVARADO, U. Y. & KOTZAB, H. 2001. Supply Chain Management The Integration of Logistics in Marketing. *Industrial Marketing Management,* 30**,** 183-183.

ANDERSON, J. C., CLEVELAND, G. & SCHROEDER, R. G. 1989. Operations strategy: a literature review. *Journal of Operations Management,* 8**,** 133-158.

ARABIE, P. & HUBER, L. 1994. *Cluster analysis in marketing research. In: Bagozzi, R.P. (Ed.), Advanced Methods in Marketing Research,* Oxford, Blackwell.

ARMISTEAD, C. G. & MAPES, J. 1993. The impact of supply chain integration on operating performance. *Logistics Information Management,* 6**,** 9-14.

AVIV, Y. 2007. On the benefits of collaborative forecasting partnerships between retailers and manufacturers. *Management Science,* 53**,** 777-794.

BABBIE, E. 1990. *Sruvey Research Methods,* Wadsworth, Belmont, CA.

BAKER, J. 1996. Agility and flexibility, what's the difference? *working Paper, The Cranfield School of Management.* Cranfield, U.K.: Cranfield University.

BARAMICHAI, M., ZIMMERS, E. W. & MARANGOS, C. A. 2007. Agile supply chain transformation matrix: an integrated tool for creating an agile enterprise. *Supply Chain Management-an International Journal,* 12**,** 334-348.

BARAMICHAI, M., ZIMMERS JR, E. W. & MARANGOS, C. A. 2006. A comprehensive framework for evaluating suppliers' agile performance. *International Journal of Agile Manufacturing,* 9**,** 37-51.

BESSANT, J., BROWN, S., FRANCIS, D. & MEREDITH, S. 2001. Developing manufacturing agility in SMEs. *International Journal of Technology Management,* 22**,** 28-54.

BLACK, A. S. & PORTER, J. L. 1996. Identification of the critical factors of TQM. *Decision Sciences,* 27**,** 1-21.

BOLDEN, R., WATERSON, P., WARR, P., CLEGG, C. & WALL, T. 1997. A new taxonomy of modern manufacturing practices. *International Journal of Operations & Production Management,* 17**,** 1112-+.

BOOTH, R. 1996. Agile manufacturing *Engineering Management Journal* 6**,** 105-112.

BREU, K., HEMINGWAY, J. C. & STRATHERN, M. 2001. Workforce agility: the new employee strategy for the knowledge economy. *Journal of Information Technology,* 17**,** 21-31.

BURGESS, K., SINGH, P. J. & KOROGLU, R. 2006. Supply chain management: a structured literature review and implications for future research. *International Journal of Operations & Production Management,* 26**,** 703-729.

CARTER, C. R., SANDERS, N. R. & DONG, Y. 2008. Paradigms, revolutions, and tipping points: the need for using multiple methodologies within the field of supply chain management. *Journal of Operations Management,* 26**,** 693-696.

CHANDRA, C. & KUMAR, S. 2000. Supply chain management in theory and practice: a passing fad or a fundamental change? *Industrial Management & Data Systems,* 100**,** 100-113.

CHEN, I., PAULRAJ, A. & LADO, A. 2004. Strategic purchasing, supply management, and firm performance. *Journal of Operations Management,* 22**,** 505-523.

CHEN, I. J. & PAULRAJ, A. 2004. Towards a theory of supply chain management: the constructs and measurements. *Journal of Operations Management,* 22**,** 119-150.

CHEN, Y. J., SESHADRI, S. & ZEMEL, E. 2008. Sourcing through auctions and audits. *Production and Operations Management,* 17**,** 121-138.

CHO, H., JUNG, M. & KIM, M. 1996. Enabling technologies of agile manufacturing and its related activities in Korea. *Computers & Industrial Engineering,* 30**,** 323-334.

CHOW, W. S., MADU, C. N., KUEI, C. H., LU, M. H., LIN, C. H. & TSENG, H. J. 2008. Supply chain management in the US and Taiwan: An empirical study. *Omega-International Journal of Management Science,* 36**,** 665-679.

CHRISTOPHER, M. 2000. The agile supply chain: competing in volatile markets. *Industrial Marketing Management,* 29**,** 37-44.

CHRISTOPHER, M. & TOWILL, D. R. 2000. Supply chain migrationfrom lean and functional to agile and customised. *Supply Chain Management-an International Journal,* 5**,** 206-213.

CHURCHILL, G. A. 1979. A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research,* 16**,** 64-73.

COOPER, M. C., LAMBERT, D. M. & PAGH, J. D. 1997. Supply chain management: more than a new name for logistics. *International journal of logistics management,* 8**,** 1-13.

