

Manufacturing Strategy, Capabilities and Performance

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To my parents

Gudrun

&

Gustav

ABSTRACT

This dissertation addresses the topic of manufacturing strategy, especially the manufacturing capabilities and operational performance of manufacturing plants. Manufacturing strategy research aims at providing a structured decision making approach to improve the economics of manufacturing and to make companies more competitive.

The overall objective of this thesis is to investigate how manufacturing companies make use of different manufacturing practices or bundles of manufacturing practices to develop certain sets of capabilities, with the ultimate goal of supporting the market requirements. The thesis aims to increase the understanding of the role of operations management and its immediate impact on manufacturing performance. Following the overall research objective three areas are identified to be of particular interest; to investigate (i) the relationship among different dimensions of operational performance, (ii) the way different performance dimensions are affected by manufacturing practices or bundles of manufacturing practices, (iii) whether there are contingencies that may help explain the relationships between dimensions of manufacturing capabilities or the effects of manufacturing practices or bundles of manufacturing practices on operational performance.

The empirical elements in this thesis use data from the High Performance Manufacturing (HPM) project. The HPM project is an international study of manufacturing plants involving seven countries and three industries.

The research contributes to several insights to the research area of manufacturing strategy and to practitioners in manufacturing operations. The thesis develops measurements for and tests the effects of several manufacturing practices on operational performance. The results are aimed at providing guidance for decision making in manufacturing companies. The most prominent implication for researchers is the manifestation of the customer order decoupling point as an important contingency variable to consider when studying manufacturing operations.

FOREWORD

At the beginning of my doctorate I was once accused of being a tourist in science, just briefly passing through the academic world. At first I was offended but the more I think of it the more it makes sense. Now, when I am about to finish the first leg of my academic venture I find the description rather appealing. I have come to view the process of becoming a researcher as a journey, where I have turned into that tourist I once so fiercely denied to be.

Although a doctorate is intended to be a one person endeavour it cannot be done without the help from a lot of people. Thus, I am greatly indebted to many friends, family and colleagues. First of all, I would like to thank my supervisor Prof. Jan Olhager for gentle guidance and for offering me to co-author a number of papers with him. I would also like to thank Prof. Roger Schroeder for his support during my period as a visiting researcher at the Carlson School of Management, University of Minnesota. The research visit was financially made possible through a fellowship with the Sweden-America Foundation for which I am also very grateful.

A special thanks to all the people involved in the High Performance Manufacturing research group who all contributed to the data collection process for which I am greatly indebted. I would also like to acknowledge the efforts of Dr. Martin West who conducted most of the data collection in Sweden.

Furthermore, I would like to thank my fellow colleagues at the Division of Production Economics for all the coffee breaks, golf tournaments, lunches and the rest of the time spent outside my cubicle.

Finally, a very special thank you to Lena, the love of my life. I cannot enough express my gratitude. Thank you for always being there for me!

Linköping in spring 2007

Mattias Hallgren

DISSERTATION OUTLINE

This publication entitled *Manufacturing Strategy, Capabilities and Performance* is a doctoral dissertation in Production Economics at Linköping University. The dissertation is constituted by two parts, where the first is an introductory part and the second provides a collection of six papers. The objective of the introductory part is to position the problems treated in the papers by relating them to earlier work as well as to give an overview of the theoretical foundation of the dissertation. Further, scope, objectives and demarcations are presented, finally the introductory part summarises the combined contribution of the papers and envisages future research directions and possible extensions. The second part comprises the papers listed below. The list indicates the origin and the current state of publication.

Paper 1

Hallgren, M. and Olhager, J., 2006. Quantification in manufacturing strategy: a methodology and illustration, *International Journal of Production Economics* 104(1), 113-124.

A draft version of this paper was presented at the *Thirteenth International Working Seminar in Production Economics*, Igls, Austria, 16 – 20 February 2004.

Paper 2

Hallgren, M. and Olhager, J., 2006. Differentiating manufacturing focus, *International Journal of Production Research* 44(18-19), 3863-3878.

An earlier version of this paper was presented at the *18th International Conference of Production Research*, Salerno, Italy, 31 July – 4 August, 2005.

Paper 3

Hallgren, M., 2006. Competitive strategies and manufacturing focus – an empirical analysis, *Working Paper WP-344*, Department of Management and Engineering, Linköping University, Linköping, Sweden.

This paper is to be revised for a second review for publication in *International Journal of Production Economics*. A draft version of this paper was presented at the *Fourteenth International Working Seminar on Production Economics*, Innsbruck, Austria, 20 – 24 February 2006.

Paper 4

Hallgren, M., Olhager, J. and Schroeder, R.G., 2007. Competitive capabilities – a contingency perspective, *Working Paper WP-345*, Department of Management and Engineering, Linköping University, Linköping, Sweden.

This paper is submitted for publication in *Journal of Operations Management*. An earlier version of paper was presented at the 13th *International Annual EurOMA Conference*, 18 – 21 June, 2006, Glasgow, Scotland.

Paper 5

Hallgren, M. and Olhager, J., 2007. Flexibility configurations – exploring volume and product mix flexibility, *Working Paper WP-346*, Department of Management and Engineering, Linköping University, Linköping, Sweden.

This paper is submitted for publication in a special issue on “Role of Flexibility in Supply Chain Design and Modeling” in *Omega – the International Journal of Management Science*. The scientific ideas of this paper were first presented at *POMS International Conference*, 19 – 23 June, 2006, Shanghai, China.

Paper 6

Hallgren, M. and Olhager, J., 2007. Lean and agile manufacturing: external and internal drivers and performance outcomes, *Working Paper WP-347*, Department of Management and Engineering, Linköping University, Linköping, Sweden.

This paper is submitted for publication in *Journal of Operations Management*. Draft versions of this paper were presented at 36th *Annual Meeting of Decision Sciences Institute*, 19 – 22 November, 2005, San Francisco, and at *Seventeenth Annual POMS Conference*, 28 April – 1 May, 2006, Boston, USA.

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1 INTRODUCTION

The overall and overarching goal of any company is long time survival and the ability to produce useful outputs. In manufacturing companies the outputs are usually products offered to customers resulting in profits divided by its owners. Within the subject of Production Economics is one leg concerned with how manufacturing companies deploy their, potentially scarce, resources into the process of transforming inputs to useful outputs. In this, manufacturing strategy offers a structured approach to decision making in facilitating an economic production. Lately, manufacturing strategy has been augmented to also incorporate service operations and is hence often labelled operations strategy. Operations management is defined as “the planning, scheduling, and control of activities that transform inputs to finished goods and services” (Cox and Blackstone, 2002) which clearly corresponds to the administrative role of production economics. Operations management is subordinated manufacturing strategy, *i.e.* strategy precedes management. While manufacturing strategy is concerned with providing long term guidelines, operations management is more concerned with the tactical actions taken to plan, schedule and control the value adding activities.

