Manufacturing Capabilities:
Expendable Commodities or Catalysts for Effective Supply Chain Management

Doctoral thesis by

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Abstract

Many large companies have for a long time been very successful in their industries by combining leading edge R&D and marketing with strong internal manufacturing capabilities. An alternative model is now getting increased attention, where R&D and marketing is conducted internally and manufacturing performed by outsourcing partners. This development is partly due to divergent views on the strategic role of manufacturing capabilities: expendable commodities that can be purchased from a low-cost provider versus resources essential for sustaining long-term competitive advantage. Although assessments of the strategic role of manufacturing capabilities have been performed previously, recent supply chain trends such as globalisation and fragmentation mean that they may no longer be relevant. The purpose of the thesis is to assess the strategic role of manufacturing capabilities for a product-owning firm, by focusing on what impact its internal manufacturing capabilities have on the effectiveness of the supply chain.

Two methods have been used for the research: survey and case study. The survey is representative for the entire Swedish manufacturing sector, whereas the case studies are to some extent industry- or company-specific. Two companies were researched: one in the telecom equipment sector, the other a supplier to multiple sectors, including the telecom equipment sector. The results of the research have been presented in five scientific articles that are also found in the appendices.

The thesis argues that in order to evaluate the strategic role of manufacturing capabilities, it is important to look at how they contribute to the focal firm’s competitive priorities. When the technology is new, the competitive priority tends to be innovation, and the role of manufacturing capabilities is to facilitate more efficient NPD. When products mature, low cost becomes the dominant competitive priority, and the role of manufacturing capabilities is to facilitate a high operational efficiency of the supply chain. Although the potential role of manufacturing capabilities is dependent on the firms’ competitive priorities, just possessing manufacturing capabilities will not automatically translate into high performance. Instead, the performance outcome is dependent on both the level of manufacturing capabilities and, even more importantly, how they are leveraged through the integration of customers, suppliers and the product development department.

This thesis contributes to the discourse on the role of manufacturing in two ways. First, the thesis investigates how competitive priorities impact the role of manufacturing capabilities in the supply chain. Second, this thesis explores how manufacturing capabilities influence the efficiency of integration. The main theoretical contribution is to develop and test the concept of manufacturing absorptive capacity within the context of manufacturing capabilities’ role in the supply chain. The thesis concludes that manufacturing capabilities are almost inevitably seen as strategic because they help firms integrate external sources more efficiently, thereby achieving performance improvement in terms of both operational efficiency and efficient product development. When the performance improvement corresponds with the prevailing competitive priority, the supply chain can be said to be effective. Manufacturing capabilities can thus act as a catalyst for effective supply chain management.
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Contents

1. Introduction 1
   1.1. Purpose and Contribution 2
   1.2. Scope 3
   1.3. Limitations 4
   1.4. Outline of the Thesis 4

2. Theoretical Framework 5
   2.1. Manufacturing Strategy and Competitive Priorities 5
       2.1.1. Corporate strategy 5
       2.1.2. Business unit strategy and competitive priorities 7
       2.1.3. Manufacturing strategy 8
   2.2. Performance 9
   2.3. Manufacturing Capabilities 10
   2.4. Supply Chain Management 11
       2.4.1. Supply chain design 11
       2.4.2. Supply chain integration 12
           2.4.2.1. Supplier integration 13
           2.4.2.2. Customer integration 14
           2.4.2.3. Whom to integrate? 15
   2.5. Absorptive Capacity (ACAP) 16
       2.5.1. Empirical studies with an indirect operationalisation of ACAP 17
       2.5.2. Further development of ACAP 18
       2.5.3. Empirical studies with an explicit operationalisation of ACAP 19
       2.5.4. Concluding remarks on ACAP 20
   2.6. The Conceptual Framework 20
       2.6.1. Competitive priorities and manufacturing strategy 21
       2.6.2. Available resources, external to the manufacturing department 21
       2.6.3. Internal manufacturing capabilities 22
       2.6.4. Integration mechanisms 22
       2.6.5. Manufacturing absorptive capacity 22
       2.6.6. Performance 23
   2.7. Research Questions 24
       2.7.1. The impact of competitive priorities 24
       2.7.2. The impact of manufacturing capabilities 25
3. Methodology
   3.1. Introduction to Methodologies
   3.2. Survey Methodology
   3.3. Case Study Methodology
   3.4. Operationalisation of Core Concepts
      3.4.1. Competitive priorities
      3.4.2. External resources available to the manufacturing department
      3.4.3. Internal manufacturing capabilities
      3.4.4. Integration mechanisms
      3.4.5. Manufacturing absorptive capacity
      3.4.6. Performance
   3.5. Validity and Reliability
      3.5.1. Construct validity
      3.5.2. Internal validity
      3.5.3. External validity
      3.5.4. Reliability
      3.5.5. The strength of multiple methods
   3.6. The Research Process

4. Overview of the Appended Papers
   4.1. Internal and External Integration and Its Effects
   4.2. Beyond Fisher's Product-Supply Chain Matrix
   4.3. Manufacturing Competence – A key
   4.4. Do Customers Improve New Product Development Efficiency?
   4.5. Manufacturing Competence and External Integration

5. Discussion
   5.1. Internal and External Integration and Its Effects
   5.2. Beyond Fisher's Product-Supply Chain Matrix
   5.3. Manufacturing Competence – A key
   5.4. Do Customers Improve New Product Development Efficiency?
   5.5. Manufacturing Competence and External Integration

6. Conclusions
   6.1. The Strategic Role of Manufacturing Capabilities
   6.2. Contribution
   6.3. Managerial Implications
   6.4. Suggestions for Further Research
   6.5. Epilogue

References
List of appended papers

1. *Internal and External Integration and its Effect on Manufacturing Firms’ Competitiveness*
   The Proceedings of the 2006 EurOMA conference, Glasgow, United Kingdom
   Page 75

2. *Beyond Fisher's Product-Supply Chain Matrix: Illustrating the Actual Impact of Technological Maturity on Supply Chain Design*
   International Journal of Logistics Systems and Management (Forthcoming)
   Page 93

3. *Manufacturing Competence – A Key to Successful Supplier Integration*
   Page 113

4. *Do Customers Improve New Product Development Efficiency? Revealing the Impact of Manufacturing-Based Absorptive Capacity*
   Under review for the International Journal of Business Performance Management
   Page 133

5. *Manufacturing Competence and External Integration: Absorptive Capacity in a First-Tier Supplier*
   The Proceedings of the 2007 EurOMA conference, Ankara, Turkey
   Page 151

Other appended material

Survey instrument for papers 1, 3 and 4 (in Swedish)
Page 169
1. INTRODUCTION

Many large companies have for a long time been very successful in their industries by combining leading edge R&D and marketing with strong internal manufacturing capabilities. For example, Nokia has even retained its manufacturing capabilities in high-cost countries, despite the fact that most of the growth in demand comes from countries where the cost of hiring workers is much lower. As may be expected, the manufacturing units are located a relatively short distance from product development units.

This traditional, horizontally integrated model is being challenged. Supported by the rise of low-cost production in countries such as China, an alternative model is getting increased attention, where R&D and marketing are conducted internally in the West and manufacturing performed by outsourcing partners in low-cost countries. Apple has achieved tremendous success by excelling in R&D and marketing while outsourcing all production to Foxconn in China. In Apple’s view, manufacturing capabilities can be purchased from the best provider and have little impact on other functions.

The examples of Nokia versus Apple illustrate that companies can have widely different strategies due to divergent ways of assessing the strategic role of manufacturing capabilities. In the case of Apple, the contemporary role of a global production system is to produce, wherever it is cheapest, the products that marketing and product development come up with. In this view, manufacturing capabilities are expendable commodities and outsourcing manufacturing is a sensible strategy, if overall costs can be reduced. This point of view has also gained recognition in the academic community by authors such as Arnold (2002) and McCarthy and Anagnostou (2004). In contrast, internal manufacturing capabilities are seen as essential for sustaining long-term competitive advantage by companies such as Nokia as well as by scholars within the manufacturing strategy field (e.g., Brown and Blackmon, 2005). Assessing the strategic role of manufacturing capabilities is thus both a timely topic and a topic that leading companies and scholars do not agree on.

Although assessments of the strategic value of manufacturing have been performed previously, recent industry trends such as globalisation and fragmentation of supply chains mean those assessments may no longer be relevant. Globalisation means that large international firms are no longer firmly based in one country, but rather locate any part of the organisation or the supply chain in the most strategic location. Fragmentation means that an increasing share of manufacturing and product development is performed by entities not directly controlled by the focal firm. Manufacturing capabilities may still have a strategic role, but that role is no longer confined to the same boundaries as in the recent past.

Although the global setting is new, the general debate about the role of manufacturing is not new. Indeed, the academic community has for almost half century been heavily engaged in it. Starting with Skinner’s seminal article in 1969, manufacturing has been seen as an important tool for achieving overall company strategy. Hayes and Wheelwright (1985) proposed that the strategic role of manufacturing increases in step with the development of its capabilities. A weak manufacturing department can at best be neutral in terms of its impact on company strategy, whereas “world-class” manufacturing can be the driver of company strategy.
Major theoretical contributions to our understanding of the role of manufacturing have been provided by the resource-based view, and in particular Barney (1991), who was influenced by Dierickx and Cool (1989) as well as Prahalad and Hamel (1990). These authors all focused on the need to identify strategic resources, using Barney’s (1991) terminology. A strategic resource is valuable, rare, imperfectly imitable, and it cannot be substituted. These resources are often used by multiple functions and successful companies leverage them in order to gain and sustain a competitive advantage. Strategy for the company is thus to develop, protect and exploit these strategic resources while non-strategic resources can potentially be divested. Assessing whether manufacturing capabilities are strategic resources or whether firms are better off divesting them is thereby an important issue, and an issue that seems particularly urgent in the light of rapid technological change. This change gives investments in product development a natural priority over investments in manufacturing capabilities, which may be short-sighted if the divested assets are important or even crucial for the efficiency or effectiveness of product development.

Many scholars have long held the view that manufacturing capabilities are indeed strategic resources, often pointing to the phenomenal success some, particularly Japanese, manufacturers have achieved through lean manufacturing (Womack and Jones, 1994; Liker, 2004). Others have highlighted that product development is often dependent on input from the manufacturing department, especially when product and process complexity are high (Clark and Fujimoto, 1991).

Few authors have, however, linked the strategic role of manufacturing capabilities to the role the capabilities can play in the wider supply chain. In this view the role of manufacturing capabilities is no longer confined to the direct contribution to overall company objectives. The focus is rather on the interaction with other entities and how manufacturing capabilities impact the efficiency of that interaction. The interaction may include both the daily operations of the supply chain as well as product development, which is increasingly becoming a supply chain issue (Lo and Power, 2010).

The ultimate goal of the supply chain is to deliver value to the customer, but companies have different ways of delivering value, which can be referred to as competitive priorities; e.g., innovation, rapid and secure delivery, or low cost. A supply chain can be considered effective when it delivers efficiency in line with the prevailing competitive priorities. A more complete picture of the strategic value of manufacturing capabilities can emerge if their roles in fulfilling the company’s competitive priorities are taken into account. This is becoming imperative due to rapid technological change, resulting in shifting competitive priorities and new roles for manufacturing, but this has not yet been extensively recognised.

1.1. Purpose and Contribution

The overall purpose of this thesis is to assess the strategic role of manufacturing capabilities for a product-owning firm, by focusing on what impact its internal manufacturing capabilities have on the integration of the manufacturing department with customers, suppliers and the product development department. The purpose will be further elaborated in chapter 3 as five research questions.
This thesis contributes to the discourse on the role of manufacturing in two ways. First, a fundamental part of the analysis must be that manufacturing’s contribution is not the same for firms focusing on innovation as it is with firms mainly seeking to optimise their production processes. The thesis will look at how competitive priorities, which are to large extent driven by technological maturity, impact the role of manufacturing capabilities in the supply chain. Second, this thesis will explore how manufacturing capabilities influence the efficiency of suppliers, customers and internal integration in product and process development.

The first theoretical contribution is to develop and test the concept of manufacturing absorptive capacity within the context of manufacturing capabilities’ role in the supply chain. Absorptive capacity is the ability to acquire, assimilate and exploit external knowledge, and is to a large extent based on the company’s previous knowledge (Cohen and Levinthal, 1990). The second theoretical contribution is to link the role of manufacturing capabilities to competitive priorities. The thesis thus contributes to the literature within the resource-based view (RBV) and in particular the absorptive capacity (ACAP) literature.

1.2. Scope

Two methods have been used for the research: survey and case study. The survey is representative for the entire manufacturing sector, whereas the case studies are to some extent industry- or company-specific. Two companies were researched: one in the telecom equipment sector, the other a supplier to multiple sectors, including the telecom equipment sector.

Although supply chain management advocates having the entire chain as unit of analysis, in practise firms are generally focused on increasing their own performance (Fawcett and Magnan, 2002). The unit of analysis for this thesis is the focal firm, in the case-study-based papers 2 and 5, and the manufacturing department of the focal firm in the survey-based papers 1, 3 and 4. Supplier and customers are treated as external entities, as is the product development department, as it is external to the manufacturing department, of the focal firm. These external entities can be integrated, or involved, in both product and process development. Integration is conducted through the use of a number of mechanisms, as will be further explained in chapters 2 and 3.