COUSINS, P. D., LAWSON, B. & SQUIRE, B. 2006. An empirical taxonomy of purchaing functions. *International Journal of Operations & Production Management,* 26**,** 775-794.

CRONBACH, L. J. 1951. Coefficient alpha and the internal structure of tests. *Psychometrika,* 16**,** 297-334.

DANGAYACH, G. S. & DESHMUKH, S. G. 2001. Manufacturing strategy - Literature review and some issues. *International Journal of Operations & Production Management,* 21**,** 884-932.

DAS, A. 2001. Towards theory building in manufacturing flexibility. *International Journal of Production Research,* 39**,** 4153-4177.

DE LIMA, E. P., DA COSTA, S. E. G. & DE FARIA, A. R. 2009. Taking operations strategy into practice: Developing a process for defining priorities and performance measures. *International Journal of Production Economics,* 122**,** 403-418.

DESS, G. & DAVIS, P. 1984. 'Porter's (1980) generic strategies as determinants of strategic group membership and organizational performance'. *Academy of Management Journal,* 27**,** 467-488.

DEVOR, R., GRAVES, R. & MILLS, J. J. 1997. Agile manufacturing research: accomplishments and opportunities. *IIE Transactions,* 29**,** 813-823.

DICKSON, G. 1966. An analysis of vendor selection systems and decisions. *Journal of purchasing,* 2**,** 5-17.

DILLMAN, D. A. 1978. *Mail and telephone survey: the design method,* New York, NY, John Wiley & Sons.

DILLON, W. R. & GOLDSTEIN, M. 1984. *Multivariate analysis: methods and applications,* New York, Wiley.
DOVE, R. 1994-1996. Agile and otherwise. *Series of articles on Agile Manufacturing, Production Magazine,* November 1994 to July 1996.
DOVE, R. 1996. Agility Forum Brief. *Agility Forum, Lehigh University, USA.*
DROGE, C., JAYARAM, J. & VICKERY, S. K. 2004. The effects of internal versus external integration practices on time-based performance and overall firm performance. *Journal of Operations Management,* 22**,** 557-573.
DRUCKER, P. F. 1968. Comeback of the entrepreneur. *Management Today,* April.
DWYER, F. R. & WELSH, M. A. 1985. Environmental relationships of the internal political economy of marketing channels. *Journal of Marketing Research,* 22**,** 397-414.
FARMER, D. 1997. Purchasing myopia revisited. *European Journal of Purchasing and Supply Management,* 3**,** 1-8.
FILIPPINI, R. 1997. Operations management research: Some reflections on evolution, models and empirical studies in OM. *International Journal of Operations & Production Management,* 17**,** 655-&.
FINE, C. H. & HAX, A. C. 1985. Manufacturing strategy: a methodology and an illustration. *Interfaces,* 15**,** 28-46.
FISHER, M. L. 1997. What is the right supply chain for your product? *Harvard Business Review,* 75**,** 105-116.
FLYNN, B. B., SAKAKIBARA, S., SCHROEDER, G. R., BATES, A. K. & FLYNN, J. E. 1990. Empirical research methods in operations management. *Journal of Operations Management,* 9**,** 250-284.
FLYNN, B. B., SCHROEDER, G. R., FLYNN, E. J., SAKAKIBARA, S. & BATES, A. K. 1997. World-class manufacturing project: overview and selected results. *International Journal of Operations & Production Management,* 17**,** 1997.
FLYNN, B. B., SCHROEDER, G. R. & SAKAKIBARA, S. 1994. A framework for quality management research and an associated measurement instrument. *Journal of Operations Management,* 11**,** 339-366.
FORNELL, C. 1978. Three approaches to canonical analysis. *Journal of the Marketing Research Society,* 20**,** 166-181.
FORZA, C. 2002. Survey research in operations management: a process-based perspective. *International Journal of Operations & Production Management,* 22**,** 152-194.
FROHLICH, M. T. 2002. Techniques for improving response rates in OM survey research. *Journal of Operations Management,* 20**,** 53-62.
FROHLICH, M. T. & DIXON, J. R. 2001. A taxonomy of manufacturing strategies revisited. *Journal of Operations Management,* 19**,** 541-558.
FROHLICH, M. T. & WESTBROOK, R. 2001. Arcs of integration: an international study of supply chain strategies. *Journal of Operations Management,* 19**,** 185-200.
GHODSYPOUR, S. H. & O'BRIEN, C. 1998. A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. *International Journal of Production Economics,* 56-57**,** 199-212.
GIACHETTI, R. E., MARTINEZ, L. D., SAENZ, O. A. & CHEN, C.-S. 2003. Analysis of the structural measures of flexibility and agility using a measurement theoretical framework. *International Journal of Production Economics,* 86**,** 47-62.
GOLDMAN, S. L., NAGEL, R. N. & PREISSK, K. 1995. *Agile Competitors and Virtual Organizations: Strategies for Enriching the Customer,* New York, Van Nostrand Reinhold.