1.1 Background

Since the first paper on manufacturing strategy by Skinner in 1969 the field has established itself as a well defined research area. Manufacturing strategy has since received much attention, both within the academic communities but also from practitioners involved in the management of manufacturing operations. One of the main purposes of research on manufacturing strategy is identification of the drivers of high performance, and more recently the sustainability of competitive advantage (Ketokivi and Schroeder, 2004). The link between practice and performance (actions and outcomes) has been the focus for much of the manufacturing strategy research where the typical dependent variable has been some kind of measure of competitive performance, whether it is financial (*e.g.* ROI, market share) or operational (quality, delivery *etc.*) performance *vis-à-vis* competition. Practices studied range from very hands on (*e.g.* setup time reduction) to practices of a more conceptual nature (*e.g.* agile manufacturing). MacDuffie (1995) and Shah and Ward (2003) suggests using bundles of practices in order to better capture the inherent nature of wider, multidimensional manufacturing concepts such as *e.g.* lean manufacturing.

Hayes and Wheelwright (1984) suggest that a strategy planning process includes identifying “ends and ways” (business objectives and strategy) and developing “means” (resources and capabilities) by which the selected ends and ways can be

realised. Similarly, Ward *et al.* (1996) note that manufacturing strategy embodies the choices among the most needed set of manufacturing capabilities for a business unit and the investments required to build that set of capabilities. From a practical standpoint, it is central for managers to both understand the business and manufacturing objectives and to identify means to build and develop manufacturing capabilities that support these objectives.

Over the years many concepts related to improving manufacturing capabilities have been advocated and put forward as *the* solution, as the key to improved performance and a sustainable competitive advantage. However, similar to the idiosyncrasy of individuals, companies are not a homogeneous group that responds equally to certain actions. Hence, there are no action plans, improvement programs or manufacturing concepts that are universally applicable due to differences in *e.g.* industry structure (Burns and Stalker, 1961; Lawrence and Lorsch, 1967) or strategic emphasis (Dean and Snell, 1996). The impact from any one concept may therefore vary significantly dependent upon the situation into which it is applied. Ketokivi and Schroeder (2004) find an important challenge in justifying and examining why and under which conditions certain actions have competitive value. In essence, fitting a manufacturing plant's practices and routines to its environmental, structural and strategic context is crucial to developing operations as a competitive advantage (*e.g.* Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Hofer, 1975; Dean and Snell, 1996, Hayes *et al.*, 2005).

The relationships among manufacturing capabilities have been the locus for much attention in operations management research. Typically, the research involve assessing the operational performance (Ward *et al.*, 1998), identifying the relationships among different operational performance dimensions (Nakane, 1986; Ferdows *et al.*, 1986; Ferdows and De Meyer, 1990), or understanding the linkage between operational performance and business and manufacturing strategy (Vickery *et al.*, 1993; Ward and Duray, 2000). Underlying theories has been the well known trade off theory initiated by Skinner (1969) and the more recent notion of cumulative capabilities (Nakane, 1986; Ferdows and De Meyer, 1990). Although the area has received much attention, there still exist differences in opinion within the academic community as to the relationships among and between different dimensions of manufacturing capabilities. Further, Swink and Way (1995) describe identification of contingencies which favour the development of cumulative capabilities as one of the important challenges for future research in operations strategy. Contingency variables tested so far include country (*e.g.* Noble, 1995), industry (*e.g.* Corbett and Claridge, 2002), process choice (*e.g.* Safizadeh *et al.*, 2000), and strategic emphasis (*e.g.* Größler and Grübner, 2006).

1.2 Scope and demarcations

Manufacturing strategy can be studied from many different perspectives. The theories presented in this thesis are mainly based on manufacturing strategy and operations management literature with some instances of organizational theory such as *e.g.* the resource-based view of the firm. The theory base sets the boundary for the research conducted.

The scope of this thesis is concerned with operational performance of manufacturing companies and the relationships between on the one hand, different dimensions of operational performance and on the other, how certain practices or bundles of practices impact operational performance. Four basic dimensions of operational performance are treated in the thesis; quality performance, delivery performance, cost performance and finally, flexibility performance. The thesis also investigates contingencies, structural and strategic, that may influence the impact on and relationships between operational performance dimensions.

The empirical elements in this dissertation use data from the High Performance Manufacturing (HPM) project. The HPM project is an international study encompassing a large number of manufacturing plants. The project is restricted to plants producing physical goods within three industries, electronics, machinery and automotive suppliers, which in itself imposes limitations as to the generalisability of the results. The nature of large-scale questionnaire surveys is almost per definition cross-sectional as opposed to longitudinal. This property precludes testing of actual improvements which is a strong limitation since some of the discussions revolve around capability developing manufacturing concepts, *i.e.* practices or bundles of practices aimed at improving operational performance.

The use of an existing database can be restrictive as to what research that can be pursued and what questions to investigate. In this case, the HPM database is very comprehensive and covers most of the areas important in manufacturing strategy research, thus offering a multitude of possibilities. During the course of this research the content of the database has never posed any restrictions as to the research ideas put forward. In fact, just a fraction of the available data has been used to explore the questions raised in the four empirical papers. Instead, the research opportunities that have arisen through the author's participation in the HPM project are greatly acknowledged and appreciated.

1.3 Objectives

The overall objective of this thesis is to investigate how manufacturing companies make use of different manufacturing practices or bundles of manufacturing practices to develop certain sets of capabilities, with the ultimate goal of supporting the market requirements. In doing so, this thesis describes the current state in manufacturing companies, tests theories and enhances the collective body of knowledge by developing conceptual models. The research objective encompasses several areas of importance in manufacturing strategy research.

Following the overall research objective three areas are identified to be of particular interest in this thesis. The three parts are; to investigate (i) the relationship among different dimensions of operational performance, (ii) the way different performance dimensions are affected by manufacturing practices or bundles of manufacturing practices, (iii) whether there are contingencies that may help explain the relationships between dimensions of manufacturing capabilities or the effects of manufacturing practices or bundles of manufacturing practices on operational performance.

2 THEORETICAL FRAMEWORK FOR THE THESIS

This section will provide an introduction into the theoretical foundation upon which the thesis rest. Theory on manufacturing strategy content, manufacturing capabilities and performance are discussed.