The manufacturing department’s main asset is its capabilities, and they can be related to technical issues, such as the use of advanced machinery; processes, such as flow-oriented manufacturing; and organisation, such as the use of independent manufacturing teams. These capabilities can have effects that go beyond the manufacturing department and influence the efficiency of the integration of external entities. Investigating these effects is the aim of this thesis.
1.3. Limitations

The focus of this thesis is on the role of manufacturing capabilities and manufacturing-related integration of customers, suppliers and the product development department, aimed at product or process development. Other types of external integration mechanisms (e.g., joint information technology platforms) as well as integration in different functional areas (e.g., basic research or marketing) are certainly also feasible, but they may have different prerequisites and are not covered in this thesis. Moreover, while the impact of trust and power is acknowledged, it has been argued that the factors covered in this thesis are additional prerequisites. Although there may be interdependency between trust and power as well as the factors in this thesis, these are not explored.

The debate about the strategic importance of manufacturing is only relevant for firms developing their own products. Discussing the strategic importance for contract manufacturers does not make much sense, as manufacturing is their raison d’être. This thesis is therefore only concerned with companies that develop, and bring to the market, physical products. The empirical research was conducted in the manufacturing sector in Sweden. Since Swedish firms compete on an international level, with a very large percentage of customers and suppliers from outside the country, the result are not country specific.

1.4. Outline of the Thesis

The thesis is divided into six chapters. The Introduction provides background to the subject and presents the purpose, contribution, scope and limitations of the thesis. The second chapter, Theoretical Framework, reviews some of the relevant literature, presents an overall conceptual framework and poses five research questions, one for each appended paper. The third chapter discusses the methodology of the research, including validity, operationalisation of concepts and a description of the research process. The fourth chapter briefly summarises the key points of each paper; the full papers can be found in the appendices. The fifth chapter, Discussion, answers the research questions and discusses the results and contribution of each paper. The final chapter, Conclusions, discusses the overall topic of the thesis, the strategic role of manufacturing capabilities, and outlines how the thesis has fulfilled the purpose. The last chapter also includes managerial implications, suggestions for further research, and a short epilogue that connects the findings to the case of Nokia versus Apple.
2. THEORETICAL FRAMEWORK

This chapter contains seven sections. The first five sections review some of the strategy, the manufacturing capability, the supply chain, the absorptive capacity and the performance literature, respectively. The strategy literature is important for understanding the role of manufacturing for two reasons, providing a tool to evaluate the strategic importance and in framing a context for the study. The manufacturing capability and supply chain literature forms the most important part in describing the operations of manufacturing companies. Absorptive capacity is used as a tool for understanding the interaction between manufacturing capability and the supply chain as well as product development. Increased performance is the ultimate aim of any commercial enterprise, and is the last part of the literature review. The sixth section presents a conceptual framework that integrates all the literature into one coherent model. This model is later used for positioning the five papers that are included in this thesis. The seventh and final part presents the research questions that the five papers answer, and they are based on the conceptual framework.

2.1. Manufacturing Strategy and Competitive Priorities

Strategy is a topic that has received a tremendous amount of attention in management sciences. Most authors agree that strategy exists at different levels: below corporate strategy there is business unit strategy, functional strategy and operating strategy (Brown, 1996). This thesis is concerned with the functional strategy, i.e. strategy for the manufacturing function and by extension the supply chain, which may involve the purchasing and logistics functions too. The supply chain view stipulates that separating the strategy for these functions is insufficient and will create sub-optimisation of the supply chain (Christopher, 2005). Strategy is usually a top-down approach, where lower levels are based on, and intended to support, higher levels of strategy (Brown, 1996). This means that a full review of literature must include different levels of strategy and how they relate to each other; the natural way is to have a top-down approach to this review as well, and start with corporate strategy.

2.1.1. Corporate strategy

Porter (1980, 1985) is most prominent among strategy authors and is particularly concerned with industrial structures and how firms can position themselves in order to maximise profitability. Porter proposed that firms should position themselves through either cost leadership or differentiation. Differentiation is attained by providing customers with something they are willing to pay more for, most often through a perception of quality. Porter also added another dimension: broad or niche market, which can be applied to both cost leadership and differentiation. The major weakness with Porter’s framework is that it assumes a stable market, where firms can position themselves depending on where it is most lucrative. In a fast-moving market there is little time to position the firm; providing a customer with some extra value added is very difficult when
customer demands evolve rapidly. Attaining cost leadership might also not be very relevant if the product is only manufactured for a few months or can command a premium price anyhow due to limited supply or other unfilled customer demand. Another weakness with Porter’s framework is that it does not take into account that companies have unique resources that will have a significant impact on their ability to position themselves.

When Barney introduced the resource-based view (RBV) in 1991, it was positioned as an alternative to the then dominant “Porter” school (Barney, 2001). According to Barney (1991), the two main schools of contemporary strategy can be compared by looking at how they relate to the classic SWOT analysis. Focusing on opportunities and threats, or being externally oriented, is characteristic of the “Porter” school of thought. By contrast, focusing more on strength and weaknesses, being internally oriented, is a hallmark of the RBV (ibid.).

In the RBV, strategy is primarily based on the availability of resources (Barney, 1991). Sustained competitive advantage can be obtained by leveraging resources that are valuable, rare, imperfectly imitable, and cannot easily be substituted (ibid.). Manufacturing capabilities can consequently be thought of as strategic resources if they possess these characteristics.

There are, however, some deficiencies with Barney’s (1991) framework, which was extensively criticised by Sanchez (2008). The main problem is the lack of definitions of concepts and a systematic framework for identifying strategic resources, which makes it impossible to analyse which resources are strategic and how they contribute to performance. Another problem concerns the focus on the presence of resources, while downplaying the way they are utilised. These problems are not unique to Barney’s (1991) framework, but are also present in similar frameworks dealing with “capabilities” and “core competencies” (Macher and Mowery, 2004).

As a solution to deficiencies of the RBV, Sanchez proposes the competence perspective, resting on four cornerstones: the dynamic, the systemic, the holistic and the cognitive cornerstone (Sanchez, 2008). The dynamic cornerstone emphasises that markets and firms are always changing, sometimes rapidly. Any strategy must therefore address the fundamental uncertainties about the market, and the availability and usefulness of firm resources. As will become clear later, this cornerstone is clearly in line with the reasoning of much of the absorptive capacity literature, as well as Christensen (1997). The systemic cornerstone states that firms are built of systems of interacting resources and processes within a certain context and guided by a certain strategy (Sanchez, 2008). Just focusing on the most valuable, strategic resource, as the RBV proposes, is therefore insufficient. On the contrary, when the value chain is dependent on a chain of resources, it is the weakest link that determines overall performance (Sanchez, 1995). This thinking is very similar to one basic proposition of the supply chain management literature: supply chains are only as strong as their weakest link (Christopher, 2005). The holistic cornerstone highlights the environment where the firm, in competition with other firms, seeks to identify and acquire external resources. In order to get the required resources from customers or suppliers, the firm must also be a good partner. The supply chain management literature, according to the holistic cornerstone, takes a competence perspective on strategy, although that is not specifically stated. The cognitive cornerstone demands that human capacity to grasp the large amount of variables and uncertainty inherent in many
management situations, particularly strategy formulation, be taken into account. The hoarding of resources that might be a result of a too rigid focus on protecting what is, or might become, strategically important is unproductive, due to the increased complexity it entails. The cognitive cornerstone leads to a high relative value on managers’ ability to coordinate resources instead of developing and protecting them.

2.1.2. Business unit strategy and competitive priorities

Whereas corporate strategy is concerned with broad issues like long-term investment decisions, the business unit strategy involves deciding which parameters are important to attract customers (Brown, 1996), henceforth referred to as competitive priorities. There are a number of models describing competitive priorities; the most commonly cited ones will be briefly reviewed in this section. First, a distinction can be made between order qualifiers and order winners (Hill, 2000). As the name describes, an order qualifier is the minimum requirement in a specific area, e.g., having less than 100 ppm defects. The order winner is, as the name implies, what actually determines who will win the order. Unless otherwise stated, in this thesis competitive priorities refer to the order-winning criteria of the companies’ most important customers and products.

Another model of competitive priorities is the sand cone model introduced by Ferdows and De Meyer (1990). According to the model there are four competitive priorities: quality, dependability (of delivery), speed and cost. The idea is that one must first fully conform to quality requirements before focusing on dependability, then speed and finally cost. It is thus a cumulative model, where the present competitive priority is dependent on what has been achieved previously. It is a well-known and intuitively sensible model, but unfortunately it has little empirical support (White, 1996). Another weakness is that it downplays trade-offs, which are a key characteristic of strategy (e.g., Porter, 1985).

Christensen (1997) bases his conceptual framework on industry dynamics. He identifies four phases of competition, although he acknowledges that there could be additional or fewer depending on the industry. These four phases of competition, functionality (referred to as innovation in this thesis), reliability/quality, convenience and cost, are separated by disruptive shifts in technology or market. Typically a new product competes over functionality, but when the functionality overshoots the requirements of most customers an opportunity opens for an alternative product with less functionality but superior reliability. The new product is seen as disruptive as it redefines the basis of competition. It is thus a cumulative model, akin to the sand cone model of Ferdows and De Meyer (1990).

However, according to Adner (2004), in the vast majority of cases a disruptive shift only occurs when the alternative technology offers lower prices, as other performance criteria (apart from the initial functionality) typically only appeal to smaller segments of the market.

Christensen (1997) suggests four phases, but a later paper (Christensen et al., 2002) proposes a dichotomy of functionality (innovation) versus non-functionality, i.e., price-based competition, which is also in line with supply chain literature (Fisher, 1997; Christopher, 2000) as well as Adner (2004). Christensen et al. (2002) also acknowledge that competition can sometimes revert from cost to functionality. Many of the proposed frameworks (e.g. Porter, 1985; Christopher, 2005) do not take into account the dynamic
aspect of competition that results from innovation. The framework used in this thesis is a synthesis of the previously mentioned literature. It is to a larger extent based on Christensen (1997), although it leaves more room for trade-offs: firms can to some extent decide whether to compete over price or some other criterion, such as innovation. The theoretical framework is meant to describe the underlying competitive priorities of the firms, whereas the consequences are the subject of the research.

2.1.3. Manufacturing strategy

Competitive priorities are not primarily decided by manufacturing or supply chain managers, and are therefore treated as external requirements that these managers must respond to. The role of manufacturing strategy is thus firstly to align decisions on developing and utilising capabilities in manufacturing and the supply chain with the competitive priorities (Hayes and Wheelwright, 1984; Colotla et al., 2003). In manufacturing strategy, the most cited competitive priorities are cost, quality, flexibility and delivery (Hayes and Wheelwright, 1984; Boyer, 1998). A successful strategy is when the actions taken correspond with the competitive priorities (ibid; Hayes and Wheelwright, 1979). Although this is widely accepted, there is surprisingly little empirical support (Boyer, 1998).

In a review of the manufacturing strategy literature, Voss (1995) identifies three different approaches. The first is competing through capabilities, where success is dependent on how well the capabilities are aligned with market requirements. The second is aligning manufacturing strategy with overall strategy and product characteristics. The third approach is the “best practise” school, where success depends on finding and imitating best practise in the industry. There is, however, a large overlap between the first two approaches; researchers such as Hayes and Wheelwright (1979) belong to both. The following authors, as well as this one, follow the first two approaches.

Skinner (1969) started the debate about the role of manufacturing by first describing the then prevailing view of manufacturing: a function that gives a competitive advantage only through high efficiency and low cost. Skinner was concerned about this fallacy and advocated connecting manufacturing strategy to the overall corporate strategy, so that trade-off decisions (e.g., between efficiency and flexibility) are in line with overall goals. In Skinner’s view, manufacturing remains a core internal function, but in need of more strategic decision making.

Hayes and Wheelwright (1979) take the discussion one step further by linking the choice of manufacturing processes, from job shop to continuous flow, with the product and the product’s life cycle. They argue that the manufacturing process must follow the product life cycle: when a product is new, a highly flexible job shop is most appropriate, and as the product matures and volume increases, the manufacturing process must become more efficient but less flexible. Hayes and Wheelwright’s (1979) product-process matrix was validated by Safizadeh et al. (1996). When companies did not align their processes with their products, their competitive priorities suffered worse performance. Hayes and Wheelwright (1979) see manufacturing as a function that responds to changes in product characteristics and must be closely integrated with marketing. However, Hayes and Wheelwright (1979) also argue that manufacturing is a “competitive weapon” and should influence overall company strategy. In line with Hayes and Wheelwright (1979), Hill
(2000) argues that the manufacturing strategy is dependent on product characteristics, i.e., volume and variety. However, Hill (2000) adds that the choice must also depend on order-winning criteria; a framework of competitive priorities.

Kotha and Orne (1989), inspired by both Hayes and Wheelwright (1979) and Porter (1980), propose generic manufacturing strategies. These strategies are linked to Porter’s (1980) generic strategies, i.e., they are designed to deliver either cost leadership or flexibility to cope with the effects of product differentiation. Kotha and Orne’s (1989) generic manufacturing strategies include three dimensions: process structure complexity (including automation), product line complexity and organisational scope. Kotha and Orne (1989) thus follow the tradition of the previously reviewed authors and see manufacturing as a function, where performance depends on how well these are aligned with the overall business unit strategy.

The classic view of manufacturing strategy is thus as an internal function that responds to either the overall business strategy or the characteristics of the products (Brown, 1996). By viewing manufacturing as a function, there is little sense in keeping it in house if there is an outsourcing partner that is better at improving performance in line with the competitive priorities. Perhaps this view partly explains why both scholars and companies have shown such a large interest in outsourcing manufacturing in recent years. In contrast, this thesis argues that there are reasons to take a wider view of the role of manufacturing, a point which will be made clearer towards the end of the thesis.