GOTTFREDSON, M., PURYEAR, R. & PHILLIPS, S. 2005. Strategic sourcing - from periphery to the core. *Harvard Business Review,* 83**,** 132-139.
GREEN, P. E. 1978. *Analyzing multivariate data,* Hinsdale, IL, Dryden Press.
GUNASEKARAN, A. 1998. Agile manufacturing: enablers and an implementation framework. *International Journal of Production Research,* 36**,** 1223-1247.
GUNASEKARAN, A. 1999. Agile manufacturing: A framework for research and development. *International Journal of Production Economics,* 62**,** 87-105.
GUNASEKARAN, A., LAI, K. H. & CHENG, T. C. E. 2008. Responsive supply chain: A competitive strategy in a networked economy. *Omega-International Journal of Management Science,* 36**,** 549-564.
GUNASEKARAN, A. & NGAI, E. W. T. 2004. Information systems in supply chain integration and management. *European Journal of Operational Research,* 159**,** 269-295.
GUNASEKARAN, A. & NGAI, E. W. T. 2005. Build-to-order supply chain management: a literature review and framework for development. *Journal of Operations Management,* 23**,** 423-451.
HALLDORSSON, A., KOTZAB, H., MIKKOLA, J. H. & SKJOTT-LARSEN, T. 2007. Complementary theories to supply chain management. *Supply Chain Management-An International Journal,* 12**,** 284-296.
HAMEL, G. & PRAHALAD, C. K. 1994. Competing for the future. *Harvard Business Review,* July-August**,** 122-128.
HAMMEL, T. R. & KOPCZAK, L. R. 1993. Tightening the supply chain. *Production and Inventory Management Journal,* 34**,** 63-70.
HARLAND, C. M., LAMMING, R. C. & COUSINS, P. D. 1999. Developing the concept of supply strategy. *International Journal of Operations & Production Management,* 19**,** 650-673.
HARRIGAN, K. R. 1985. An application of clustering for strategic group analysis. *Strategic Management Journal* 16**,** 55-73.
HAYEN, G. J. J. M. 1988. Change, challenge and continuity: An entrepreneurial vision from an electronics multinational. *International Journal of Technology Management,* 3.
HAYES, R. H. 1985. Strategic planning-forward in reverse. *Harvard Business Review,* November-December.
HAYES, R. H. & SCHMENNER, R. W. 1978. How should you organize manufacturing? *Harvard Business Review,* January-February**,** 105-119.
HAYES, R. H. & WHEELWRIGHT, S. C. 1984. *Restoring our competitive edge: competing through manufacturing,* New York, John Wiley and Sons.
HENSLEY, R. L. 1999. A review of operations management studies using scale development techniques. *Journal of Operations Management,* 17**,** 343-358.
HILL, T. 2000. *Manufacturing strategy: text and cases,* Basingstoke, U.K., Palgrave.
HOCHBERG, Y. & TAMHANE, A. C. 1987. *Multiple comparison procedures,* Canada, John Wiley & Sons.
HOLWEG, M. 2005. The three dimensions of responsiveness. *International Journal of Operations & Production Management,* 25**,** 603-622.
HUANG, S. H. & KESKAR, H. 2007. Comprehensive and configurable metrics for supplier selection. *International Journal of Production Economics,* 105**,** 510-523.
HULT, G. T. M. & CHABOWSKI, R. B. 2008. Sourcing research as an intellectual network of ideas. *Decision Sciences,* 39**,** 323-335.

HULT, G. T. M., KETCHEN, D. J. & ARRFELT, M. 2007. Strategic supply chain management: Improving performance through a culture of competitiveness and knowledge development. *Strategic Management Journal,* 28**,** 1035-1052.

INMAN, R. A., SALE, R. S., JR GREEN, W. K. & WHITTEN, D. 2010. Agile manufacturing: relation to JIT, operational performance and firm performance. *Journal of Operations Management*.

ISMAIL, H. S., SNOWDEN, S. P., POOLTON, J., RIED, I. R. & AROKIAM, I. 2006. Agile manufacturing framework and practice. *International Journal of Agile Systems and Management,* 1**,** 11-28.