2.1 Manufacturing strategy

In order to succeed with the goal of long term survival and the ability to produce useful output manufacturing companies continuously make decisions regarding *e.g.* the deployment of resources. Irrespective of whether the decisions are conscious or not, they determine how the company is operated. By actively taking charge over the decisions the competitive position of a company can be shaped over time. In this, manufacturing strategy plays an integral part. Manufacturing strategy as a concept was first recognised by Skinner (1969), referring to a manufacturing strategy as to exploit certain properties of the manufacturing function to achieve competitive advantages. Hayes and Wheelwright (1984) describe manufacturing strategy as a consistent pattern of decision making in the manufacturing function linked to the business strategy. Swamidass and Newell (1987) describe manufacturing strategy as a tool for effective use of manufacturing strengths as a competitive weapon for achievement of business and corporate goals. A more comprehensive definition of manufacturing strategy is provided by Platts *et al.* (1998):

“a pattern of decisions, both structural and infrastructural, which determine the capability of a manufacturing system and specify how it will operate, in order to meet a set of manufacturing objectives which are consistent with the overall business objectives.” (Platts *et al.*, 1998, p.517)

The definition acknowledges two key properties of manufacturing strategy content; decisions that determine the capabilities of the manufacturing system, and the existence of specific manufacturing objectives. Leong *et al.* (1990) summarises these into what has become the predominant model of manufacturing strategy content (Figure 1). The model identifies two major constituents of manufacturing strategy content, competitive priorities and decision categories (Leong *et al.* 1990; Dangayach and Deshmukh, 2001). These will be dealt with in the following sections.

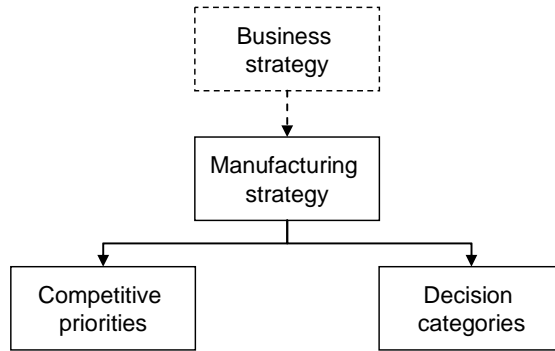


Figure 1. Manufacturing strategy content model (based on Leong et al. 1990)

2.1.1 Competitive priorities

Competitive priorities defines the set of manufacturing objectives and represents the link to market requirements (e.g. Hayes and Wheelwright, 1984; Leong *et al.* 1990; Dangayach and Deshmukh, 2001; Slack and Lewis, 2002; Greasley, 2006). Dimensions commonly used are; cost, quality, flexibility, and delivery (Hayes and Wheelwright, 1984; Leong *et al.* 1990; Garvin, 1993; Hill, 2000). While some studies suggests innovativeness and service as additional priorities empirical research and strategy theories consistently stress the four basic dimensions (Schmenner and Swink, 1998; Ward *et al.*, 1998; Boyer and Lewis, 2002; Größler and Grübner, 2006; Schroeder *et al.*, 2006). The common set of competitive priorities with descriptions is presented in Table 1.

Most researchers consider the competitive priorities part of manufacturing strategy as the link between market requirements and manufacturing (e.g. Hill, 2000; Slack and Lewis, 2002; Greasley, 2006). Of particular interest is the relative weighting of different dimensions of competitive priorities. Among the competitive priorities there are often trade-offs inherent and to focus the attention to certain dimensions is the essence in the factory focus literature drawing on Skinner's (1974) work. However, limiting the scope brings another problem, which dimensions to focus on. Hill (1995) presented the concept of order winners and qualifiers related to the importance of competitive priority dimensions. Qualifying criteria (dimensions) are those that a company must meet for the product to even be considered in the market place. Common criterions considered qualifiers are conformance quality and delivery reliability (Berry *et al.*, 1991; Safizadeh *et al.*, 1996; Menda and Dilts, 1997; Hill *et al.*, 1998). Order winning criteria are those that differentiate the manufacturer from its competitors and "win" the order.

Table 1. Competitive priorities with descriptions

Competitive priorities	Description
Quality	Manufacture of products with high quality and performance standards
Delivery	Reliable (on time) and fast (short delivery lead time) delivery of products
Cost	Production and distribution of the product at low cost
Flexibility	Ability to handle volume and product mix changes

Although the concept of order winners and qualifiers provides a categorisation and prioritisation of competitive dimensions it gives a rather rough account. More precise is to rank requirements by relative weight. Fine and Hax (1985), as well as Hill (2000) suggest apportioning 100 points between requirements. The approach leads to a composite set of priorities where the dimensions are ranked according to importance to the competitive position of the company. Based on that it is possible to define the manufacturing task, *i.e.* the task the manufacturing function must perform well to support the overall market requirements. Related organisational perspectives are those of competitive strategies presented by *e.g.* Porter (1980), Treacy and Wiersema (1993) and Martinez and Bititci (2006).

2.1.2 Decision categories

Decisions in manufacturing related issues are often grouped into categories, usually denoted decision categories. Since Hayes and Wheelwright (1984) first presented the concept numerous authors have contributed to the development and establishment of the set of decision categories, and associated policy areas, normally used. Rudberg and Olhager (2003) provide a summary of a number of decision category frameworks in the literature and find that the division of categories into structural and infrastructural categories as proposed by Hayes and Wheelwright (1984) still is valid and useful. Table 2 lists some examples of decision categories and associated policy areas, based on Leong *et al.*, (1990). Similar descriptions can be found in *e.g.* Fine and Hax (1985), Platts *et al.* (1998) and Rudberg and Olhager (2003).

Table 2. Examples of decision categories and associated policy areas (based on Leong et al., 1990)

Decision categories	Policy areas
Structural	
Process choice	Process choice, technology, integration
Facilities	Size, location, focus
Capacity	Amount, timing, increments
Vertical integration	Direction, extent, balance
Infrastructural	
Manufacturing planning and control	System design, decision support,
Performance measurement	Measurements, methods of measures
Organisation	Human resources, design
Quality	Definition, role, tools

As noted in the definition in section 2.1 the operationalisation of manufacturing strategy comes through a pattern of decisions. This observation acknowledges the influence from management on the development and performance of the system, although seemingly trivial it is a very important observation also noted by Hayes and Pisano (1994). Decisions within the manufacturing functions determine which resources to use, what routines to use, *i.e.* what practices to employ and emphasise in order to achieve the manufacturing objectives. The set of practices, resources, routines used ultimately determine the operating characteristics of the manufacturing system, *i.e.* the manufacturing capabilities (Tan *et al.*, 2006).

2.2 Manufacturing capabilities

Manufacturing capabilities are characterised by the set of practices in use. The capabilities are formed by the objectives for the manufacturing system paired with the history of decisions in manufacturing related issues (Größler and Grübner, 2006). Also, dependent on the set of capabilities inherent in the system at hand different performance levels can be achieved, *i.e.* capabilities are the basis for operational performance. Thus, manufacturing capabilities can be viewed as the linkage between manufacturing strategy content and manufacturing performance as depicted in Figure 2.