Rather surprisingly, Boyer (1998) finds that competitive priorities have little influence on actual implementation of manufacturing practises. This implies that implementing specific practises aims at improving general competitiveness, not improving a particular priority. However, Boyer’s (1998) study only concerns how competitive priorities influence manufacturing, and not the wider supply chain. The trade-offs inherent in the strategic planning may be made at the supply chain level, and may not be visible on the manufacturing level, except as a general inclination to invest (or not) in a certain manufacturing unit. This implies that in order to study how competitive priorities and capabilities are aligned, the analysis must include the supply chain. Indeed, analysing how competitive priorities are aligned with the supply chain may be more important than the relative alignment of specific manufacturing capabilities. This also means that it may not be necessary to indentify clearly divergent manufacturing capabilities appropriate for the different competitive priorities. A key concern remains whether the manufacturing unit possesses adequate capabilities for interacting with other parts of the supply chain, no matter whether they are aimed at reducing costs or improving quality, delivery or flexibility.

### 2.2. Performance

The aim of a strategy is to increase performance, in terms of achieving the objectives the strategy has set. This means that performance metrics should be directly related to competitive priorities, but could be more specific. This thesis primarily contrasts NPD efficiency and operational cost-efficiency, but also deals with supply–chain-related issues such as rapid, on-time delivery.
For a new product to be considered successful, it must be widely adopted by users and produce a satisfactory return on investment (Ettlie and Pavlou, 2006). Many different factors influence the success of the product, not least the actual design. In this thesis the focus is not on the design of attractive products, but rather on the efficiency of the design effort (which in turn influences the return on investment). A new product development process is considered to become more efficient when development costs are reduced and time to market is shorter, irrespective of how well the product actually performs in the market.

This thesis has a manufacturing focus; the effectiveness of the manufacturing department should be measured by those factors it can chiefly affect (Slack, 2005; Vickery et al., 1993). According to Vickery et al. (1993), they are volume flexibility, product mix flexibility, production cost, delivery lead time, delivery dependability, production lead time and product quality. Some of these contribute to cost-efficiency and some to responsiveness to customer demand, whereas many of them contribute to both. For example, product mix flexibility will reduce the cost of changeovers and increase the delivery flexibility to customers. Consequently, multiple performance indicators will be used for assessing both cost-efficiency and responsiveness.

2.3. Manufacturing Capabilities

There is little coherence in the definition of manufacturing capability in the literature, where for example Cleveland et al. (1989) define manufacturing competence as a capability that enables manufacturers to carry out a product- or market-specific business strategy. Some authors have not bothered to clearly define it at all, but assume that factors such as flexibility or lead time are competencies (e.g., Vickery et al., 1993), whereas others call these capabilities (e.g., Flynn and Flynn, 2004).

Capabilities exist at different levels, where a first-order capability can directly improve performance and a second-order or dynamic capability can improve the first-order capabilities (Teece and Pisano, 1994. Manufacturing capabilities as they are used in this thesis are a first-order capability. Absorptive capacity is, however, classified as a second-order or dynamic capability (Zahra and George, 2002).

This thesis will adopt the terminology of Ray and Ramakrishnan (2006), Day (1994), Grant (1991) and Narasimhan et al. (2001). In this view resources are tangible and intangible assets that firms utilise, and they can be external or internal (Ray and Ramakrishnan, 2006). As this thesis focuses on manufacturing, all resources that are not directly related to manufacturing in the focal firm will be treated as external resources, including resources in other departments, such as product development. Capabilities are a combination of internal firm resources (Day, 1994; Grant, 1991), meaning they are particular types of bundled resources. Manufacturing capabilities are thus a combination of different manufacturing resources, both tangible and intangible. For example, manufacturing capabilities include the use of advanced machinery, where the resources needed for this capability are advanced machinery, personnel skilled at using them, and appropriate raw materials. The capabilities can be utilised both individually or in bundles.
When the capabilities are utilised in an effective manner, the outcome is increased performance, such as in more efficient NPD or increased productivity.¹

2.4. Supply Chain Management

It is widely believed that it is no longer enough to be internally excellent, when the focal company is only a relatively small part of the supply chain (e.g., Lambert et al., 1998). The central premise of supply chain management is that it is increasingly supply chains that compete with each other, as opposed to individual firms (e.g., Christopher, 2005). Leading-edge companies have responded by allocating significant resources to utilising their supplier base more effectively as well as increasing their cooperation with their most important customers (ibid.), although integration beyond first-tier customers and suppliers remains rare (Fawcett and Magnan, 2002). The most successful companies are usually those that have managed to integrate customers and suppliers with their internal processes (Frohlich and Westbrook, 2001). There is, however, often a wide gap between management literature and reality (Fawcett and Magnan, 2002). This means that the holistic view of the supply chain with an emphasis on win-win partnerships, advocated by early supply chain literature, remains something of a red herring. Instead, firms have started to recognise the importance of supply chain management as a tool to increase their own performance (ibid.), not overall supply chain performance.

Supply chain management can be divided into two main areas: coordination or execution (including integration) and supply chain design (Harrison, 2001; Lau and Yam, 2005). Colotla et al. (2003) call the former infrastructural decisions and the latter structural decisions. Supply chain design mostly resembles an extension of manufacturing’s structural decisions, according to Lau and Yam (2005), and is concerned with the location of plants and warehouses, the choice of transportation modes and the choice of manufacturing processes. Supply chain coordination, or integration, is concerned with everyday operations, including relationships with customers and suppliers. Product development is today also increasingly seen as a supply chain integration process, instead of just relying on an internal product development department (Petersen et al., 2005). Both supply chain design and supply chain integration are important when assessing the role of manufacturing.

2.4.1. Supply chain design

The most cited author within the supply chain design field is Fisher (1997), who proposed that supply chains should be designed based on the characteristics of the company’s main product, in line with Hayes and Wheelwright’s (1979, 1984) ideas about the basis of a manufacturing strategy. However, Fisher (1997) does not connect the supply chain strategy to overall company strategy or competitive priorities. He is not concerned with the strategic importance of manufacturing or other company functions, only their ability to deliver present products to customers in an effective manner. A more strategic view of

¹ Note that the terminology of papers 3 and 5 differ, where the term manufacturing competence is used instead of manufacturing capability.
the supply chain would include how present resources can be used for future competitive advantage, or what new resources need to be developed or acquired.

In the supply chain design literature, there is usually a distinction between two types of supply chains, responsive and efficient, that are designed according to the demands of the products (see paper 3). The demands of the products can, on the other hand, be seen as a manifestation of competitive priorities, meaning that it can be assumed that products are designed in accordance with the competitive priorities prevailing at the time. As Christensen (1997) points out, competitive priorities can change over time, meaning that the product or the supply chain may not always be optimal. The two types of supply chains, responsive and efficient, are not mutually exclusive. As paper 3 explains, there is usually a need for a compromise between the two for various reasons. And taking into account that there may be more than two competitive priorities, this seems inevitable. How could only two types be optimal for more than two competitive priorities? This means that there are a number of possible configurations of a number of variables, each ranging from supporting efficiency to enabling responsiveness, in order to optimise the supply chain in accordance with the firms’ competitive priorities.

It must be noted that there is a large overlap between the supply chain strategy and strategy of other functions, particularly manufacturing. Moreover, many authors within the field have an implicit or explicit focus on a particular function, such as manufacturing (Holweg, 2005), marketing (Fisher, 1997) or information technology (Gunasekaran et al., 2008). For a more comprehensive review of supply chain design, see paper 2.

2.4.2. Supply chain integration

Supply chain integration is, as mentioned previously, concerned with the everyday management of operations, and can include both manufacturing and product development (Lau and Yam, 2005). There is little consensus on the terminology of the supply chain management literature; what some refer to as involvement, cooperation, coordination, collaboration or partnering, others refer to as integration. Droge et al. (2004), for example, call it “partnering” when a firm treats the supplier as a “strategic collaborator” and involves them early in new product development, but they also call this process of achieving unity of efforts “integration”. Cousineau et al. (2004) even talk about supply source integration and refer to the early involvement of suppliers in the product development process. Simatupang et al. (2002) take the view that supply chain integration is achieved through four modes of coordination: logistics synchronisation, information sharing, incentive alignment and collective learning.

In the remainder of the thesis the term integration will be used to describe the use of some of the key mechanisms inherent in effective supply chain management. Supplier and customer integration is thus seen as bundle of mechanisms aimed at collaborative product as well as process development, and involve a company’s most important customers and/or suppliers. The literature review of external integration will focus on the integration of customers and suppliers, ignoring issues like strategic alliances and the integration of the entire chain. As most authors make the distinction between customer and supplier integration, it seems an appropriate way of arranging the review as well. It can, however, be argued that supplier and customer integration are exactly the same phenomena but from different perspectives. While acknowledging that, the literature still highlights
different problems and advantages depending on whether the integration is aimed upstream, i.e. towards suppliers, or downstream, towards customers.

2.4.2.1. Supplier integration

Many studies of the benefits of integrating suppliers in product development have focused on the Japanese automotive industry (e.g., Clark and Fujimoto, 1991; Kamath and Liker, 1994) and the evidence is usually compelling. Other authors have focused on Western firms; and many also found wide support for the advantages of supplier integration in terms of more effective new product development (e.g., Ragatz et al., 1997, 2002; Primo and Amundson, 2002). Some of the advantages claimed for increased integration concern access to knowledge, reduced complexity, easier coordination of information flow, broader scope, as well as better working relationships (Ragatz et al., 2002; Clark and Fujimoto, 1991). Better product quality has also been mentioned as a key outcome of integrating suppliers early in the design process (Takeichi, 2001). Moreover, supplier integration has been advocated as the natural extension of the lean manufacturing concept (Lamming, 1996). Lean manufacturing received massive attention in the 1990s following publication of a book by Womack et al. (1990).

Petersen et al. (2005) focused on examining when suppliers should be involved in NPD as well as what level of responsibility they should have to ensure a new product development project’s success, and they found that it is crucial to be selective about which ones to integrate. Rather surprisingly they also found that the effectiveness of supplier involvement in setting objectives was dependent on supplier responsibility, where very high responsibility had a negative impact on the effectiveness. Ragatz et al. (1997) listed the success factors for effective supplier integration and found that the most effective integration is supplier participation in NPD teams. The most important success factors were identified as trust, frequent communication, clear focus and structure, but also confidence in the supplier’s capabilities as well as a firm’s own capabilities in areas such as technology, customer focus and cross-functional teams. Takeichi (2001) identifies knowledge of product architecture and components as particularly important for effective supplier integration, and concludes that firms need to develop capabilities internally in order to benefit from the specialised expertise of suppliers. Das et al. (2006) suggest there is an optimal level of supplier integration and that integrating more when the overall level of integration is low yields significant benefits, whereas negative outcomes are expected for those firms with an already inflated level of integration.

In a review of potential negative effects of supplier integration, Primo and Amundson (2002) highlighted factors like longer project development times, negative effects due to the amount of resources needed and supplier obstructionism, but proposed an explanation for the mixed results of previous research. First, different authors use different definitions of supplier integration; the results are therefore not comparable. Second, the results are often described in broad terms such as project success, whereas more detailed metrics like increased speed or quality might give a more nuanced picture. Third, they propose using a contingency approach based on a firm’s technological capability. The first one is rather difficult to take into account – since there is no consensus on what constitutes supplier integration it is rather difficult to follow the consensus. The latter two points, on the other hand, should be considered in any study.
aimed at furthering the understanding of factors contributing to the success of supplier integration.

Some authors have measured the extent of supplier integration by looking at how much technology and information sharing are occurring between the focal firm and its suppliers (Ragatz et al., 2002). Das et al. (2006) use a rather comprehensive list of supplier integration mechanisms, spanning 24 different factors from joint training to new product development to purchasing to cost information sharing. In the survey-based part of this thesis, only a few general mechanisms of integration will be employed and they all concern product and process development (see papers 1, 3 and 4). The case studies (papers 2 and 5) list a few but not all of the mechanisms the firms employ, such as supplier audit or sharing of production forecasts.

2.4.2.2. Customer integration

Customer integration can mean different things to different people; the main distinction is found by defining who the customers are. The customers can be both internal, e.g., the next person on an assembly line, or external. The customer can also be either the next process or the end user. Traditionally, in the marketing literature (see Griffin and Hauser, 1996, for a review), the end users have been in focus and the need to integrate them in new product development has mainly been advocated as a means of assuring compliance with their needs. Authors like von Hippel (2005) have taken the argument one step further and describe how the lead user should be identified and integrated, since that customer possesses the knowledge to drive the innovative process forward and thereby assure the long-term survival of the company. Prahalad and Ramaswamy (2000) discuss the organisational challenges companies face when involving lead users in product development.

The focal firm’s attractiveness in the eyes of their customers can be enhanced through developing innovation capabilities (Petroni and Panciroli, 2002). According to these authors, customers assign different roles to their suppliers depending on their innovation capabilities (see also Kamath and Liker, 1994). Swink and Mabert (2000) agree that capability is a key to increasing the attractiveness of suppliers.

Campbell and Cooper (1999) are critical of the universal belief that it is always beneficial to be close to the customer, and reported that firms who involved customers in their product development project were no more successful than firms with in-house projects. They believe the main reason was an asymmetric power structure, where the customer is usually larger and able to appropriate most of the value. Seungwha and Gyeong (2003) investigated benefits gained by the supplier in new product development partnerships and found that suppliers do benefit, but the results were mixed. Firms with extensive partnering with their customer were no better in innovation or quality, but had significantly better financial performance.

The success of customer integration in new product development can also depend on at what stage they are being involved, according to Gruner and Homburg (2000). Interestingly, they found that early involvement and late involvement increase the likelihood of success, whereas involvement at medium stages had no impact on product success. Enkel et al. (2005) acknowledge the risks associated with customer integration, such as knowledge leaks or increased dependence, but focus mainly on how to mitigate
these risks. They suggest choosing trustworthy customers without too much power and also emphasise the need to draw up formal contracts. Stock and Tatikonda (2004) found that a high level of external integration is most effective when technological uncertainty is high.