JOHNSON, R. A. & WICHERN, D. W. 1998. *Applied multivariate statistical analysis,* Prentice-Hall International, Inc.

JONES, T. C. & RILEY, D. W. 1987. Using inventory for competitive advantage through supply chain management. *International journal of Physical Distribution & Materials Management,* 17**,** 94-104.

KATAYAMA, H. & BENNETT, D. 1999. Agility, adaptability and leanness: a comparison of comcepts and a study of practice. *International journal of production economics,* 62**,** 43-51.

KATHAWALA, Y. K. & ABDOU, K. 2003. Supply chain evaluation in the service industry: a framework development compared to manufacturing. *Managerial Auditing Journal,* 18**,** 140-149.

KATHURIA, R. 2000. Competitive priorities and managerial performance: a taxonomy of small manufacturers. *Journal of Operations Management,* 18**,** 627-641.

KAUFFMAN, R. G. 2002. Supply management: what's in a name? Or, do we know who we are? *The Journal of Supply Chain Management,* Fall**,** 46-50.

KEHOE, D. F., DANI, S., SHARIFI, H., BURNS, N. D. & BACKHOUSE, C. J. 2007. Demand network alignment: aligning the physical, informational and relationship issues in supply chains. *International Journal of Production Research,* 45**,** 1141-1160.

KERLINGER, F. N. 1986. *Foundations of behavioral research,* Holt, Rinehart & Winston, New York.

KETCHEN, D. J. & HULT, G. T. M. 2007. Bridging organization theory and supply chain management: The case of best value supply chains. *Journal of Operations Management,* 25**,** 573-580.

KETCHEN, D. J. & SHOOK, C. L. 1996. The application of cluster analysis in strategic management research: An analysis and critique. *Strategic Management Journal,* 17**,** 441-458.

KETCHEN, D. J., THOMAS, J. B. & SNOW, C. C. 1993. Organizational configurations and performance: a comparison of theoretical approaches. *Academy of Management Journal,* 36**,** 1278-1313.

KIDD, P. T. 1994. *Agile Manufacturing: Forging New Frontiers,* Reading, MA, Addison-Wesley.

KOSTE, L. L. & MALHOTRA, M. K. 1999. A theoretical framework for analyzing the dimensions of manufacturing flexibility. *Journal of Operations Management,* 18**,** 75-93.

KOSTE, L. L., MALHOTRA, M. K. & SHARMA, S. 2004. Measuring dimensions of manufacturing flexibility. *Journal of Operations Management,* 22**,** 171-196.

KOTHA, S. & SWAMIDASS, P. M. 2000. Strategy, advanced manufacturing technology and performance: empirical evidence from US manufacturing firms. *Journal of Operations Management,* 18**,** 257-277.

KRAUSE, D. R. & ELLRAM, L. M. 1997. Critical elements of supplier development. *European Journal of Purchasing and Supply Management,* 3**,** 21-31.
LA LONDE, B. J. 1998. Supply chain evolution by the numbers. *Supply Chain Management Review* 2**,** 7-8.
LAMBERT, D. M. & COOPER, M. C. 2000. Issues in supply chain management. *Industrial Marketing Management,* 29**,** 65-83.
LAMBERT, D. M. & HARRINGTON, T. C. 1990. Measuring nonresponse bias in customer service mail surveys. *Journal of Business Logistics,* 11**,** 5-25.
LANCIONI, R. A. 2000. New developments in supply chain management for the millennium. *Industrial Marketing Management,* 29**,** 1-6.
LANNERS, W. J. & LOGAN, J. W. 2004. A technique for assessing an organisation's ability to change. *IEEE Transaction on Engineering Management,* 51**,** 483-488.
LAU, H. C. W., LEE, C. K. M., HO, G. T. S., IP, W. H., CHAN, F. T. S. & IP, R. W. L. 2006. M-commerce to support the implementation of a responsive supply chain network. *Supply Chain Management-an International Journal,* 11**,** 169-178.
LEE, E. K., HA, S. & KIM, S. K. 2001. Supplier selection and management system considering relationships in supply chain management. *IEEE Transactions on Engineering Management,* 48**,** 307-318.
LEONG, G. K., SNYDER, D. L. & WARD, P. T. 1990. Research in the process and content of manufacturing strategy. *Omega-International Journal of Management Science,* 18**,** 109-122.
LEWIS, P. & THOMAS, H. 1990. The linkage between strategy, strategic groups and performance in the U.K. retail grocery industry. *Strategic Management Journal,* 11**,** 385-397.
LI, D. & O'BRIEN, C. 1999. Integrated decision modelling of supply chain efficiency. *International Journal of Production Economics,* 59**,** 147-157.
LI, S. H., RAGU-NATHAN, B., RAGU-NATHAN, T. S. & RAO, S. S. 2006. The impact of supply chain management practices on competitive advantage and organizational performance. *Omega-International Journal of Management Science,* 34**,** 107-124.
LIN, C. T., CHIU, H. & CHU, P. Y. 2006. Agility index in the supply chain. *International Journal of Production Economics,* 100**,** 285-299.
LISSITZ, R. W. & GREEN, S. B. 1975. Effect of the number of scale points on reliability: A Monte Carlo approach. *Journal of Applied Psychology,* 60**,** 10-13.
LUMMUS, R. R., KRUMWLEDE, D. W. & VOKURKA, R. J. 2001. The relationship of logistics to supply chain management: developing a common industry definition. *Industrial Management & Data Systems,* 101**,** 426-431.
MALHOTRA, M. K. & GROVER, V. 1998. An assessment of survey research in POM: from constructs to theory. *Journal of Operations Management,* 16**,** 407-425.
MARTIN-PENA, M. L. & DIAZ-GARRIDO, E. 2008. A taxonomy of manufacturing strategies in Spanish companies. *International Journal of Operations & Production Management,* 28**,** 455-477.
MASON-JONES, R., NAYLOR, B. & TOWILL, D. R. 2000. Lean, agile or leagile? Matching your supply chain to the marketplace. *International Journal of Production Research,* 38**,** 4061-4070.
MAYER, R. J. & MOORE, J. 1983. Applying manufacturing strategy concepts to practice. *Operations Management Review,* Fall**,** 45-50.
MCADAM, R. & MCCORMACK, D. 2001. Integrating business processes for global alignment and supply chain management. *Business Process Management Journal,* 7**,** 113-130.