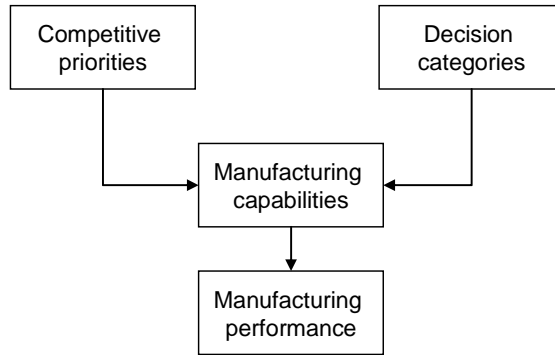


Figure 2. Manufacturing capabilities as central elements of manufacturing strategy (based on Größler and Grübner, 2006)

Manufacturing strategy has adopted the notion of capabilities from the strategic management literature, particularly the resource-based view (RBV) of the firm proposed by Wernerfelt (1984) and Barney (1991). The basis in RBV is that resources are not uniformly distributed across firms and thus provides the potential of being a source to competitive advantage. Resources are referred to as assets, routines, practices *etc.* controlled by a firm that are valuable, rare, imperfectly imitable and unsubstitutable (Barney, 1991). Hayes and Pisano (1996) suggest that a company needs to differentiate itself from its competitors on the basis of something valuable to the customer. The way to do this is to harness the benefits of various improvement programs or bundles of practices, like Lean manufacturing or TQM, “in the service of a broader manufacturing strategy that emphasizes the selection and growth of unique operating capabilities” (Hayes and Pisano, 1996, p.40). Corbett and Claridge (2002) denote capabilities as the ability of a firm to apply resources to do something and further states that capabilities form the primary basis for competition between firms.

In the manufacturing strategy literature, capabilities are often conceptualised as a business unit’s intended or realised competitive performance or operational strengths (*e.g.*, Ferdows and De Meyer, 1990; Noble, 1995; Boyer and Lewis, 2002; Koufteros *et al.*, 2002; Flynn and Flynn, 2004; Größler and Grübner, 2006; Schroeder *et al.*, 2006) and are therefore assessed using measures of operational performance, which typically includes cost, quality, flexibility, and delivery measures. Swink and Hegarty (1998) suggest that the performance-based approach to capabilities is conceptually aggregated to clearly direct the proper use of manufacturing resources. Different from the performance-based approach to capability research that is dominating the manufacturing strategy literature is the routine based approach to explaining the heterogeneity of firms.

Capabilities are identified as high-level routines or bundles of routines (Winter, 2003; Zollo and Winter, 2002). Compared to resources, routines and capabilities built on routines are embedded in the dynamic interaction of multiple knowledge sources and are more firm-specific and less transferable. For instance, a firm may have machines, input material, financial resources, operators *etc.* available to manufacture their products. However, to facilitate efficient manufacture and to achieve superior performance effective routines need to be developed to make all resources work in harmony and to enable the dynamic information and knowledge exchange among individuals. Again, this clearly implies that manufacturing practices constitute a very important part in the development of manufacturing capabilities.

2.3 Manufacturing performance

It is difficult to fairly assess manufacturing performance. Financial measures, such as ROI, profitability *etc.*, are usually plant level measures that are subject to many factors outside the scope of manufacturing operations. An attempt to isolate the performance of the operations function is to utilise measures where the management of operations plays an integral part, *i.e.* operational performance measures (*e.g.* Boyer and Lewis, 2002; Schroeder *et al.*, 2002; Shah and Ward, 2003; Flynn and Flynn, 2004). Dimensions used conveniently coincide with the common set of competitive priorities, *i.e.* quality, delivery, flexibility and cost performance. Important to acknowledge is that every dimension, to some extent is vital for all operations, which one is the most important is just a matter of competitive positioning (*c.f.*, Porter, 1980; Treacy and Wiersema, 1993).

Table 3. Examples of internal and external measures of operational performance

Operational performance dimension	Internal performance measures	External performance measures
Quality	Rework cost, percentage of passed quality inspection, cost of quality control	Conformance to agreed upon specification, product performance
Delivery	Production lead time, accuracy of inventory status, dependability of internal lead times	Delivery lead time, on-time deliveries, stock availability
Cost	Unit cost of manufacturing, inventory turnover, capacity utilisation, yield	Product selling price, market price
Flexibility	Set up time/cost, length of fixed production schedule, amount of operating capacity,	Product range, number of products offered, ability to handle volume and product mix changes

All dimensions can be measured from both an internal as well as external perspective. The internal perspective represents measures that are useful for the internal monitoring and management of the manufacturing process while the external facing ones are measures apparent to and evaluated by the customers. Examples of measures are provided in Table 3.

2.3.1 *Quality performance*

Quality is a multifaceted term. According to Garvin (1987) quality can be viewed from up to eight different perspectives; performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality. Within manufacturing operations the conformance dimension is most influential since it refers to the process' ability to produce products to their predefined specification reliably and consistently (Ward *et al.* 1996; Slack and Lewis, 2002). High levels of conformance quality must be attained before trying to improve any other of the performance dimensions (Nakane, 1986; Ferdows and De Meyer, 1990). The logic being that scrap and rework is the outcome from poor conformance quality which in turn requires more buffers and the like. Higher total levels of inventory increases production lead times and thus negatively influence delivery performance. Internal measures of quality performance include percentage of products that pass final inspection, scrap rate among others. Customer satisfaction is often regarded as the prime measure of external quality performance (*e.g.* Anderson and Sullivan, 1993).

2.3.2 *Delivery performance*

The two main dimensions of delivery performance are delivery reliability and delivery speed (Ward *et al.* 1996). Delivery reliability is sometimes referred to as dependability or on-time delivery and concerns the ability to deliver according to a promised schedule or plan. This sub dimension of operational performance is often regarded a prerequisite (Berry *et al.*, 1991; Menda and Dilts, 1997; Hill *et al.*, 1998). Delivery speed is concerned with the length of the delivery cycle. Ward *et al.* (1996) argues that although the dimensions are separable, long run success requires that promises of speedy deliveries be kept with a high degree of reliability.

There is a caveat with the delivery dimension, companies in different environments relate differently to both delivery speed and reliability. Delivery speed is, from a market perspective, the elapsed time from the receipt of a customer order to final delivery (Handfield and Pannesi, 1992). This definition is quite straightforward for companies operating in a make-to-order environment. However, for companies operating under a make-to-stock strategy this definition is rather strange since the actual customer order enters the system more or less on the shelf leading to a delivery

lead time that is zero (time of transport *etc.* not accounted for). Likewise, in make-to-stock environments high delivery reliability is interpreted as the percentage of orders filled directly from inventory while in make-to-order environments delivery reliability is to honour the promises made to customers.

2.3.3 Flexibility performance

Flexibility is also regarded to be a multidimensional concept (Sethi and Sethi, 1990; Gerwin, 1993). D'Souza and Williams (2000) define four dimensions of manufacturing flexibility; volume, variety, process and material handling flexibility. Further, they note that volume and variety are “mainly externally driven” towards meeting the needs of the market. Similarly, Suarez *et al.* (1996) and Slack (1987) proposes volume, mix, new-product, and delivery-time flexibility as those types that directly influence the competitive position of the company. Within existing manufacturing operations the most influential types are the ability to adjust manufacturing volume and the ability to change between products (Olhager, 1993; Hutchison and Das, 2007).