In sum, the literature suggests that the desirability of customer integration is at best mixed. Some empirical evidence suggests that benefits will outweigh costs under certain conditions, whereas other studies see no evidence of success at all. The focus of this thesis will not be on the end user but rather the customer firm in dyadic customer-supplier relationships. Customer integration in this respect is the mirror image of supplier integration, and typically firms that sell to other businesses are to some extent engaged in both. Thus, customer integration as described here can be seen as the same as supplier integration, just seen from the perspective of the supplier (see also Stjernström and Bengtsson, 2004).

2.4.2.3. Whom to integrate?

As all companies have limited resources, it is not feasible to integrate all customers and suppliers. Although the advantages seem to be more consistently positive for supplier integration than for customer integration, they are both just different sides of the same coin. The inconsistency in proclaimed benefits implies that customers may gain more from the integration than the suppliers do. The marketing literature is, on the other hand, fairly consistently positive about being close to the customer, but usually refers to end users (see Griffin and Hauser, 1996). The discrepancy between the marketing and the supply chain management literature can be explained by the difference in power structure. Whereas end users are usually small, e.g., the individual consumer, in business-to-business relationships the customer is often much larger and larger customers are in a better position to appropriate value (Cox 1999, 2001). Benefits of customer integration may also be more implicit, as it may turn the customer into a loyal buyer, but that is more difficult to measure. Indeed, Lambert and Burduloglu (2000) acknowledge that although customer satisfaction is the most commonly used measure of success, only rarely can it be proven to lead to increased sales or higher prices. An intangible effect of customer integration can also be to take advantage of learning from the best customer and apply that knowledge when dealing with other customers (Liker and Wu, 2000). Once again, the benefits may be extensive but very difficult to measure.

A number of authors have seized upon the dilemma of which side to integrate, often focusing on whether it is more fruitful to integrate customers or suppliers. Morash (2000) propose that supplier integration is more effective for companies that aim for cost leadership and customer integration than for those aiming for differentiation (see also the review of competitive priorities). Frohlich and Westbrook (2001) propose a more inclusive framework by introducing “the arc of integration”. They find that the wider the arc is, the more benefits accrue to the focal firm, but they do not take into account that firms have limited resources or any contingency factors. As it is not feasible to integrate all customers or suppliers, the firms should focus on those with the highest potential payoff (Swink and Mabert, 2000), while also taking into account the needs of the external partner.
The focus of Droge et al. (2004) is on whether it is beneficial to integrate externally, i.e. both customer and suppliers, as well as internally, i.e. engineering design and manufacturing. They found that both internal and external integration had a positive effect on many performance indicators. They also noticed some interaction effects between internal and external integration, and recommend this area for further research. Hillebrand and Biemans (2004) develop this premise further in an exploratory study, suggesting three explanations for why internal integration facilitates external integration. First, internal integration mechanisms are used to coordinate external integration. Second, the norms of external and internal integration are similar, and third, external cooperation may stimulate internal cooperation.

2.5. Absorptive Capacity (ACAP)

As we have seen in the previous sections, both supply chain design and supply chain integration are important to secure long-term competitive advantage, and both to some extent involve manufacturing. The impact of manufacturing capabilities on the effectiveness of the supply chain of can be studied using many different frameworks. In this thesis the concept of absorptive capacity will be reviewed, developed and applied in order to understand and explain how manufacturing capabilities impact the effectiveness of the supply chain. The next few paragraphs will survey the most important literature on absorptive capacity and explain how it relates to the other concepts of this thesis.

As mentioned in the previous paragraphs, there have been many attempts at explaining the success, or lack thereof, of external integration. This thesis will contribute to the body of literature but will take a more unusual approach. While acknowledging the previous findings of other relevant literature, this thesis aims to consider a few factors that have not been taken into account previously. First, the role of manufacturing capability in facilitating successful integration has not been widely recognised; instead the focus has been on integrative capabilities (see, e.g., Wagner and Boutellier, 2002). Integrative capability is the set of actual abilities and mechanisms that are used in order to integrate outside constituents, not the capabilities needed to assimilate and utilise the acquired knowledge.

The second weakness of most literature in the field is that it assumes that one size fits all. Except for case study–based research, most empirical studies show either that integration is beneficial or, less often, that it is not beneficial. There is a shortage of research arguing that external integration is beneficial under some circumstances, but not under others. The few researchers that have taken such an approach have usually focused on aspects such as technological uncertainty (Ragatz et al., 2002; Stock and Tatikonda, 2004) or relational capability (Wagner and Boutellier, 2002).

This thesis takes a complementary approach and focuses on the underlying capabilities of the manufacturing department that allow it to value, assimilate and use the capability it has extracted from external sources. One conceptual framework suitable for this task is the concept of absorptive capacity, originally introduced by Cohen and Levinthal (1989). This model is, however, also incomplete, as it does not take into account the differing needs of different firms, which can be explained by the term competitive priorities. The next
few paragraphs will review the absorptive capacity framework; competitive priorities were reviewed in the beginning of this chapter.

Cohen and Levinthal (1989) introduced the concept of absorptive capacity in a widely cited article, where they showed that firms gain two benefits from investing in research and development. The first one is obviously technical knowledge, and the other is the ability to absorb knowledge from the external environment. The benefits would, according to the authors, outweigh disadvantages such as direct cost and the risk of knowledge leakage. The message in this article is fairly simple; the combined benefits should be taken into account when making investment decisions. The first article from Cohen and Levinthal (1989) does not provide any clues as to where this absorptive capacity comes from, or what it really is. The second article on absorptive capacity from Cohen and Levinthal (1990) goes further in explaining the concept. In their paper a clear emphasis is put both on the ability to value and assimilate knowledge as well as on the ability to commercialise it. These form two distinct dimensions, the structure of internal and external communication as well as the nature of know-how.

According to Cohen and Levinthal (1990), the basis of absorptive capacity is previous knowledge in a particular area, which lies mostly within individuals. However, they also point out that organisational absorptive capacity is not simply the sum of each individual’s absorptive capacity, as organisational structures and mechanisms also play a part. This thesis, following Cohen and Levinthal’s line of reasoning, accepts that a large part of the absorptive capacity resides within individuals, but will attempt to measure it on an organisational level.

Cohen and Levinthal (1990) argue that the necessary absorptive capacity for product and process innovation is often firm-specific and difficult to acquire, and hence must be developed internally. There is a striking similarity with core competence as described by Prahalad and Hamel (1990), as those capabilities are also firm-specific and difficult to imitate. Absorptive capacity is furthermore path-dependent, so the accumulated absorptive capacity is only effective when acquiring, utilising and commercialising related knowledge (Cohen and Levinthal, 1990). In other words, there must be a fit between the particular type of absorptive capacity and the integration effort, as well as the knowledge the firm wish to integrate.

2.5.1. Empirical studies with an indirect operationalisation of absorptive capacity

Many authors have used the arguments of Cohen and Levinthal (1990) to explain the role of existing knowledge for the effectiveness of knowledge transfer. Szulanski (1996) showed that a lack of absorptive capacity is the largest barrier to intra-firm sharing of best practices, bigger than all motivational or social factors. The absorptive capacity was seen as a function of the existing stock of knowledge, manifested by an ability to identify, value and apply new knowledge.

Veugelers (1997) found that external cooperation in R&D has no effect on innovation unless firms have their own R&D infrastructure and cooperation stimulates R&D expenditures. She also reported that firms with higher R&D spending are more likely to be engaged in external R&D cooperation. These results are interpreted as supporting the absorptive capacity argument, and in line with Cohen and Levinthal (1990). Veugelers
(1997) does not provide any evidence for which specific factors contribute to absorptive capacity, and recommends this area for further research.

Shenkar and Li (1999) found that firms will not seek knowledge in an area where they already have some knowledge, but that they seek complementary (as opposed to specific) knowledge. The firms’ predisposition to complementary knowledge is interpreted as a sign that the absorptive capacity, which is a function of previous knowledge, determines which type of knowledge it will seek. This is in line with Levinthal and March (1993), who by extending the argument of path dependence warn of the dangers of being too narrowly focused, as it can make the firm blind to knowledge outside its centre of attention.

Stock et al. (2001) have a rather simple approach to measuring absorptive capacity by measuring the level of R&D as a percentage of sales. They find that higher levels of absorptive capacity spending increase the performance of a firm’s products up to a certain point. That is hardly surprising, as they in fact have shown that higher R&D spending contributes to product performance without any need to cite absorptive capacity. Petroni and Panciroli (2002) have a similar approach, considering absorptive capacity along two dimensions: R&D expenditure as a percentage of sales and as investment in personnel training.

A paper by Mowery et al. (1996) shows that being R&D intensive does not help firms absorb capabilities from alliance partners. But when measuring absorptive capacities as experience in related capabilities, they do, however, find significant support for the notion. This implies that it is not enough to just measure the investment in monetary terms, but more insight is required into what particular capabilities have been developed.

2.5.2. Further development of ACAP

There are some weaknesses in Cohen and Levinthal’s (1990) framework. First of all, they are rather vague on what actually constitutes absorptive capacity, and mostly describe a tacit asset that somehow appears as a result of investments in knowledge. Moreover, they state on the one hand that the absorptive capacity is the firm’s existing knowledge base, but on the other hand that it is partly found in the way the firm structure their communication with their external environment. If the communication with the external environment is absorptive capacity, it could be interpreted as stating the obvious; one must acquire knowledge (if acquisition is deemed part of a firm’s absorptive capacity) in order to benefit from it. The question arises whether external communications is indeed an absorptive capacity or a mechanism for which absorptive capacity is required in order to be successful. Furthermore, although Cohen and Levinthal (1990) acknowledge the multidimensional nature of the absorptive capacity, they only operationalised it as R&D spending. A few authors have seized upon the vagueness of Cohen and Levinthal (1990) and propose some reconceptualisations.

Lane and Lubatkin (1998) introduced the concept of relative absorptive capacity, arguing that it is not enough to look at a firm in isolation. Instead, the potential for inter-organisational learning is dependent on the relative levels of absorptive capacity of the two firms engaged in the knowledge transfer. They investigated the relative absorptive capacity along three dimensions: related knowledge, similarity in structure and similarity in business logic. This is partly in line with Cohen and Levinthal (1990), who write about the structure of communications as well as the character and distribution of knowledge, but
nothing comparable to Lane and Lubatkin’s (1998) business logic. Moreover, Cohen and Levinthal (1990) looked at individual firms and not dyadic relationships.

Zahra and George (2002) distinguish between potential and realised absorptive capacity, where the former refers to valuing, acquiring and assimilating external knowledge, whereas the latter refers to transforming and applying it commercially. Both potential and realised absorptive capacity are required to improve firm performance, and when these two are fairly equal the firm reaches optimum performance. This argument is very similar to the concepts of exploration and exploitation (March, 1991), and both Zahra and George (2002) as well as March (1991) emphasise the necessity to combine the two dimensions. March (1991) also acknowledges the path dependence of capabilities, as do Cohen and Levinthal (1990), and suggests increasing returns by sticking to the firm’s core field of expertise, although there is a risk the field is a suboptimal one (see also Levinthal and March, 1993). The problem of too much exploration and too little exploitation could also be described as an increased level of potential absorptive capacity without the realised absorptive capacity needed to commercialise it (Zahra and George, 2002). In fact, it is difficult to see any definite difference between the concept of potential versus realised absorptive capacity and exploration vs. exploitation, although the former seems to be a broader concept. This thesis will adopt Zahra and George’s (2002) terminology, as it fits better within the overall concept of absorptive capacity.

Within the two types of absorptive capacity, Zahra and George identify four dimensions, two for potential and two for realised absorptive capacity. These dimensions are acquisition and assimilation, which are both classified as potential absorptive capacity, as well as transformation and exploitation, which are realised absorptive capacity. When compared to Cohen and Levinthal’s (1990) original paper, Zahra and George (2002) have added the dimension transformation which Cohen and Levinthal does not mention; the other three are to some extent covered. Transformation refers to the internal mechanisms that allow the firm to combine existing knowledge with newly acquired knowledge.

2.5.3. Empirical studies with an explicit operationalisation of ACAP

A number of authors have taken a more enhanced view of absorptive capacity when operationalising the concept, looking at different mechanisms and contributing factors. Jones (2004), influenced by Zahra and George’s (2002) concept of potential and realised absorptive capacity, suggests that the potential of small service firms is dependent on their ability to respond by acquiring and exploiting external information. Lin et al. (2002) link the effectiveness of technology transfer with absorptive capacity. In absorptive capacity they include factors such as technology diffusion channels, interaction mechanisms and R&D resources. They conclude that absorptive capacity is critical for effective technology transfer. Caloghirou et al. (2004) selected a set of variables representing what they considered “an enhanced notion of absorptive capacity”, such as R&D spending, human resource training and mechanisms for internal and external knowledge flow, and found that they do indeed contribute to innovation. Nieto and Quevedo (2005) operationalised absorptive capacity along four dimensions: communication with the external environment, level of know-how and experience, diversity and overlap in the knowledge structure, and strategic positioning. They found that absorptive capacity has a high explanatory power for the success of innovation. Another interesting finding is that firms’
innovative efforts in an environment of technological change and opportunity are aided by a critical mass of know-how and certain absorptive capacity. This means that firms that have sufficient internal absorptive capacity are better suited both to innovate and to adapt to changes in external conditions.