MENTZER, J. T., DEWITT, W. J., KEEBLER, J. S., MIN, S., NIX, N. W., SMITH, C. D. & ZACHARIA, Z. G. 2001. Defining supply chain management. *Journal of business logistics,* 22**,** 1-26.

MEREDITH, J. R., RATURI, A., AMOAKO-GYAMPAH, K. & KAPLAN, B. 1989. Alternative research paradigms in operations. *Journal of Operations Management,* 8**,** 297-326.

MIEMCZYK, J. & HOWARD, M. 2008. Supply strategies for build-to-order: managing global auto operations. *Supply Chain Management: An International Journal,* 13**,** 3-8.

MILLER, D. 1996. Configurations revisited. *Strategic Management Journal,* 17**,** 505-512.

MILLER, D. C. 1991. *Handbook of research design and social measurement,* London, Sage Publications.

MILLER, J. G. & ROTH, A. V. 1994. A Taxonomy of Manufacturing Strategies. *Management Science,* 40**,** 285-304.

MIN, S. & MENTZER, J. T. 2004. Developing and measuring supply chain management concepts. *Journal of business logistics,* 25**,** 63-99.

MONTGOMERY, J. C. & LEVINE, L. O. 1996. *The transition to agile manufacturing-staying flexible for competitive advantage,* Milwaukee, WI, ASQC.

MORASH, E. A. 2001. Supply chain strategies, capabilities, and performance. *Transportation Journal,* Fall**,** 37-54.

MORGAN, J. & MONCZKA, R. M. 1996. Supplier integration: a new level of supply chain management. *Purchasing,* 120**,** 110-113.

NAGEL, R. & DOVE, R. 1991. 21st Certury Manufacturing: An Industry-lead View. *volume 1. (Bethlehem, PA: Iacocca Institute).*

NAHM, A. Y., VONDEREMBSE, M. A. & KOUFTEROS, X. A. 2003a. The impact of organizational culture on time-based manufacturing and performance. *Decision Sciences,* 35**,** 579-607.

NAHM, A. Y., VONDEREMBSE, M. A. & KOUFTEROS, X. A. 2003b. The impact of organizational structure on time-based manufacturing and plant performance. *Journal of Operations Management,* 21**,** 281-306.

NARASIMHAN, R. & DAS, A. 1999. Manufacturing agility and supply chain management practices. *Production and Inventory Management Journal,* 40**,** 4-10.

NARASIMHAN, R. & DAS, A. 2000. An empirical examination of sourcing's role in developing manufacturing flexibilities. *International Journal of Production Research,* 38**,** 875-893.

NARASIMHAN, R. & JAYARAM, J. 1998. Causal linkages in supply chain management: An exploratory study of North American manufacturing firms. *Decision Sciences,* 29**,** 579-605.