A property that distinguishes flexibility from other dimensions of operational performance is that it is a measure of potential rather than actual performance. Also, the level of flexibility is not directly evaluated by the customer; it is more of an operational means to provide possibilities for more customised products and product deliveries (Slack, 1983). Flexibility can thus be referred to as an enabler, enabling the manufacturing system to offer shorter delivery lead times, wider product range *etc.* The externally visible properties of a highly flexible manufacturing system include a very broad product range, major opportunities to product customisation and highly flexible delivery times (Slack, 1983).

2.3.4 Cost performance

Cost is an absolute term and measures the amount of resources used to produce the product. Slack and Lewis (2002) stress that all producers, even those whose primary source of competitiveness is different from product selling price, will be interested in keeping their costs low. Every dollar removed from the operation's overall cost is a dollar added to the bottom line profits. Therefore cost performance is the most important of the different operational performance dimensions (Slack and Lewis, 2002), although cost often is ranked least important in empirical studies (*e.g.* Boyer and Lewis, 2002). Important to note is that a reduction in the actual cost of manufacturing does not necessarily translate to an equally large decrease in the products selling price, *i.e.* there are managerial degrees of freedom in the distribution of cost reductions.

3 RESEARCH DESIGN

The research presented in this thesis sets out to investigate properties of, and relationships between, aspects of manufacturing operations. This is done by theoretical reasoning and conceptual modelling but also using large-scale survey based empirical methods to test and develop theory. The development of conceptual models is often one of the first steps when conducting research, irrespective of whether the research is descriptive, exploratory or confirmatory (Meredith, 1993). In conceptual modelling the researcher uses already established theories, combines them, intertwines them or extends them, into a model that help better explain the studied problem. The key point is that conceptual modelling draws on existing theories and logical deduction to develop models and testable hypotheses that eventually can lead to the formation of new theory.

Two of the papers (papers 1 and 2) are strictly theoretical and makes use of already established theory to develop conceptual models. The remaining four papers in this thesis (papers 3, 4, 5 and 6) are, apart from established theory, also based on data from a multi-industry, multi-country survey, the High Performance Manufacturing (HPM) study. The HPM-project and the survey study will be presented below. The data used in the four empirical papers are treated using several statistical methods, *e.g.* factor analysis, path analysis and structural equation modelling. These methods are briefly described in section 3.2.

3.1 High Performance Manufacturing project

The High Performance Manufacturing project is a systematic international study of manufacturing plants. It was initiated in 1989 by Prof. Roger G. Schroeder and Prof. Barbara B. Flynn under the name World Class Manufacturing. It was initiated in response to the growing awareness that there were indeed manufacturing plants that were much better than others, in all dimensions of operational performance and thus challenging the, by that time, well established trade-off theory. What lay as a foundation for the study was this observation by Hayes and Wheelwright (1984).

“... well-run factories around the world share many similarities. That is, a well-run German factory is much more like a well-run Japanese factory than German society is like Japanese society. And, well-run American factories have important similarities to both. They are clean and orderly. They emphasize quality and dependability. They are characterized by well-trained workers and the kind of high morale that comes from a combination of the

workers' sense of their own competence and their confidence in the competence of their managers" (Hayes and Wheelwright, 1984, p. 389.)

The aim of the project was to investigate the methods and practices used by those high performing plants in order to understand how they could achieve that superior performance. Hitherto there have been three rounds of the study. The first round was focused around plants operating within USA. The second round commenced in 1996 and was geographically expanded to also include United Kingdom, Italy, Japan and Germany to encompass a larger portion of the industrialised parts of the world. The third and most recent round began in 2004 and was set out to cover 10 countries. However, the research presented in this thesis use data from the first seven countries to produce data (*i.e.* countries whose data were available by the end of 2005); Austria, Finland, Germany, Japan, South Korea, Sweden and USA, a total of 211 manufacturing plants.

3.1.1 Survey instrument and data collection

The data used in this thesis comes from the third round of HPM. Although the survey instrument have expanded and evolved between the rounds it has also been refined. Research using data from the earlier rounds is widely published which ensures reliability of those measurement items that are reused in the current study. Still, the current questionnaires have been pilot tested and thorough reliability and validity analysis of this data has been conducted. The questionnaires comprise both objective and perceptual questions and measurements. Most questions were answered by multiple informants to ensure reliability. Content validity is provided by thorough literature reviews and a series of plant visits, which included structured interviews with a number of managers.

The unit of analysis is manufacturing plant. However, as noted by Forza (2002) the plant itself cannot produce answers to any questionnaires, this has to be done by individuals. The data was obtained through written surveys, where multiple informants within each plant, ranging from top management and business unit level informants to shop floor operators. 12 different positions were targeted at each plant (listed in Table 4). Each position with their own set of questions. This was done to allow respondents to answer questions in their area of expertise. Also, by using multiple informants the possible effects of common response bias can be eliminated. The data was later, after initial screening and data cleaning, aggregated to plant level and all subsequent analyses are done using plant level data.

Table 4. Responding positions to HPM-questionnaire

Responding position
Plant accounting manager
Direct labour
Human resources manager
Information systems manager
Production control manager
Inventory manager
Member of product development team
Process engineer
Plant manager
Quality manager
Supervisor
Plant superintendent

Multiple informants at each plant reported their perceptions on the degree of implementation across various manufacturing practices, manufacturing strategy goals and performance. The implementation of different manufacturing practices was measured using psychometric scales.

Data in each country were gathered in the native language of each country. The questionnaires were first translated into the foreign language and back-translated by other individuals to eliminate translation errors and to check for consistency across countries. Of the contacted plants between 30-70 % chose to participate in the study. This relatively high response rate was achieved by contacting each plant personally and promising the participating plants an individual profile for comparison within their own industry.

3.1.2 Sample

The targeted sample was mid-sized to large (>100 employees) manufacturing plants in ten countries (Austria, Canada, Finland, Germany, Italy, Japan, South Korea, Spain, Sweden and USA). Throughout the whole HPM-project three industries has been targeted; electronics, machinery and automotive suppliers. The three industries are chosen to represent a variety in product characteristics and competition. A stratified sampling design was used to obtain a approximate equal number of plants for each industry-country combination. A description of the sample is provided in Table 5 below and is characterised by size, plant age, and number of product families.

Table 5. Description of sample

Number of Plants				
Country	Industry			Total
	Electronics	Machinery	Auto suppliers	
Austria	10	8	4	22
Finland	14	6	10	30
Germany	9	13	19	41
Japan	10	11	13	34
South Korea	10	10	11	31
Sweden	7	10	7	24
United States	9	11	9	29
Total	69	69	73	211
Median (mean) plant size – total number of hourly and salaried personnel employed				379 (936)
Median (mean) plant age – years				34 (40)
Median (mean) number of product families in the plant				9 (72)

The sample represents a mix of small and large plants with a median size of 379 employees. The typical plant in the sample is 34 years old and manages nine different product families. In general, the sample exhibits high variety and seems appropriate for examining the research questions in the papers in this dissertation.