2.5.4. Concluding remarks on absorptive capacity

A clear development in the concept of absorptive capacity has apparently occurred. Although Cohen and Levinthal (1989, 1990) clearly state that absorptive capacity is both a resource as well as the structure of communications (an integration mechanism, in the terminology of this thesis), they still operationalised it only as a by-product of R&D spending. Other early empirical studies followed their example and regarded absorptive capacity only as a resource. In later papers, in particular Zahra and George (2002), the concept has evolved into representing both a resource as well as the mechanisms through which that resource is utilised. This development has a striking similarity to the development within the strategy literature (see previous section): from the first articles on the resource-based view (Barney, 1991) to the competence perspective of Sanchez (2008). It can therefore be concluded that the studies of Cohen and Levinthal (1989, 1990) and those empirical studies with a straightforward interpretation are in line with Barney (1991), whereas later absorptive capacity studies are in line with Sanchez (2008). The same development can be observed in the appended papers of this thesis: the third paper is line with the former and papers 4 and 5 are in line with the latter.

ACAP is thus a useful tool for analysing the strategic role of manufacturing capabilities for the two dimensions of supply chain management identified by Lau and Yam (2005): supply chain integration and supply chain design. In integration an enhanced view of ACAP and the competence perspective is preferential, as it allows the researcher to discern how manufacturing capabilities influence the effectiveness of external and internal integration.

In most of the ACAP literature, ACAP is defined as both the knowledge assets a company possess and they way they are utilised and managed. Similarly, absorptive capacity in a manufacturing context is in this thesis defined as both the manufacturing-related knowledge assets (termed manufacturing capabilities), as well as the way these are managed and utilised (termed integration mechanisms). However, paper 3 differs, as it defines ACAP as a resource that can be utilised through supplier integration.

2.6. The Conceptual Framework

The purpose of this thesis is to assess the strategic role of manufacturing capabilities for a product-owning firm, by focusing on what impact its internal manufacturing capabilities have on the integration of the manufacturing department with customers, suppliers and the product development department. This chapter has reviewed literature that can be used for that purpose. This meant reviewing concepts such as manufacturing capability and strategic resources, describing the supply chain context, as well as providing a tool for analysing the interface between the concepts. In this section all the concepts will be integrated into one conceptual framework (figure 1). The model will also be used for
illustrating how the appended five papers relate to the overall topic of the thesis. The conceptual framework consists of five broad concepts that are connected to each other in accordance with figure 1. The concepts are manufacturing strategy and competitive priorities, manufacturing capabilities, external resources, integration mechanisms and performance. Contextual factors are external factors that decide the context in which competitive priorities are framed. The distinction between resources and mechanisms is in line with the competence perspective of Sanchez (2008), where resources are only useful if they are managed appropriately. The research questions in the next section will also be related to the conceptual framework. The concepts presented below are operationalised in the next chapter, Methodology.

2.6.1. Competitive priorities and manufacturing strategy

Competitive priorities should guide not only the development of internal manufacturing capabilities and other resources, but also the design of the supply chain. As was discussed previously, competitive priorities are mostly identified at the business unit level. The main factors influencing competitive priorities are overall corporate strategy and product characteristics, including technological maturity. Competitive priorities are typically innovation (functionality in Christensen’s 1997 terminology), quality, speed or low cost. This thesis will contrast between innovation and low cost. The role of a manufacturing strategy is to fulfil the competitive priorities by deciding which capabilities and practices are needed, both in the company’s own manufacturing unit as well as in the supply chain. The role of manufacturing strategy is therefore also to design an appropriate supply chain.

2.6.2. Available resources, external to the manufacturing department

A resource is a useful asset available to the firm (Sanchez, 2008). Note that the term available to the firm is used, meaning the firm does not have not own them, which fits well with the supply chain context of this thesis. It is, however, useful to make the distinction between internal and external resources. As the thesis has a manufacturing focus, internal resources refer to resources internal to the manufacturing department, whereas resources in other departments, as well as supply chain partners, are seen as external. Thus, all resources that are not internal manufacturing resources are treated as external resources.

As noted previously, useful resources available are often external, and some of them reside in supply chain partners. Both customers and suppliers can possess relevant resources that can be used for both product and process development. External resources are useful to the firm because they can contribute to performance, and some of them are outside direct control. This means that they do not respond directly to competitive priorities. Moreover, external resources do not contribute to the performance of the focal firm directly; they contribute to the performance of their owners. Thus, the firm must seek to acquire and assimilate these resources in order to improve performance in line with competitive priorities. Once the appropriate resources are located, appropriate integration mechanisms need to be deployed, supported by adequate manufacturing capabilities.
Note that in contrast to Barney’s (1991) focus on strategic resources, the conceptual framework only identifies the presence of a resource, which may or may not be strategic. A strategic resource is valuable, rare, imperfectly imitable, and non-substitutable. As pointed out by Sanchez (2008), this distinction makes sense at first glance, but both in theory and in practise it is impossible to actually identify which resources fulfil these criteria. Another deviation from the resource-based view proposed by Barney (1991) is the distinction that will be made between capabilities and they way they are utilised (integration mechanisms). This distinction also alleviates an inherent weakness of Barney’s framework, as identified by Sanchez (2008).

2.6.3. Internal manufacturing capabilities
According to Sanchez (2008), capabilities are bundles of resources (coordinated through appropriate management processes); internal manufacturing capabilities are thus bundles of a firm’s own manufacturing resources. Examples of manufacturing capabilities are the use of advanced machinery or the use of flow-oriented manufacturing. These capabilities should be developed in accordance with the firm’s competitive priorities. When the capabilities are utilised in an effective manner, the outcome is increased performance, in terms of e.g., increased productivity or lower cost of NPD. Internal manufacturing capabilities can also be used in combination with external resources, if appropriate integration mechanisms are utilised and if the level of capabilities are at a sufficient level, i.e., the firm has adequate manufacturing ACAP.

2.6.4. Integration mechanisms
According to Simutapang et al. (2002), in order to achieve external integration, a company must coordinate a number of external parties, whereas Sanchez (2008) highlights the importance of management processes for this intention. The management processes that are relevant for the theoretical framework of this thesis are referred to as integration. Integration is thus the way the supply chains, including product development, are managed. Customers, suppliers and the product development department can be integrated with the manufacturing department; this is referred to as different types of integration. Each type of integration consists of a number of mechanisms for both new product development and everyday operations. Examples of mechanisms used for integrating customer and suppliers are early involvement in new product development and joint efforts to reduce costs. Since new product development is regarded as a supply chain activity, external integration can also include the product development department. The integration of the manufacturing and product development departments is also treated as external integration, as product development is outside of the manufacturing department. Integration mechanisms for this type of integration include designing production processes concurrently with the product development process and manufacturing personnel contributing early in the product development process.

2.6.5. Manufacturing absorptive capacity
Absorptive capacity is the tool used for assessing manufacturing’s extended role. ACAP is a combination of manufacturing capability and integration mechanisms. The role
manufacturing can play is determined by its ACAP, whereas the role it should play is determined by its competitive priorities. A distinction can also be made between potential ACAP, which is a combination of capabilities and mechanisms, and realised ACAP, which is the ACAP that has actually been exploited for increasing performance (Zahra and George, 2002). Paper 5 also recognises that ACAP is relative, meaning that the potential for successful integration of two parties, in this case customer and supplier firm, is determined by the similarity of their capabilities and mechanisms (Lane and Lubatkin, 1998). The more similar two firms are, the higher the relative ACAP is.

![Figure 1. The conceptual framework.](image)

2.6.6. Performance

The aim of a strategy is to increase performance, but performance can be measured very differently. The relevant performance metrics will depend on competitive priorities. For firms aiming for lower cost, productivity is one of the most important performance metrics. If the competitive priority is to increase innovation, the most relevant performance metrics will for example be the number of new products, market success or product development efficiency. This thesis is mostly concerned with efficiency, which means that the most important performance metrics are productivity and delivery for cost-focused firms, and NPD efficiency for innovation-focused firms. New product development efficiency will be operationalised as shorter time to market and lower cost of new product development.
2.7. Research Questions

The model above outlines the main concepts of the thesis and how they are linked to each other. In this section the model will be used for positioning the research questions used in the five papers. The research questions can be grouped into two main categories: the impact of competitive priorities and the impact of manufacturing capabilities on integration mechanisms.

2.7.1. The impact of competitive priorities

As was highlighted previously, competitive priorities have, or should have, an impact on how companies choose to arrange their manufacturing operations, as well as the wider supply chain. In particular, this thesis is concerned with how competitive priorities influence the integration mechanisms and what the effect is on performance. Competitive priorities’ influence can be specified in the following research question:

RQ 1a: How do a company’s competitive priorities influence the level of integration between the manufacturing department and the company’s customers, suppliers, and product development department?

The level of integration is of little use if the outcome of the integration effort does not result in the intended effect, i.e., performance improvements corresponding to competitive priorities. Research question 1b can thus be phrased as:

RQ 1b: How do competitive priorities influence the outcome of integration between manufacturing and a company’s customers, suppliers, and product development department?

As was mentioned in the literature review, integration is only one part of supply chain management. The other main part, supply chain design, concerns the overall shape of the supply chain, including the location of facilities and the choice of transport modes. Competitive priorities are at least as important for these strategic decisions. The second research question can thus be phrased as:

RQ 2: How do competitive priorities influence the design of the overall supply chain?

Supply chain design ultimately determines the location of internal and external manufacturing capabilities and the importance of internal and external integration. Research questions 1a and 1b are answered in paper 1, whereas research question 2 is answered in paper 2.
2.7.2. The impact of manufacturing capabilities

The second topic of this thesis is the interaction effects of manufacturing capabilities and integration mechanisms. The chosen theoretical framework, ACAP, suggests that these mechanisms will be more efficient if the company possesses relevant internal resources. The research of this thesis focuses on how one type of internal resources, manufacturing capabilities, will impact the efficiency of three types of integration. One of these types of integration is supplier integration. The third research question is thus:

RQ 3: Do internal manufacturing capabilities make supplier integration more efficient in terms of increased performance for the focal firm?

Supplier integration is one type of integration the company can employ. Other relevant types of integration include customer integration and integration between manufacturing and product development departments. These two are very often used for new product development. Research questions 4a and 4b are thus:

RQ 4a: Do internal manufacturing capabilities make customer integration more efficient in terms of more efficient new product development?
RQ 4b: Do internal manufacturing capabilities make the integration of manufacturing and product development departments more efficient in terms of more efficient new product development?

More efficient new product development is in this thesis defined as lower cost of NPD and shorter time to market.

There are many types of manufacturing capabilities that may have an impact on integration mechanisms. The final research question will explore these in more detail, in order to shed some light on which capabilities have an impact and how they influence integration mechanisms. The fifth and final research question is thus:

RQ 5: How do manufacturing capabilities influence integration mechanisms in practice?

Research question 3 is answered in paper 3, research questions 4a and 4b in paper 4, and research question 5 in paper 5.
3. METHODOLOGY

This chapter is dedicated to describing and discussing the methodology that was used for the empirical part of this research. The chapter is divided into six sections. The introduction discusses, on a general level, how the research questions shape the choice of methodology. The second section describes the quantitative, i.e., survey part of the study (used in papers 1, 3 and 4), and the third section describes the qualitative case study research for papers 2 and 5. The fourth section describes how the concepts of conceptual framework have been operationalised. The fifth section discusses validity and reliability for both the quantitative and the qualitative parts of the study, and the relative strength of each methodology. The sixth and final section is a description of the research process that led up to the writing of the thesis.

3.1. Introduction to Methodologies

Many social scientists adopt a social constructionist approach, where the focus is on the perception of reality and not the ‘objective’ reality itself, whereas a positivist approach is more prominent in natural science (Silverman, 2000). The positivist approach is more concerned with explaining social or other phenomena with the belief that there is an ultimate truth out there, whereas social constructionists want to understand complex social interactions. As the purpose of this study is explanatory and to a large extent based on a survey of a representative sample of the Swedish manufacturing industry, the overall approach is inevitably tilted towards positivism. However, the study is not purely positivist, because it acknowledges that a survey can only measure the respondent’s perception of reality, not reality itself. The ability to generalise the findings to a larger population is very desirable in survey research, and is a characteristic of positivism (Silverman, 2000). However, a later part of the study (paper 5) involves qualitative data and is concerned with refining the findings of the quantitative study (see also Voss et al., 2002). In order to keep coherence between the different parts of the study, it is appropriate to adopt the same approach in all parts. In fact a mismatch between different underlying assumptions of the world could produce highly dubious findings. Another justification for adopting a positivist approach is the desire, in the long run, to be able to generalise the findings to the whole population of similar firms. Managerial implications of the research are quite important in the field of operations management and related disciplines; to obtain those, confidence in the explaining power of the proposed model is useful. By contrast, understanding one particular firm is only helpful to another firm if the research can point to similarities and differences.

According to most scholars, the main requirement of a research methodology is that it be suitable for answering the research questions (e.g., Silverman, 2000; Yin, 2003). In other words, there is no ‘best’ methodology, and a prudent researcher should adopt the practises best suited to the task at hand.

The first paper deals with both research questions 1a and 1b, i.e., to what extent do competitive priorities influence the level as well the outcome of integration, which leads to theory testing. This requires its own specific set of logic. The phases in this type of
research are literature review, designing a conceptual framework, operationalising the framework, testing the framework, and then analysing the results. For this type of question, generalisability is at a premium; since the usefulness of the framework is highest if it can be proven that it applies to a wide range of cases. One of the best ways of assuring generalisability is to have a large sample size, and a large-scale survey is a practical way of accomplishing that. Other methods are certainly also possible, but conducting in-depth case studies of a very large number of firms is simply not feasible except for large research teams.