NARASIMHAN, R., SWINK, M. & KIM, S. W. 2006. Disentangling leanness and agility: An empirical investigation. *Journal of Operations Management,* 24**,** 440-457.

NARUS, J. A. & ANDERSON, J. C. 1995. Using teams to manage collaborative relationships in business markets. *Journal of Business-to-Business Marketing,* 2**,** 17-47.

NAYLOR, J. B., NAIM, M. M. & BERRY, D. 1999. Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. *International Journal of Production Economics,* 62**,** 107-118.

NEW, S. J. 1997. The scope of supply chain management research. *Supply Chain Management* 2**,** 15-22.

NUNNALLY, J. 1978. *Psychometric theory,* New York, McGraw-Hill.

O'LEARY-KELLY, W. S. & VOKURKA, J. R. 1998. The empirical assessment of construct validity. *Journal of Operations Management,* 16**,** 387-405.
OLIVER, R. K. & WEBBER, M. D. 1992. *Supply chain management: logistics cathches up with strategy. Outlook Cit. Christopher, M.G.: Logistics, the strategic issue,* London, Chapman and Hall.
PALLANT, J. 2007. *SPSS Survival manual: a step by step guide to data analysis,* Maidenhead, Berkshire, England, McGraw-Hill Education.
PHILLIPS, W. L. 1981. Assessing measurement error in key informant reports: a methodological note on organizational analysis in marketing. *Journal of Marketing Research,* 18**,** 395-415.
POIRIER, C. C. & REITER, S. E. 1996. *Supply chain optimization,* San Francisco, CA., Berrett-Koehler Publishers.
PRATER, E., BIEHL, M. & SMITH, M. A. 2001. International supply chain agility - Tradeoffs between flexibility and uncertainty. *International Journal of Operations & Production Management,* 21**,** 823-839.
PREISS, K., GOLDMAN, S. L. & NAGEL, R. N. 1996. *Cooperate to Compete: Building Agile Business Relationship,* New York, Van Nostrand, Reinhold.
QUAYLE, M. 2003. A study of supply chain management practice in UK industrial SMEs. *Supply Chain Management-An International Journal,* 8**,** 79-86.
QUINN, R. D., CAUSEY, G. C., MERAT, F. L. & SARGENT, D. 1997. An agile manufacturing workcell design. *IIE Transactions,* 29**,** 901-909.
RAMASESH, R., KULKARNI, S. & JAYAKUMAR, M. 2001. Agility in manufacturing systems: An exploratory modelling framework and simulation. *Integrated Manufacturing Systems,* 12**,** 534-548.
REID, L. R., TAPP, B., LILES, D. H., ROGERS, K. J. & JOHNSON, M. E. Year. An integrated management model for virtual enterprise vision, strategy and structure. *In:* Engineering and Technology Management, 1996. IEMC 96. Proceedings., International Conference on, 1996 Banff, AB, Canada.
ROBERTSON, P. W., GIBSON, P. R. & FLANAGAN, J. T. 2002. Strategic supply chain development by integration of key global logistical process linkages. *International Journal of Production Research,* 40**,** 4021-4040.
ROMANO, J. D. 1983. *Operations strategy,* New York, McGraw-Hill, Inc.
RUNGTUSANATHAM, M. J., CHOI, T. Y., HOLLINGWORTH, D. G., WU, Z. H. & FORZA, C. 2003. Survey research in operations management: historical analyses. *Journal of Operations Management,* 21**,** 475-488.
SAKAKIBARA, S., FLYNN, B. B. & SCHROEDER, G. R. 1993. A framework and measurement instrument for just-in-time manufacturing. *Production and Operations Management,* 2**,** 177-194.
SCHONSLEBEN, P. 2000. With agility and adequate partnership strategies towards effective logistics networks. *Computers in Industry,* 42**,** 33-42.
SCHROEDER, R. G., ANDERSON, J. C. & CLEVELAND, G. 1986. The content of manufacturing strategy: An empirical study. *Journal of Operations Management,* 6**,** 405-415.
SCOTT, C. & WESTBROOK, R. 1991. New Strategic Tools for Supply Chain Management. *International Journal of Physical Distribution & Logistics Management,* 21**,** 23-33.
SELLDIN, E. & OLHAGER, J. 2007. Linking products with supply chains: testing Fisher's model. *Supply Chain Management-an International Journal,* 12**,** 42-51.

SEN, S., BASLIGIL, H., SEN, C. G. & BARACLI, H. 2008. A framework for defining both qualitative and quantitative supplier selection criteria considering the buyer-supplier integration strategies. *International Journal of Production Research,* 46**,** 1825-1845.