3.1.3 Role of the author in HPM

Sweden entered the HPM project in late 2003. By then the survey instruments were already developed and pilot tested by the project leaders in USA. The Swedish team was at the time constituted by Prof. Jan Olhager and Dr. Martin West. They conducted the actual data collection using the readily available questionnaires during 2004. By this time the author of this thesis was a doctoral student under the supervision of Prof. Olhager with manufacturing strategy as research area, however not yet involved in a particular research project. Early 2005 Dr. West left the Department for an industry position whereby the author of this thesis was invited to take his place. Since then the role of the author has been to coordinate the data with the other countries participating in the study and to respond to questions related to the Swedish data. The study has also provided the author with the opportunity to spend a semester with Prof. Roger Schroeder at University of Minnesota.

3.2 Statistical techniques for empirical analyses

3.2.1 Factor analysis

Factor analysis is concerned with explaining the variance-covariance structure of a set of variables through a few linear combinations of these variables, random quantities called factors (Johnson and Wichern, 2002). The factors are formed to maximise their explanation of the entire variable set, or to predict a dependent variable. Basically, it is a way to single out groups of variables that exhibit high correlations within the group and at the same time low correlation with variables in other groups. The principle of factor analysis is that the groups of variables can be represented by a single factor that is responsible for the observed correlations. For example, correlations from the group of test scores in *e.g.* foreign languages, physics, mathematics, and music can suggest an underlying “intelligence” factor. Another group of variables, representing physical fitness scores, might correspond to another factor. It is this type of structure that factor analysis seeks to confirm. Hence, factor analysis has two primary purposes; data reduction and interpretation (Johnson and Wichern, 2002).

To illustrate the logic behind data reduction let p be the number of variables (measurement items), k the number of factors ($k \leq p$), and n the number of observations. Although p components are needed to reproduce the total system of variability, often much of this variability can be accounted for by a small number k of the principal components, *i.e.* factors. If this can be done, the resulting set of k factors contains almost as much information as the original set of p variables. The k factors can then replace the initial p variables, and the original data set, consisting of n measurements on p variables, is reduced to a data set consisting of n measurements on k factors. The factors are orthogonal if they are extracted using principal components analysis which is also the most common extraction method (Shah and Goldstein, 2006).

For each variable a factor loading is assigned to all factors. The factor loading represents the correlation between each variable and the factor and can range from -1 to +1. The interpretations of the factors are based on the level of the individual loadings in each factor. Factor loadings above 0.60 are considered high and significant, *i.e.* the variable is important for that particular factor or more rightly put, the factor explains much of the variation in that particular variable. Loadings below 0.30 are considered not important. Variables showing loadings above 0.40 on several factors, *i.e.* cross loading, should be handled with care since they can dilute the factors. Rotation of the factors is performed to increase the interpretability of factors. When performing the factor analysis there are often several loadings that are between 0.30

and 0.60. By rotating the reference axis for the factors around the origin the factor loadings can become closer to either one or zero. The rotated solution contains exactly the same amount of covariance information as the original factor solution (Johnson and Wichern, 2002). However, a solution with loadings closer to one or zero within a factor makes the interpretation significantly easier.

Factor analysis can be used in different ways depending on the research objective. If the researcher wants to identify logical combinations of variables a factor analysis is often a good method. However, most often factor analysis is more of a means to an end than an end in itself. It is often used as an intermediate step in statistical analyses where the outcome of a factor analysis is used as inputs into *e.g.* multiple regression or cluster analysis. For this purpose a composite factor score can be computed to represent each of the factors.

Factor analysis is used in primarily two different ways in manufacturing strategy research, exploratory or confirmatory. Confirmatory factor analysis (CFA) is used to confirm an *a priori* defined set of measurement items (indicators or measured variables) used to capture an unobservable variable to investigate the reliability of measurement. An exploratory factor analysis (EFA) is used to identify logical combinations of variables within a dataset for more exploratory purposes.

3.2.2 *Structural equations modelling*

Structural equations modelling (SEM) represents a technique to specify, estimate and evaluate models of linear relationships among a set of observed variables in terms of a generally smaller number of unobserved variables (Byrne, 2001; Shah and Goldstein, 2006). SEM has the ability to examine multiple relationships simultaneously and allows for measurement errors (Bollen, 1989). The increased use of SEM in manufacturing strategy is reported by Shah and Goldstein (2006). The usefulness of SEM in manufacturing strategy research is based on two attractive properties; (i) it provides a straightforward method for dealing with multiple relationships simultaneously while providing statistical efficiency and (ii) its ability to assess the relationships comprehensively has provided a transition from exploratory to confirmatory analysis (Hair *et al.*, 1995). Mueller (1996) describes SEM as follows:

“Structural equations modelling, including classical path analysis, may be used to help bridge the gap between empirical and theoretical research; it is a multivariate statistical technique that uses empirical evidence to estimate the strengths of *a priori* hypothesized structural relationships within a particular theory-derived model” (Mueller, 1996, p. 57-58).

Structural equation modelling is characterised by two basic components; (i) the structural model, and (ii) the measurement model. The structural model is the path model which relates independent to dependent variables. The model is guided by theory, prior experience *etc.* as for which dependent variables affect which independent variables. Important to acknowledge is that the structural model can place a dependent variable as an independent variable in a subsequent relationship; it is this property that gives rise to the interdependent nature of structural model. Moreover, many of the same variables will affect each of the dependent variables, but with differing effects. The proposed relationships are translated into a series of structural equations for each dependent variable.

The measurement model allows the researcher to use several variables (indicators) for a single independent or dependent variable, *i.e.* allow the use of latent variables. In the measurement model the researcher can assess the contribution of each scale item as well as incorporate how well the scale measures the concept into the estimation of the relationships between dependent and independent variables.

The resulting set of equations can be solved using second generation multivariate methods included in many software packages *e.g.* AMOS, LISREL, and EQS. Such methods simultaneously estimate the values of the variables as well as the relationships between all variables, based on actual covariance structure inherent in the dataset. The results are then compared to the covariance structure implied by the relationships in the structural model. The comparison renders several goodness-of-fit statistics, *i.e.* measures of how well the proposed model “fit” the data. Overall model fit includes both the structural and the measurement models. Two widely accepted overall model fit measures are χ^2/df , normed Chi-square (Chi-square divided by the degrees of freedom) and RMSEA (Root Mean Square Error of Approximation).

Path analysis and confirmatory factor analysis are two special cases of SEM frequently used in operations management research. Path analysis is simply put a SEM model without the use of latent variables and confirmatory factor analysis is a SEM model where the relationships between latent variables are non-directional.

4 OVERVIEW AND SUMMARY OF PAPERS

4.1 Paper overview

In Table 6 an overview of the papers in the thesis is presented. The papers are categorized according to their relationships to thesis objective, methodological purpose and research method.