The aim of this particular study is to achieve a high level of generalisability, which favours a survey. The study aims to answer a ‘how much’ type of question (the level of integration) as well as a causal relationship (how do they influence…). A survey is ideally suited for answering the ‘how much’ questions, but the causal relationship questions are worth paying particular attention to. To overcome the risk of drawing causal conclusions from a correlation between two factors, a solid theoretical framework is required (Forza, 2002).

Research question 2 (paper 2) of this thesis was aimed at exploring how supply chains should be designed now and in the near future. An explorative study, with a large number of unknown factors, can only be conducted using a qualitative methodology. In this paper a case study methodology was used.

Research questions 3 and 4 (papers 3 and 4 respectively) deal with the question as to what extent manufacturing capability contributes to the success of different types of integration, which also implies theory testing, and the same process as described earlier.

Research question 5 (paper 5) investigates how the absorptive capacity of a manufacturing firm looks in practise, and is thus aimed at theory refinement (Voss et al., 2002). Provided that the concept of absorptive capacity is valid, why does the observed phenomenon take place? A survey cannot, despite substantive efforts to devise an all-encompassing instrument, take into account all the potential factors that might influence absorptive capacity. In order to answer this question satisfactorily, a qualitative study is thus called for. There are, however, many different methodologies that could be appropriate for this task, and combining different types according to the situation allows the methodology to match the task as well as possible.

Different methodologies were thus applied in order to answer the different research questions, where the key distinction is between quantitative and qualitative research. Research questions 1, 3 and 4 are answered using quantitative methods, based on a large-scale survey. The large-scale survey was not only used to answer the research questions, but also to develop a framework for the qualitative part, particularly paper 5.

In this study, there was ample theory to build up a theoretical construct without any need for an explorative qualitative study at the early stages. The constructs, described in chapter 2, are fairly straightforward; a broad survey would provide enough details to answer the research questions adequately. What no survey can provide, however, is detailed accounts of complex relationships among many variables. Thus, there was a need to follow up the survey with a more detailed qualitative study. There was also a practical reason to conduct the quantitative part of the study before the qualitative – a more or less immediate access to a substantial database whose value would deteriorate if the
quantitative study were to be postponed. The collection and use of the database will be further discussed in the next few paragraphs.

3.2. Survey Methodology

Papers 1, 3 and 4 are based on a large-scale survey that was mailed out during the early months of 2004 to the plant managers of a representative sample of the Swedish manufacturing industry. All plants in the sample had more than 50 and less than 6500 employees and operated in the following sectors: metal goods, machinery, office equipment and computers, other electronics, telecommunications, instrumentation, and automotive (ISIC codes 28-35). This constitutes a diverse cross-section of both the Swedish and the European manufacturing sectors. Because many of these firms compete successfully in the global marketplace, the results are of interest for manufacturing firms competing world-wide. A representative sample was desired, as the aim was to investigate the validity of the previously mentioned conceptual framework for general manufacturing environments. The sample was limited to firms with at least 50 employees, since smaller firms have limited resources for developing elaborate manufacturing and supply chain practices and programmes.

Table 1: The survey sample

<table>
<thead>
<tr>
<th>Strata (No. of employees)</th>
<th>Total Population</th>
<th>Stratified sample</th>
<th>Adjusted sample</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-99</td>
<td>496</td>
<td>200</td>
<td>188</td>
<td>80</td>
</tr>
<tr>
<td>100-199</td>
<td>251</td>
<td>150</td>
<td>144</td>
<td>77</td>
</tr>
<tr>
<td>200-499</td>
<td>169</td>
<td>169</td>
<td>155</td>
<td>69</td>
</tr>
<tr>
<td>500-999</td>
<td>55</td>
<td>55</td>
<td>48</td>
<td>24</td>
</tr>
<tr>
<td>1000+</td>
<td>32</td>
<td>32</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>1003</td>
<td>606</td>
<td>563</td>
<td>267</td>
</tr>
</tbody>
</table>

The total population was 1003 firms, from which 606 were randomly selected, in accordance with five strata (see table 1). The number was later adjusted to 563 due to factors such as that the company was no longer in business. After sending three reminders, complete responses from 267 companies were obtained, a response rate of 47%. A separate analysis of non-respondents was conducted by telephoning a random and stratified sample of non-respondents. When comparing the answers on background questions (size, kind of production, whether the company has design capability, as well as the complexity in design and production), no bias was detected. Another analysis comparing early and late responses confirmed the validity of the sample. The survey
instrument includes a total of 51 questions, resulting in 198 items. These cover many different areas but papers 1, 3 and 4 are only concerned with those questions dealing with internal capabilities, supplier integration and plant operating performance.

The survey contained a set of questions, 13 in total, about the change the manufacturing department has witnessed in the last three years. There were also 12 items describing the performance improvement of the manufacturing department. That these two topics are strongly linked is theoretically well understood and the survey did indeed show a strong correlation between them. The survey had five items concerning relations with suppliers, four items about customer relations, and five items about relations between the manufacturing and the product development departments.

3.3. Case Study Methodology

The findings of the three survey-based papers did not provide a complete and accurate picture of the phenomena predicted by theory. The solution was thus to extend the research to case studies. Two case studies were done: the first aimed at serving as an illustrative example of absorptive capacity, whereas the second aimed at providing a richer picture of manufacturing’s role in the supply chain.

The main source of inspiration for planning and conducting the case studies has been the seminal work of Yin (2003). This work is a widely quoted qualitative methodology book in the field of operations management, as well as related disciplines. The widespread use of the book can be seen as comforting, as a rigorous following of the procedures described in the book can hardly be seen as unconventional. However, an uncritical adoption of any model is always dangerous. It is important to pay attention to the context, and in a research setting that means, more than anything, looking at how the chosen methodology conforms to the requirements of the research question. Another work that serves as a guideline when attempting qualitative research is Voss et al. (2002), who describe how case studies can, and have been, used in operations management. An author who is highly sceptical about an overly positivist approach to case study research is Silverman (2000), and may thus serve as a useful complement to Yin (2003).

In the first case study, a case study protocol prepared according to the guidelines in Yin (2003) consisted of the following parts: an overview of the research project, the case study questions and instructions for the interview procedure. The objective of the case study protocol is to help the interviewer keep the interview procedures similar and according to plan, as well as to facilitate a reliable inter-case as well as cross-case analysis. It was highly useful to have such a document prepared in advance, although this particular protocol had serious shortcomings. The most serious one was that there were a large number of questions that called for fairly short, almost survey-like answers. Another problem was that the same protocol was used for all interviewees regardless of their position within the firms. Subsequent questions for the sales managers included items concerning supplier relations. On the other hand, the firm was rather small, so most managers had some knowledge in areas that were not part of their formal job description. All the same, limiting the questions to the areas where the interviewee has most expertise saves time and facilitates more comprehensive answers.
The first firm studied was selected for having most of the required characteristics, i.e., it was a manufacturing firm that has manufacturing capability as the key to its long-term survival (it is a contract manufacturer, with limited engineering design capability). It is fairly successful as a supplier to major Swedish industries like Ericsson and ABB, and it supplies complex products and strives to increase the level of sub-assemblies. A practical reason for selecting this particular supplier is also that one of its managers, who is also in the process of doing a PhD, volunteered to be a key informant.

The interviewees in the first case study were selected based on a mutual understanding of who possessed most of the relevant knowledge. Their roles are the CEO (and production manager), market (sales) manager, sales engineer, quality and environmental manager, and purchasing manager. Individual interviews were subsequently conducted with each one, lasting between one and two hours. All interviews were conducted during a single visit. The interview transcripts were later reworked and tabulated, with precautions to establish a trail of evidence. The evidence was complemented by the obtained documents, including the annual financial report. The results, presented in tabular form to ensure multiple sourcing of evidence, were then reworked into a written document. Subsequent reassessments of the document produced a draft paper which was reviewed by the key informant.

The second case study was initially more open ended, and thus also less structured. An opportunity to follow an internal supply chain development project at Ericsson was the initial part of the study. The project team was led by a senior supply chain architect, and the other four members of the team were supply chain managers. Little structuring was initially possible, as managers at Ericsson were in charge of the agenda. Simultaneously, a vast quantity of internal Ericsson documentation was read and was indeed vital for understanding the highly technical jargon, as Ericsson’s technical writers have a particular fondness for acronyms. Later stages of the study involved more systematic methods, particularly semi-structured interviews of present and former managers of research, logistics and accounting, as well as an external expert in the economics of mobile networks. The multiple sources of information allowed triangulation of the findings. The subsequent findings were confirmed and approved for publication by the key informant and his superior.

3.4. Operationalisation of Core Concepts

The core concepts of the conceptual framework (figure 1), are: (1) competitive priorities, (2) manufacturing absorptive capacity, which consists of (3) internal manufacturing capabilities and (4) integration mechanisms, (5) available resources external to manufacturing and finally (6) performance. The following paragraphs will describe how these were measured.

3.4.1. Competitive priorities

Competitive priorities were measured in papers 1 and 2. In paper 1, they were measured as the extent to which the surveyed companies rank a number of criteria as important for why customers choose their company. There were a total of 12 possible criteria, where
quality was deemed by far most important, followed by functionality of the product and price. However, quality was found not to be a differentiating factor for companies: most companies think quality is important, irrespective of their industry or overall strategy. Price and functionality were, on the other hand, differentiating factors. In the subsequent analysis, the companies were divided into three groups based on their answer: cost, functionality of the product (level innovation) and market responsiveness (a number of other criteria). Paper 2 contrasts innovation with low cost.

3.4.2. External resources available to the manufacturing department

External resources available to the manufacturing department were not measured, because it can be reasonably assumed that a large amount of resources are external but available to manufacturing. In fact, most resources are external to the manufacturing department, and some of them can be acquired, assimilated and exploited. The challenge is rather to utilise external resources, which is indeed the topic of this thesis. The types of resources that are relevant are knowledge of product and production processes, including the supply chain.

3.4.3. Internal manufacturing capabilities

Internal Manufacturing capabilities were measured using eight items in paper 3 and six items in paper 4. These items are displayed in table 2. In paper 5 (a case study), a larger number of manufacturing-related capabilities, such as industrialisation of the product (design for manufacturing) and knowledge of production and processes was found to have an impact on customer and supplier integration.

3.4.4. Integration mechanisms

Three types of integration were considered: customer, supplier as well as manufacturing/product development department. In the survey-based papers (1, 3 and 4) the number of items used for these were five, four and five, respectively, as displayed in table 2. As can be observed in the table, not all papers utilised all measures of manufacturing capability or integration mechanisms. In addition to the types of integration previously mentioned, paper 4 also utilised cross-functional teams in process development as a type of integration used for exploiting external resources. The case study papers had a more holistic perspective and highlighted some other mechanisms such as the audit of suppliers (paper 5) and supplier involvement in NPD, as well as sharing of demand forecasts in paper 2.

3.4.5. Manufacturing absorptive capacity

Manufacturing absorptive capacity was measured in paper 3 as the level of manufacturing-related capabilities that could be leveraged through supplier integration. In paper 4 a more elaborate construct was utilised, separating manufacturing ACAP into manufacturing capabilities (same as paper 3), and three types of integration: customer, manufacturing and product development departments, as well as the use of cross-functional teams in product
and process development. The case study in paper 5 followed the same approach as in paper 4, but provided a more detailed account of the concepts and how they are related.

3.4.6. Performance
Performance was measured with a total of 16 items in papers 1 and 3 and included productivity, production lead time, cost of NPD and changes in financial results. As paper 4 was focused on NPD efficiency, performance was measured by cost of NPD and time to market. The case study papers (2 and 5) did not measure performance.
Table 2: The operationalisation of manufacturing capabilities and integration mechanisms in the survey-based papers

<table>
<thead>
<tr>
<th>Manufacturing Capabilities</th>
<th>Paper 1</th>
<th>Paper 3</th>
<th>Paper 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A change in the usage of advanced machinery and technical equipment</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. An increase in the utilisation of machinery</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Increased flow-oriented manufacturing</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. More specific programmes aimed at increasing flexibility</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>e. Change in proportion of independent teams with responsibility for planning and performing</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>f. Systematic efforts aimed at increasing the competence of personnel</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Customer integration

| a. Early customer involvement in NPD                                                      | X       |         |         |
| b. Customer collaboration in cost reduction                                               | X       |         |         |
| c. Customer access to production planning & systems                                        | X       |         |         |
| d. “Customer contributes significantly to product improvements”                           |         |         | X       |

Supplier Integration

| a. Our most important suppliers contribute early in the product development (PD) process. | X       |         |         |
| b. We pursue joint efforts to reduce costs.                                                | X       |         |         |
| c. We give suppliers access to manufacturing plans and systems.                            | X       |         |         |
| d. Suppliers contribute to significant product improvements.                               | X       |         |         |
| e. We cooperate actively to integrate our manufacturing processes.                         | X       |         |         |

Integration of mfg. and product development depts.

| a. Manufacturing dept. informs PD dept. about its capabilities.                           | X       |         |         |
| b. Mfg. dept. suggests improvements that improve manufacturability.                       | X       |         |         |
| c. Production processes are designed concurrently with PD.                                 | X       |         |         |
| d. Manufacturing personnel are involved early in PD projects.                             | X       |         |         |
| e. “Manufacturing and PD personnel collaborate intensively”.                                | X       |         |         |

The use of cross-functional teams

| a. Cross-functional teams are used for developing production processes.                    | X*      |         |         |
| b. Cross-functional teams are used for designing supply and distribution systems.         | X*      |         |         |
| c. Cross-functional teams are used for market development.                                 |         |         | X       |
| d. Cross-functional teams are used for systematic improvements.                           | X*      |         |         |

* The use of cross-functional teams was classified as a manufacturing capability in paper 3.
3.5. Validity and Reliability

Construct, internal and external validity as well as reliability are key concepts for ensuring high quality in positivist research. These four will each be discussed in the following sections.