SEURING, S. 2009. The product-relationship-matrix as framework for strategic supply chain design based on operations theory. *International Journal of Production Economics,* 120**,** 221-232.

SHARIFI, H. 1999. *A methodology for assisting manufacturing organisations to implement agile manufacturing.* PhD Thesis, University of Liverpool.

SHARIFI, H., ISMAIL, H. S. & REID, I. 2006. Achieving agility in supply chain through simultaneous "design of" and "design for" supply chain. *Journal of Manufacturing Technology Management,* 17**,** 1078-1098.

SHARIFI, H. & ZHANG, Z. 1999. A methodology for achieving agility in manufacturing organisations: An introduction. *International Journal of Production Economics,* 62**,** 7-22.

SHARIFI, H. & ZHANG, Z. 2001. Agile manufacturing in practice - Application of a methodology. *International Journal of Operations & Production Management,* 21**,** 772-794.

SHARP, J. M., IRANI, Z. & DESAI, S. 1999. Working towards agile manufacturing in the UK industry. *International Journal of Production Economics,* 62**,** 155-169.

SHAW, N. E., BURGESS, T. F., DE MATTOS, C. & STEC, L. Z. 2005. Supply chain agility: The influence of industry culture on asset capabilities within capital intensive industries. *International Journal of Production Research,* 43**,** 3497-3516.

SKINNER, W. 1969. Manufacturing - Missing Link in Corporate Strategy. *Harvard Business Review,* 47**,** 136-145.

SKINNER, W. 1974. The focused factory. *Harvard Business Review,* 52**,** 113-119.

SKINNER, W. 1978. *Manufacturing in the business strategy,* New York, John Wiley & Sons.

SLONE, R. E. 2004. Leading a supply chain turnaround. *Harvard Business Review,* October**,** 114-121.

SPRING, M. & BOADEN, R. J. 1995. One more time: how do you win orders? A critical reappraisal of the Terry Hill manufacturing strategy framework. *International Journal of Operations & Production Management,* 17**,** 757-779.

STOCK, G. N., GREIS, N. P. & KASARDA, J. D. 2000. Enterprise logistics and supply chain structure: the role of fit. *Journal of Operations Management,* 18**,** 531-547.

STOREY, J., EMBERSON, C., GODSELL, J. & HARRISON, A. 2006. Supply chain management: theory, practice and future challenges. *International Journal of Operations & Production Management,* 26**,** 754-774.

STRATTON, R. & WARBURTON, R. D. H. 2003. The strategic integration of agile and lean supply. *International Journal of Production Economics,* 85**,** 183-198.

SUM, C. C., KOW, L. S. & CHEN, C. S. 2004. A taxonomy of operations strategies of high performing small and medium enterprises in Singapore. *International Journal of Operations & Production Management,* 24**,** 321-345.

SUNDARAM, R. M. & MEHTA, S. G. 2002. A comparative study of three different SCM approaches. *International journal of Physical Distribution & Logistic Management,* 32**,** 532-555.

SWAFFORD, P. M., GHOSH, S. & MURTHY, N. 2006a. The antecedents of supply chain agility of a firm: Scale development and model testing. *Journal of Operations Management,* 24**,** 170-188.