Table 6. The six papers categorised according to research objective, methodological purpose and research method

	Paper 1: Quantification in manufacturing strategy: a methodology and illustration	Paper 2: Differentiating manufacturing focus	Paper 3: Competitive strategies and manufacturing focus – an empirical analysis	Paper 4: Competitive capabilities – a contingency perspective	Paper 5: Flexibility configurations – exploring volume and product mix flexibility	Paper 6: Lean and agile manufacturing: external and internal drivers and performance outcomes
Research objective treated						
Relationships among operational performance dimensions	✓			✓	✓	
Effects on operational performance from manufacturing practices	✓	✓	✓		✓	✓
Contingencies to help explain relationships and/or practice-performance linkages	✓	✓	✓	✓		✓
Methodological purpose						
Descriptive	✓				✓	
Confirmatory			✓		✓	
Exploratory			✓	✓		✓
Theory development		✓		✓		
Research method						
Conceptual modelling	✓	✓		✓		
Empirical - survey			✓	✓	✓	✓

The objective of this thesis is threefold as stated in section 1.3. The first part of the objective is concerned with the relationships among and between different dimensions of operational performance. To understand the relationships is recognised to be an

integral part in manufacturing strategy research (Schroeder *et al.*, 2006). Paper 1 deals with quantifications in manufacturing strategy and touches conceptually this first part of the thesis objective. Further, paper 4 is devoted to empirically investigate the nature of relationships between the four basic dimensions of operational performance, quality, delivery, cost and flexibility, while paper 5 focuses on exploring how different flexibility configurations are related to the other operational performance dimensions.

The second part of the thesis objective concerns the way different performance dimensions are affected by practices or bundles of practices. As noted by *e.g.* Tan *et al.* (2006) practices and routines make up the operating characteristics of a manufacturing system and therefore important to manufacturing strategy. A structured methodology for the identification of which performance dimensions that need to be improved is presented in paper 1. The paper is however not explicit on what practices should be employed to achieve the wanted improvements but rather conceptual to nature. Manufacturing focus can be seen as a high level notation of a manufacturing practice and as such it is conceptually dealt with in paper 2 and empirically dealt with in paper 3. In paper 6 lean manufacturing and agile manufacturing are regarded as bundles of practices. Their respective effect on different operational performance dimensions are the investigated and analysed. Likewise, paper 5 investigates how certain flexibility enabling practices are used to create different types of manufacturing flexibility.

The third part of the thesis objective is concerned with the investigation of contingency factors that may help explain either relationships between dimensions or the effects of practices or bundles of practices on operational performance. Classical contingency factors are strategic contingencies as *e.g.* strategic positioning, structural contingencies as *e.g.* environmental factors, competition, market characteristics *etc.* Paper 1 includes market requirements in the presented methodology. Paper 2 considers product and market characteristics when discussing the position of the customer order decoupling point and relates these to different types of manufacturing focus. The paper then presents conceptually how different dimensions of performance should act together. Paper 3 investigates whether manufacturing focus is more important for certain competitive strategies in achieving performance based competitive advantages. Competitive strategy is also considered a contingency in paper 6, as is the competitiveness of industry. CODP is the major contingency factor treated in paper 4 when investigating the relationships between performance dimensions.

In summary, the six papers touch parts of the thesis objective in various ways. Together the objective is covered in the collection of papers that constitute the second part of this thesis.

4.2 Summary of papers

The six papers in this dissertation are summarised below so as to give the reader a brief understanding of their respective aims and results. The papers are however appended in full in the second part of the thesis. For each of the five papers that are co-authored, there is a brief statement to clarify the contributions and responsibilities of the author of this thesis.

4.2.1 *Paper 1: Quantification in manufacturing strategy: a methodology and illustration*

Paper 1 presents a review of the use of quantitative modelling approaches in manufacturing strategy. The paper also presents a framework and a methodology for the quantification of strategic manufacturing decisions. The framework is illustrated with examples from the manufacturing strategy literature. Four basic building blocks, *i.e.* measure, link, compare, and model, are used at different stages for the quantification necessary to support the manufacturing strategy process. The paper concludes that a quantitative model for manufacturing strategy should include three dimensions; *i.e.* market requirements or manufacturing capabilities, decision categories and a modelling approach in order to help structure strategic decision modelling in manufacturing for the fundamental purpose of improving manufacturing capabilities.

This paper was co-authored with Prof. Jan Olhager. The results were jointly developed while the basic idea was provided by Prof. Olhager. The authors jointly wrote and edited the paper and commented on each other's contributions.

4.2.2 *Paper 2: Differentiating manufacturing focus*

Paper 2 combines the concept of manufacturing focus with that of the customer order decoupling point (CODP). Reviewing the manufacturing focus literature reveals that the number of approaches can be condensed into basically two types, product and process focus. Further, we find few guidelines on how to choose among the types in the reviewed literature. However, after discussing the two basic focus types relative the customer order decoupling point the paper finds that the CODP is a simpler and more direct approach to selecting manufacturing focus. Consequently, we propose that the customer order decoupling point acts as a base for differentiating manufacturing focus, and provide a framework for the choice of focus approach for operations upstream versus downstream the CODP including key properties for the manufacturing system and performance improvement priorities.

The paper was co-authored with Prof. Jan Olhager. The results were jointly developed while the basic scientific idea was provided by Prof. Olhager. The authors jointly wrote and edited the paper and commented on each other's contributions.

4.2.3 Paper 3: Competitive strategies and manufacturing focus – an empirical analysis

Paper 3 employs Porter's (1985) framework to investigate the mediating effects of manufacturing focus between competitive strategy and operational performance based competitive advantages. The paper provides empirical support for Porter's typology for competitive strategy. The results show that manufacturing focus has a positive effect on cost performance based competitive advantage, and that the formation of cost leader advantage is mediated by manufacturing focus. The empirical part of this paper utilises data from the HPM study.

The author of this dissertation wrote this paper as the sole author, thus responsible for all aspects of the paper.

4.2.4 Paper 4: Competitive capabilities – a contingency perspective

Paper 4 takes a contingency theoretical perspective and uses research on the customer order decoupling point (CODP) to try to explain some of the problems of replicating the cumulative models of capability attainment presented in literature (*i.e.* Nakane, 1986 and Ferdows and De Meyer, 1990). The results of the empirical study show that there is a major difference between make-to-stock (MTS) and make-to-order (MTO) operations in terms of which manufacturing capabilities to pursue, and consequently how to pursue them. Building on the distinction between order winners and qualifiers, we propose that manufacturing operations upstream the CODP (such as pure MTS) follow the path of quality, delivery, and cost, whereas operations downstream (such as pure MTO) follow another, different path: quality, delivery, and flexibility. Quality and delivery act as qualifiers across all CODP positions, whereas cost and flexibility are related to the different order winning criteria for MTS and MTO operations, respectively. The results show the CODP to have a major influence on the relationships between different performance dimensions of manufacturing systems.