3.5.1. Construct validity

Construct validity refers to whether the reported phenomena genuinely reflect actual events or if they have been clouded by the researcher’s preconceptions. The researcher should rigorously approach the subject in such a manner as to minimise potential bias and assure objectivity (Yin, 2003). In quantitative research, construct validity is focused on the convergence between different measures of the same construct as well as the difference between constructs, although the latter is not used commonly in operations management research (Forza, 2002). Testing for construct validity can be done using factor or confirmatory factor analysis, which was indeed successfully carried out in papers 1, 3 and 4.

However, there may still be some concerns about construct validity in these three papers. The operationalisation of competitive priorities in paper 1 may cause some concern. The survey instrument did not specify whether the competitive priorities describe order winners or order qualifiers (Hill, 2000); doing so could have caused confusion among the respondents. Therefore, it is not entirely certain that the questions used captured the intended measure of competitive priorities, which according to the theory of this paper should be seen as the order winners.

In the third and fourth papers, absorptive capacity is assumed to increase when a firm invests in manufacturing capability, as was discussed in the literature review. There are, however, many ways of operationalising the construct, and the constructs used in papers 3 and 4 may not be optimal. But it is indeed in line with previous research, as pointed out by the literature reviews in the papers.

There was also a fairly straightforward operationalisation of integration, which was just supplier integration (five items) in the third paper and customer (four items), supplier and internal integration (five items) in the first and fourth paper. More items could have been included in order to accomplish a more complete assessment of the level of integration, but more measures may result in lower convergence. The measures that were employed do indeed show a very high level of convergence, as demonstrated by the factor analyses.

Assuring construct validity is difficult in a case study, whereas a survey can follow a rigid, widely recognised set of procedures when operationalising the conceptual framework and analysing the results. In a case study a researcher must carefully pre-select the variables he intends to study and demonstrate that measuring the selected variables is done in a way consistent with the pre-defined selection (Yin, 2003). Yin recommends using three methods for assuring construct validity: establishing a chain of evidence, using multiple sources of evidence and having key informants review a draft case study report. Silverman (2000) maintains that there is no simple ‘golden key’ to validity and questions the effectiveness of these methods. He is particularly critical of the likelihood of achieving better validity by using multiple sources of evidence, since many people within the same organisation will hold the same views without it actually being the ‘whole truth’. Although
Silverman (2000) does have a valid point, the alternatives he offers are much more time-consuming and would require the researcher to be embedded in the organisation for quite some time. Due to time constraints, Yin’s (2003) methodology seems sufficiently appropriate for the task at hand. Surely no methodology is perfect, and subsequently no result of a qualitative study could have zero margin of error. The quest for perfection is more important than perfection in itself.

The chain of evidence was established using the following logic: First, the field notes were rewritten to increase clarity and annotated in areas of interest. The different variables were written in a tabulated form to establish patterns as well as coherence between the different respondents. Conclusions were drawn based on the table and a draft case study report was written. The case study report was reviewed by the key informant to ensure that the observed phenomena were reasonably coherent with her experience as a manager at the studied firm. Multiple sources of evidence mostly consist of different interview data in paper 5, although Yin (2003) does recommend using other secondary data as well. Although only a few relevant documents were obtained (such as annual reports), these were certainly also included. Paper 2 has considerably more and diverse data, collected through participant observation, interviews and a large amount of internal documentation.

3.5.2. Internal validity

Internal validity is a concern for explanatory studies such as papers 1, 3 and 4, where the researcher is trying to establish causal relationships. There are some problems one should pay attention to. For example, if the researcher claims that A causes B, is the opposite true? Or is there perhaps a third factor C that causes both A and B? Yin (2003) does not offer any simple solutions to this problem, but the key is to have a rigid theoretical framework. The framework presented in chapter 2 stipulates that manufacturing capability would give a company the absorptive capacity to benefit from supplier integration. Cohen and Levinthal (1990) pointed out that absorptive capacity is usually a by-product of investment in a certain area, in this case manufacturing capability. That means that reverse causality cannot be true according to the theory used in this thesis, i.e. absorptive capacity cannot give the firm a higher investment in manufacturing capability. The other type of error, a third factor causing both manufacturing capability and an ability to integrate suppliers, is not plausible either, as the very definition of capability is the set of underlying abilities that allow the company to improve. An unknown factor that underlies the underlying capabilities does not make any sense.

Another issue concerning internal validity is the concept of inference. A researcher makes an inference when a causal relationship is not directly observable, for example a researcher might conclude that result A occurred because of action B. In this case the researcher must consider potential rival explanations and, by using multiple sources of evidence (in case study research) as well as a sound theoretical framework, establish that the only reasonable explanation is indeed that B caused A. This thesis aims to establish that the presence of manufacturing capability causes the link between integration and plant performance to become stronger. If that is the case, the conclusion is that the cause is an absorptive capacity that has been gained through an investment in manufacturing capability. A number of rival explanations can indeed be contemplated. First, the
effectiveness of integration may not be dependent on manufacturing capability but on capability in managing suppliers or customers, which in turn is dependent on manufacturing capability. This explanation is indeed plausible, but it is only a variation of the proposed explanation – the underlying capability is still the source of the absorptive capacity. Second, the presence of manufacturing capability can be directly attributable to (and owned by) suppliers and customers, if many of them work at the focal plant. This would still imply that the manufacturing capability at the production site is the root cause of the effectiveness of integration (although it would be defined as suppliers’ internal integration), and it does not matter much whether that capability is formally owned by the focal firm or by its suppliers.

3.5.3. External validity

External validity, also known as generalisability, refers to whether the finding is generalisable beyond the studied case. When doing a survey, it is quite easy to achieve high levels of external validity (or statistical generalisation) and the key is to have a large sample size with a high response rate representing the group of firms that are the subject of the study. The survey that forms the backbone of this thesis has 267 respondents and a response rate of 47%; the sample does adequately represent the entire Swedish manufacturing industry. These numbers are very high indeed, implying a high level of generalisability. In a case study the same methodology is not applicable, as that would imply studying a large number of firms. The alternative methodology used in case studies is instead analytical generalisation, where the researcher chooses a case specifically suitable for testing and validating the theoretical framework (Yin, 2003). In order to increase the external validity, the study can then be repeated and the results replicated. In the fifth paper the results of the case study are analysed using the theoretical framework that has been partly validated using the survey and strongly supported by theory.

3.5.4. Reliability

The aim of ensuring reliability is that another researcher analysing the same data using the same theoretical framework would arrive at the same conclusion. The aim is thus to minimise errors and bias. This is not a major concern for quantitative research if widely accepted statistical tools are used. In a case study, one way of assuring high reliability is to collect as many reliable documents as possible, in addition to using a case study protocol (Yin, 2003). An obvious requirement for any good researcher is personal integrity and rigour; this is particularly true for quantitative researchers. The aim of this study is certainly to achieve a high level of reliability, and the main strategy for achieving this is to use a highly structured approach, as was indeed the case for paper 5. Particularly for a fairly inexperienced researcher, and in order to achieve high reliability, it is also useful to rely on key informants and other researchers. As mentioned, paper 2 was based on a large amount of diverse and reliable data. The key informant played an active role in reviewing the findings in order to minimise error and bias.
3.5.5. The strength of multiple methods

We can now see that there is no single best method; the main criterion when choosing a methodology is that it is appropriate for the research question. However, the research question can naturally be phrased so that it favours a particular methodology, perhaps due to access to an interesting case or availability of other data. This means that there may in fact be other criteria that influence the methodology than purely the research question. One approach is to evaluate the need to achieve high validity and reliability. Qualitative and quantitative methodologies have entirely different capacities to achieve high validity and reliability, respectively.

The table above shows the relative strengths of case study and survey methodology. In the table we can see that surveys are relatively stronger in construct and external validity as well as in reliability, whereas case studies can achieve a higher internal validity. Most researchers would like to have high scores in all four measures of research quality, which may be very difficult to achieve using a single method. The most effective way is thereby to combine two or more methods. This is one of the key strengths of this thesis, where papers 3 and 4 research ACAP’s impact on external integration and paper 5 refines the findings by looking more closely at which particular manufacturing capabilities and mechanism have the most impact. Likewise, paper 1 demonstrates the impact of competitive priorities in internal and external integration, whereas the case study of paper 2 refines the findings by illustrating how competitive priorities influence the design of the entire supply chain.

3.6. The Research Process

The research of this thesis commenced in September 2004 and was originally concerned with the role of manufacturing within the context of increased levels of outsourcing. There was a general concern that the future of manufacturing in Sweden was at risk, and that all new manufacturing jobs would be located in low-cost countries in Eastern Europe and in Asia.

Because previous studies (such as my MSc thesis), had focused on the supply chain management field, it was natural to have a supply chain perspective on manufacturing. This means a more holistic view of manufacturing, where the relations between the focal manufacturing firm and its suppliers and customers are key to maintaining efficient production. When exploring the role of manufacturing in the supply chain, the concept of absorptive capacity seemed a fruitful way of describing the role manufacturing plays in facilitating external integration. Other approaches were certainly also feasible, and the concept of dynamic capabilities (Teece and Pisano, 1994) was indeed also considered. The main weakness of the absorptive capacity literature is the lack of universally agreed definitions, and perhaps another framework would have brought more clarity. Also, the lack of coherent theories about absorptive capacity, particularly in manufacturing, meant that there was great deal of room for interpretation.

The literature contains several studies predicting that both manufacturing capability and external integration should contribute positively to plant performance, but the link between these two was less developed. When it became apparent that those firms that
had positive development of the manufacturing department also were more likely to have a strong correlation between the variables concerned with customer/supplier relations and plant performance, an interesting subject for a thesis was established. Studies explaining the observed phenomenon were thereafter reviewed, and the most promising explanation was absorptive capacity (Cohen and Levinthal, 1990). The first phase of the research can thus be described as being a mix between inductive and deductive reasoning. The second element of the quantitative data analysis had a clear deductive approach. During a course in innovation management, I read an illuminating book by Christensen (1997) and curiosity compelled me to test how Christensen’s theories relate to integration.

The reading of Christensen’s (1997) book influenced paper 1, which is the main reason the term competitive priorities forms an important part of this thesis. Basing that part of the research on literature focused on manufacturing would have been a more conventional approach to the subject. However, the way Christensen’s (1997) framework is used in this thesis does not deviate much from more traditional approaches to manufacturing strategy. The main difference, and indeed strength, is that Christensen’s (1997) framework is more dynamic compared to manufacturing strategy–based frameworks. A competitive priority is not set in stone, but changes over time, sometimes rapidly, in response to changing technology or customer preferences. Christensen (1997) provides a more detailed description of why competitive priorities change when technologies and markets mature, and what the consequences are.

After the appropriate literature was reviewed, a conceptual framework for investigating the desired phenomenon was devised. The operationalisation of the concepts had to be coherent with the identified literature, but also with the data that had already been collected. This poses some issues concerning validity that will be further discussed later in this chapter. After the appropriate statistical analysis was conducted using the SPSS software package, the results were presented in two conference articles that were accepted at the 2005 and 2006 EurOMA conferences. The second paper of this thesis is identical to the one presented in the 2006 conference, whereas the first paper has been reworked for publication in the International Journal of Manufacturing and Technology Management.

The choice of the survey methodology was also more or less predetermined. When research commenced survey data had already been collected by former PhD student Stefan Westin. Data analysis combined with simultaneous literature studies was thereby the first step on the journey, not the more traditional literature studies – data collection – analysis sequence. There are both advantages as well as disadvantages with the conducted approach. The main advantage concerns the time gained in not having to design, distribute and collect the questionnaire. The main disadvantage is that the survey was not designed in an optimal way for the theory used, which may raise some questions about validity. It would, for example, have been better if manufacturing capabilities had been measured in line with the findings of the case study in paper 5. This paper highlighted some of the most important capabilities needed for successful external integration, which were not the same as the one picked up by the survey. Operationalisation of the constructs had to be done so that they fit with the obtained data. This is a main concern, especially for paper 4, as was also pointed out by reviewers.

The findings of the survey-based papers did not give a satisfyingly clear picture of the studied phenomena, and therefore more in-depth studies of a small number of firms were needed. A case study methodology was chosen because it could fulfil the research criteria.
within the available time frame. The aim of the first case study, presented in paper 5, was to illustrate manufacturing-related absorptive capacity and to get a better picture of what integration mechanisms and capabilities contribute. A rather short case study, where data was collected mainly through semi-structured interviews, was deemed adequate. By contrast, the aim of paper 2 was to get a more complete picture of the challenges firms face when designing their supply chain. The methodology and the data collected were in this case more inclusive. The opportunity to take part in a preliminary study at Ericsson, and the openness of the managers there, was naturally the main determinant of the chosen case as well as the data collection method.

As mentioned, responsibility for collection of the survey data was originally Stefan Westin’s, but since he quit the university and took no part in the data analysis of the papers, his name is not included in any of papers, although his efforts deserve to be acknowledged in this thesis. The case study data was collected by me. I also conducted all data analysis and writing of papers, with very helpful feedback from colleagues, reviewers and most of all PhD programme supervisors. In acknowledgement of his endless support and substantial insights, the main supervisor, Lars Bengtsson, also appears as co-author of papers 1, 3 and 5.
4. OVERVIEW OF THE APPENDED PAPERS

This chapter provides an overview of the five thesis papers, whereas the next chapter will outline how the papers answer the research questions. This chapter is divided into five sections, one for each of the appended papers. The overview reiterates the research questions addressed and shows how each paper fits in with conceptual framework, and then briefly presents the aim, background, methodology and results of each paper.