SWAFFORD, P. M., GHOSH, S. & MURTHY, N. N. 2006b. A framework for assessing value chain agility. *International Journal of Operations & Production Management,* 26**,** 118-140.
SWAMIDASS, P. M., DARLOW, N. & BAINES, T. 2001. Evolving forms of manufacturing strategy development - Evidence and implications. *International Journal of Operations & Production Management,* 21**,** 1289-1304.
SWAMIDASS, P. M. & NEWELL, W. T. 1987. Manufacturing strategy, environmental uncertainty and performance: a path analytic model. *Management Science,* 33**,** 509-524.
SWINK, M., NARASIMHAN, R. & WANG, C. 2007. Managing beyond the factory walls: Effects of four types of strategic integration on manufacturing plant performance. *Journal of Operations Management,* 25**,** 148-164.
SWINK, M. & WAY, M. H. 1995. Manufacturing strategy: Propositions, current research, renewed directions. *International Journal of Operations & Production Management,* 15**,** 4-&.
TALLURI, S. & NARASIMHAN, R. 2004. A methodology for strategic sourcing. *European Journal of Operational Research,* 154**,** 236-250.
TAM, M. C. Y. & TUMMALA, V. M. R. 2001. An application of the AHP in vendor selection of a telecommunications system. *Omega,* 29**,** 171-182.
TAN, K. C., KANNAN, V. R. & HANDFIELD, R. B. 1998. Supply chain management: supplier performance and firm performance. *International Journal of Purchasing and Materials Management,* Summer**,** 2-9.
TAN, K. C., LYMAN, S. B. & WISNER, J. D. 2002. Supply chain management: a strategic perspective. *International Journal of Operations & Production Management,* 22**,** 614-631.
THOMPSON, J. 1967. *Organisation in Action,* New York, McGraw-Hill.
THORELLI, H. 1986. Networks: between markets and hierarchies. *Strategic Management Journal,* 7**,** 37-51.
TOWILL, D. R. & MCCULLEN, P. 1999. The impact of agile manufacturing on supply chain dynamics. *The International Journal of Logistics Management,* 10**,** 83-96.
TRACEY, M., LIM, J. S. & VONDEREMBSE, M. A. 2005. The impact of supply-chain management capabilities on business performance. *Supply Chain Management-an International Journal,* 10**,** 179-191.
TSOURVELOUDIS, N. C. & VALAVANIS, K. P. 2002. On the measurement of enterprise agility. *Journal of Intelligent & Robotic Systems,* 33**,** 329-342.
TULLY, S. & MARTIN, T. J. 1994. You'll never guess who really makes. *Fortune,* 130**,** 124-128.
VAN HOEK, R. I., HARRISON, A. & CHRISTOPHER, M. 2001. Measuring agile capabilities in the supply chain. *International Journal of Operations & Production Management,* 21**,** 126-147.
VAZQUEZ-BUSTELO, D., AVELLA, L. & FERNANDEZ, E. 2007. Agility drivers, enablers and outcomes - Empirical test of an integrated agile manufacturing model. *International Journal of Operations & Production Management,* 27**,** 1303-1332.
VONDEREMBSE, M. A., UPPAL, M., HUANG, S. H. & DISMUKES, J. P. 2006. Designing supply chains: Towards theory development. *International Journal of Production Economics,* 100**,** 223-238.
WEMMERLOV, U. 1984. Assemble-to-order manufacturing: implications for materials management. *Journal of Operations Management,* 4**,** 347-368.

WHEELWRIGHT, S. C. 1984. Manufacturing strategy: defining the missing link. *Strategic Management Journal,* 5**,** 77-91.

WHITE, G. P. 1996. A survey and taxonomy of strategy-related performance measures for manufacturing. *International Journal of Operations and Production Management,* 16**,** 42-61.

YANG, B., BURNS, N. D. & BACKHOUSE, C. J. 2004. Management of uncertainty through postponement. *International Journal of Production Research,* 42**,** 1049-1064.

YANG, B., YANG, Y. & WIJINGAARD, J. 2007. Postponement: an inter-organizational perspective. *International Journal of Production Research,* 45**,** 971-988.

YANG, S. L. & LI, T. F. 2002. Agility evaluation of mass customization product manufacturing. *Journal of Materials Processing Technology,* 129**,** 640-644.

YOUSSEF, M. A. 1994. Editorial. *International Journal of Operations & Production Management,* 14**,** 4-6.

YOUSSUF, M. A. 1994. The impact of the intensity level of computer-based technologies on quality. *International Journal of Operations & Production Management,* 14**,** 4-25.

YUSUF, Y. Y. & ADELEYE, E. O. 2002. A comparative study of lean and agile manufacturing with a related survey of current practices in the UK. *International Journal of Production Research,* 40**,** 4545-4562.

YUSUF, Y. Y., GUNASEKARAN, A., ADELEYE, E. O. & SIVAYOGANATHAN, K. 2004. Agile supply chain capabilities: Determinants of competitive objectives. *European Journal of Operational Research,* 159**,** 379-392.

YUSUF, Y. Y., SARHADI, M. & GUNASEKARAN, A. 1999. Agile manufacturing: The drivers, concepts and attributes. *International Journal of Production Economics,* 62**,** 33-43.

ZHANG, Z. & SHARIFI, H. 2000. A methodology for achieving agility in manufacturing organisations. *International Journal of Operations & Production Management,* 20**,** 496-512.

ZHANG, Z. W. & SHARIFI, H. 2007. Towards theory building in agile manufacturing strategy - A taxonomical approach. *IEEE Transactions on Engineering Management,* 54**,** 351-370.

ZHAO, X., SUM, C.-C., QI, Y., ZHANG, H. & LEE, T.-S. 2006. A taxonomy of manufacturing strategies in China. *Journal of Operations Management,* 24**,** 621-636.

ZHOU, H. & BENTON, W. C. 2007. Supply chain practice and information sharing. *Journal of Operations Management,* 25**,** 1348-1365.