This paper was co-authored together with Prof. Roger G. Schroeder and Prof. Jan Olhager. The basic scientific idea was initiated by Prof. Olhager but further developed together with the author of this thesis and Prof. Schroeder during the time the author of this thesis spent at University of Minnesota. The author of this thesis has been responsible for all data analysis. All authors jointly integrated the concepts discussed, developed the conclusions, edited the paper and commented on each other's contributions.

4.2.5 *Paper 5: Flexibility configurations – exploring volume and product mix flexibility*

Paper 5 keeps with operational performance dimensions, but narrows down the scope to just the flexibility dimension. The paper takes the perspective of manufacturing flexibility as an enabler, a means providing the capability to respond quickly to changes in the market, following Slack (1983). The paper uses a clustering approach to identify four different flexibility configurations based on actual performance along volume and mix flexibility. The groups are then contrasted with respect to operational performance and flexibility source factors. The results show that volume flexibility is generally more important for achieving higher levels of operational performances supporting the notion of flexibility as an enabler. Further the results show that adaptive approaches to flexibility are differentiators between how volume and mix flexibility competencies are acquired. The design of the research answers Gerwin's (1993) call for research aimed at providing managerial guidelines as how to develop manufacturing flexibility.

This paper is the joint work of the author of this thesis and Prof. Jan Olhager. The basic scientific idea was provided by the author of this thesis who also was responsible for all data analysis. Both authors have jointly written and edited the paper as well as commented on each other's contributions.

4.2.6 *Paper 6: Lean and agile manufacturing: external and internal drivers and performance outcomes*

Paper 6 aims at investigating drivers and performance outcomes of agile manufacturing and lean manufacturing. We view them as bundles of practices that provide the manufacturing systems with distinct characteristics and develop discriminating measurement constructs for the two. The results are clear in that the drivers for leanness and agility differ, while the impact on performance measures shows both some similarities and some differences. The major differences in performance outcomes are related to cost and flexibility, such that leanness has a significant impact on cost performance (whereas agility does not), and that agility has stronger positive effects on flexibility dimensions than leanness. The results follow the well investigated trade-off between cost and flexibility (Adler *et al.*, 1999).

This paper was developed and written together with Prof. Jan Olhager. The basic scientific idea was provided by the author of this thesis but further developed in collaboration with Prof. Olhager. The development of measurement constructs as well as all subsequent data analysis was performed by the author of this thesis while the responsibility for writing, editing and commenting was shared between both authors.

5 CONCLUSION

5.1 Research contribution

As an overall thesis contribution, an enhanced understanding of operations management is sought for and provided. The thesis contribution is touching several areas of manufacturing strategy, especially the management and development of manufacturing operations to arrive at a certain set of capabilities and corresponding performance levels. Additionally, focus is on investigating the contingent role of the customer order decoupling point in manufacturing management and development.

The thesis contributes to the existing body of knowledge by taking a novel perspective on the relationships among and between different operational performance dimensions. In the extant literature there are two predominant views of the relationships, *i.e.* trade-off and cumulative view as proposed by Skinner (1969) and Nakane (1986), Ferdows and De Meyer (1990). The results, from the conceptual and empirical analysis, show that the views do not have to be in conflict. Instead, the views are complementary with quality and delivery dimensions showing cumulative relations while the cost and flexibility dimensions are subject to trade-offs. Higher levels of flexibility are found to be generally associated with high levels along the other dimensions of operational performance when addressing all types of manufacturing environments, which would support the cumulative model. However, when dividing the sample into subsamples based on the position of the customer order decoupling point we find that make-to-order plants show a different pattern than make-to-stock plants. The differences are particularly visible when analysing cost and flexibility dimensions where the relationships are in support of the trade-off view. Hence it is concluded that the position of the customer order decoupling point is an important determinant in the choice of emphasised performance dimensions. Paper 2 relates the position of the customer order decoupling point to the choice of manufacturing focus and again concludes that the CODP is an important variable in decisions regarding the management and development of manufacturing operations.

The competitive value of manufacturing focus is empirically investigated in Paper 3 and the result shows that manufacturing focus, operationalised as product focus, significantly contribute to the formation of cost performance based competitive advantage. The analysis also provides additional empirical support for Porter's (1985) framework on generic competitive strategies. The Porter framework is also used as input in Paper 6 where drivers and performance outcomes of agile manufacturing and lean manufacturing are investigated. Lean is found to have positive effects on several operational performance dimensions, yet primarily cost oriented. Agile manufacturing

is confirmed to provide stronger effects on the flexibility dimension of operational performance. Moreover, the results connected to the drivers of lean and agile manufacturing show that efforts aimed at achieving more agile characteristics are driven by both external and internal drivers while lean manufacturing is mainly driven by internal drivers. So it seems that while agile manufacturing is the response to an overall tougher competitive intensity of industry is lean manufacturing more a managerial means in pursuit of cost efficiency. The paper also make a significant contribution by developing measurement constructs for both lean manufacturing and agile manufacturing based upon discriminating characteristics of the two programs.

From the result it is also possible to identify methodological contributions. The major implication for research found in this thesis is the manifestation of the customer order decoupling point as an important variable to consider in decision making in manufacturing related issues. The CODP should therefore be included as a control variable when investigating manufacturing performance and also the use of manufacturing practices in general. This also means that measures of CODP should be included in questionnaires aimed at capturing information about manufacturing organisations.

5.2 Ideas for future research

In my future research into the management and development of manufacturing operations it would be most interesting to more thoroughly investigate other position of the customer order decoupling point. The assemble-to-order (ATO) environment in particular would be very intriguing to study from a manufacturing capability perspective. The challenge comes due to the nature of ATO environment that constitutes of both a forecast driven upstream part and a downstream customer order driven part. The division into upstream and downstream parts makes the use of questionnaire based survey research difficult for all intermediate CODP positions. Instead, I would like employ a multiple case study research design to better understand the situations faced by those companies. Another interesting avenue of research would be to do a longitudinal study of manufacturing operations in order to better capture actual changes over time with respect to different manufacturing practices.

As for the field of manufacturing strategy I think that much of the future research will be focused around environmental issues. How to manage the transformation process in order to minimize the environmental impact? How to design products to facilitate effective recovery of input material and energy? Many of the contemporary trends of outsourcing, off shoring and global competition will be radically reduced by raising

fuel costs and stricter transportation and environmental legislations. This brings new perspectives on operations.

Another very interesting and what I would think important future area within manufacturing strategy research is how to act when the differential in manufacturing cost between countries or regions diminishes. Many of the countries now regarded as low-cost countries show among the highest economic growth rate in the world wherefore the cost differential eventually will disappear. For how long should companies keep their operations in those regions or countries? Another related question is what will happen when the costs of transportation rise, either due to higher overall fuel costs or increased responsibility for environmental issues? Will higher transportation costs regress the trend of globalisation and turn organisations to act more locally again? These are all questions that I believe lies in the future of operations management and manufacturing strategy research.

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