4.1. Internal\textsuperscript{2} and External Integration and its Effect on manufacturing firms’ competitiveness

The Proceedings of the 2006 EurOMA conference, Glasgow, United Kingdom

The first paper aims to answer research questions 1a and 1b:

RQ 1a: How do a company’s competitive priorities influence the level of integration between the manufacturing department and the company’s customers, suppliers and product development department?

RQ 1b: How do competitive priorities influence the outcome of integration between manufacturing and a company’s customers, suppliers and product development department?

The first research question deals with two parts of the conceptual framework: competitive priorities and integration mechanisms, as well as how they are related. The second research question also includes performance, as highlighted in figure 2.

According to Christensen (1997), competitive priorities are dependent on the maturity of the technology, and according to papers such as Christensen et al. (2002) it should have an effect on how companies integrate. The first paper investigated how the integration between the manufacturing department and customers, suppliers and product development relate to competitive priorities, and how three different competitive priorities influence the performance outcome. Competitive priorities were seen as external decisions for the manufacturing department to respond to, where one of the key decisions is which type of integration to employ. Thus, contextual factors, and their influence on competitive priorities, were not part of the analysis. When the right integration mechanisms have been employed, the performance outcome should mirror the competitive priorities. Note that this paper does not include the concept of ACAP to describe integration mechanisms and their effect on performance. Instead it was assumed that the outcome of integration is independent of the level of manufacturing capability.

Based on a large-scale survey, Swedish manufacturing companies were divided into three groups based on what they stated was the main reason customer chose their company

\textsuperscript{2} As opposed to the terminology in the rest of the thesis, in paper 1 internal integration refers to the integration of the manufacturing and the product development departments.
instead of competing ones. The three groups consisted of functionality of the product (innovation), the price of the product, and a collection of other criteria, mostly related to service level or delivery (termed market responsive). The level of integration, i.e., to what extent the manufacturing department are developing products and production processes in collaboration with customers, suppliers and the product development department (for more details, see table 2 in section 3.4), was then compared among the three groups. Finally a relationship among the three types of integration and various performance measures was investigated using a correlation analysis.

![Diagram](image)

**Figure 2. The conceptual framework and paper 1.**

For the level of integration no distinction between the groups was detected, except that the firms competing over the functionality of the product had significantly more integration of the manufacturing department and the department responsible for product development. This finding is supported by literature, including Christensen (1997). The need to quickly convert designs into manufactured products, and the challenge to do so, is most important in sectors experiencing rapid technological change.

Comparing outcome of integration, it differs widely depending on the firm’s competitive priorities. Innovation-focused firms seem to benefit most from integration of manufacturing with the product development department and supplier integration, with the greatest benefits in the areas of innovation and flexibility/lead time. The market-responsive firms gained only from customer and supplier integration in terms of improved dependability of deliveries as well as more effective new product development. The cost-focused firms did not see any gain from internal integration either, whereas customer and supplier integration contributed to flexibility and rather surprisingly to some innovation factors. The majority of performance indicators were, however, not correlated with the integration of customers, suppliers or the product development department.
4.2. Beyond Fisher’s Product-Supply Chain Matrix: Illustrating the Actual Impact of Technological Maturity on Supply Chain Design

Forthcoming in the International Journal of Logistics Systems and Management

The research question for the second paper is:

RQ 2: How do competitive priorities influence the design of the overall supply chain?

The aim of paper 2 is to discuss the challenges of designing a supply chain based on competitive priorities, which are in this case mainly driven by product technological maturity, and to illustrate how a leading technology-based company solves the problems of conflicting and fast-evolving supply chain demands. The contribution of the paper to this thesis is outlined in figure 3. Note that it is acknowledged that many contextual factors influence competitive priorities, but this paper primarily deals with technological maturity. Also note that concept of manufacturing ACAP is not part of the analysis.

![Figure 3](image)

Figure 3. The conceptual framework and paper 3.

The research for the second paper of this thesis was originally aimed at exploring how supply chains should be designed now and in the near future. As the framework for competitive priorities used in this thesis is based on literature stressing the dynamic nature of competition, technological maturity forms an important dimension. According to the literature (Christensen, 1997), companies typically compete over the functionality of a product when technology is relatively new, whereas companies in mature industries mainly compete over price. According to Fisher (1997), the main characteristic of
innovative products is that demand is unstable and unpredictable. However, there are factors influencing demand other than the level of innovation, and this study takes into account different types of sales, referred to as “product” and “project.” Product sales are relatively stable and involve a large number of sales, each with relatively low volumes. Project sales are uncertain in terms of timing, geographical location and volume.

Moreover, the level of innovation influences aspects of supply chain design other than the ability to cope with unpredictable swings in demand. Fast-changing innovative products require a firm to develop and bring to market new products in an efficient and effective manner, whereas the focus is more on operational efficiency for less innovative products. All the previous aspects have a great impact on the design of supply chains, both theoretically and in practice. The paper is based on a single case study and aims to investigate how well the case study is aligned with the identified theory. Parts of the theory were previously tested by numerous authors (see paper 3 for a review), whereas this paper aims to provide a more detailed illustration of the supply chain challenges in a fast-moving, high-technology setting. The study can thus be classified as theory refinement (Voss et al., 2002). The methods used were participant observations, semi-structured interviews and a review of a large amount of internal documentation.

In line with the literature, the study found that technological maturity is driving a change towards a more efficient supply chain. The efficient supply chain is, however, not suitable for all products. Ericsson, the case company, has solved the problem of efficiency with two partly separated supply chains: a responsive one when demand is uncertain and a more efficient one for standard products with predictable demand. The paper concludes that the supply chain will of necessity be both a compromise and segmented based on the characteristics of the company’s many products and other factors, such as the type of sales, which impact the predictability of demand.
4.3. Manufacturing competence\(^3\) – A key to successful supplier integration


The research question for the third paper is:

**RQ 3:** Do internal manufacturing capabilities make supplier integration more efficient in terms of increased performance for the focal firm?

The third paper aims to analyse the effect on performance of the interaction between the manufacturing capabilities of the focal firm and supplier integration, which is one type of integration firms can employ. The ACAP framework is used for analysing this interaction. The contribution of the paper to this thesis is outlined in figure 4.

![Figure 4. The conceptual framework and paper 3.](image)

According to the early literature on ACAP, in this thesis referred to as having indirect operationalisation, the mere presence of capabilities would assist any effort at acquiring more resources from external sources. The higher the capabilities, the higher the ACAP and the more efficient supplier integration is going to be. To test the propositions of the early ACAP literature, a large-scale survey was utilised, in order to achieve high external validity and reliability.

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\(^3\)The term *competence*, used in the article, is replaced by the term *capability* in the thesis.
Manufacturing capabilities were operationalised using eight items including the use of advanced machinery, increased flow-oriented manufacturing and cross-functional teams in process development. These were subsequently divided into three categories using factor analysis: ‘technology’, ‘lean’ and ‘cross-functional teams’. Supplier integration was measured using five items, including early involvement in NPD and suppliers given access to production plans and systems. The propositions were tested using 16 performance indicators, including production lead time, cost of NPD and changes in market share. For more details of how the construct were operationalised, see section 4.3.

The companies were subsequently divided into two clusters, one with a low level of manufacturing capability and one with high, for each of the three categories of manufacturing capabilities. A partial correlation analysis was then conducted individually for each cluster, to determine the correlation between supplier integration and performance.

The results demonstrate that firms with higher manufacturing capability gain more from supplier integration than firms with less capability, as there is a significant correlation between supplier integration and performance in 20 instances for the ‘high capability’ clusters, versus 7 for the ‘low capability’ clusters. The pattern is particularly strong for the ‘technology’ clusters, whereas the results are more ambiguous for the ‘lean’ clusters.

The link between performance and supplier involvement is, as hypothesised, to some degree dependent on internal manufacturing capabilities. Companies that have well developed capability, and have subsequently gained a manufacturing absorptive capacity, show a strong correlation between supplier integration and overall plant performance, as well as some other operational and innovation indicators. For all three considered categories of capabilities, there is a strong correlation between supplier integration and changes in financial results, but only for the ‘high’ capability cluster.
4.4. Do Customers Improve New Product Development Efficiency? Revealing the Impact of Manufacturing-Based Absorptive Capacity

Submitted to: International Journal of Business Performance Management

The research questions for the fourth paper are:

RQ 4a: Do internal manufacturing capabilities make customer integration more efficient in terms of more efficient new product development?

RQ 4b: Do internal manufacturing capabilities make the integration of manufacturing and product development departments more efficient in terms of more efficient new product development?

![Figure 5. The conceptual framework and paper 4.](image)

The fourth paper aimed to analyse the interaction between the manufacturing capabilities of the focal firm and three types of integration mechanisms: customer integration, integration of the product development and the manufacturing department, as well as the use of cross-functional teams in manufacturing. For the purpose of the thesis, only the first two are of interest. The choice of integration mechanisms was guided by the need to develop and test a framework in line with an explicit operationalisation of ACAP (see theoretical framework). The original aim of the paper was also to explicitly test the ACAP framework, whereas the contribution of each integration mechanism was a secondary concern. The research question and the contribution of the paper to this thesis are outlined in figure 5.
This paper is in line with the explicit operationalisation of ACAP, described in the theoretical framework chapter. The method used for this chapter was a large-scale survey, the same survey used for papers 2 and 3. An ACAP model was developed and tested by factor and hierarchical regression analysis. Customer integration was measured using four items, including early involvement in NPD and access to production plans and systems. Internal integration was measured using five items, including production personnel being involved early in NPD and production processes being designed concurrently with products. The use of cross-functional teams was measured in terms of the extent these are used in production and supply chain development, marketing, and for systematic improvement (a total of four items). Manufacturing capability was measured using six items, including the use of advanced machinery and an increase in flow-oriented manufacturing. For more details, see table 2 in section 3.4.

The first step of the hierarchical regression analysis consisted of the independent variables acquisition (customer integration), assimilation (internal integration), exploitation (use of cross-functional teams) and manufacturing capability, without any interaction effect. The second step included the hypothesised interaction effects between manufacturing capability and the three types of integration mechanisms. By including the interaction effect, the explanatory power of the models is significantly increased for dependent variables, time to market (TTM) and the cost of new product development (NPD). This result supports the notion that both components of ACAP are needed for effective new product development. The interaction effects of manufacturing capability and acquisition are significant for TTM and NPD cost. In fact, the interaction effects explain more of the variance than the independent variables do on their own. However, there is only a significant contribution from the interaction effect between customer integration and manufacturing capability. The contribution from the interaction effect is not significant for the integration of manufacturing and product development departments or the use of cross-functional teams.
4.5. Manufacturing competence\(^4\) and external integration: Absorptive capacity in a first-tier supplier

The Proceedings of the 2007 EurOMA conference, Ankara, Turkey

The research question for the fifth paper is:
RQ 5: How do manufacturing capabilities influence integration mechanisms in practice?

The fifth paper aims at providing more insight into how manufacturing capabilities interact with integration mechanisms. Although papers 3 and 4 covered ACAP, the use of survey methodology limited the scope for exploring the full breadth of capabilities and mechanisms that contribute to manufacturing ACAP. Another difference between paper 5 and papers 3 and 4 is that paper 5 does not link ACAP to performance. The contribution of the paper to the thesis is outlined in figure 6.

According to the conceptual framework of paper 5, there are two sources of absorptive capacity: manufacturing capability and integration mechanisms. The framework stipulates that the two dimensions must be combined in order to achieve a positive outcome. Moreover, ACAP exists at three different levels: acquisition, assimilation and exploitation.

The fifth paper is based on a single case study methodology and uses Yin (2003) as the principal guideline. The target company was chosen because they cooperate extensively with their customers and to some extent also their suppliers. The choice was also

\(^4\) The term *competence*, used in the article, is replaced by the term *capability* in the thesis.
influenced by relative ease of access. The data was collected by semi-structured interviews. The interview transcripts were later reworked and tabulated to allow both triangulation and the establishment of a trail of evidence. The main findings of paper 5 are displayed in table 3.

**Table 3: Manufacturing capabilities and the effect on integration mechanisms**

<table>
<thead>
<tr>
<th>Manufacturing-related capabilities</th>
<th>The effect on integration mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rapid changeovers and quick production ramp-up</strong></td>
<td>Can select customer with high capabilities (learn from the best) because they request this capability; can have a more diverse selection of customers</td>
</tr>
<tr>
<td><strong>The ability to combine capabilities</strong></td>
<td>Can get more complex orders, and more responsibility, from demanding customers</td>
</tr>
<tr>
<td><strong>Knowledge of components</strong></td>
<td>Sharing knowledge of components with customers</td>
</tr>
<tr>
<td><strong>Forming and implementing mfg. strategies</strong></td>
<td>Sharing and aligning mfg. strategies with customers and suppliers</td>
</tr>
<tr>
<td><strong>High “general” mfg. capabilities</strong></td>
<td>Customers auditing the focal firm, benchmarking with suppliers, auditing suppliers, suppliers and customers seek closer relations with highly capable firms; sharing “best practises”</td>
</tr>
<tr>
<td><strong>Design for manufacturing</strong></td>
<td>Joint product development with customers that also allows mutual learning</td>
</tr>
</tbody>
</table>

The findings of the paper show some of the manufacturing-related capabilities that are required for effective external integration. For company A the most important one is what has been termed a ‘combinative capability’ (Kogut and Zander, 1992), i.e., an ability to combine different capabilities in order to produce value. The company employs many different integration mechanisms with its customers and suppliers, and the paper argues that the effectiveness of many of these are to a large extent dependent on manufacturing-related capabilities.

Customers and the focal firm often have similar capabilities because both assemble relatively complex products using a number of components. In contrast, suppliers have focused on developing niche skills, often involving machining but not assembly. This is sometimes a problem, as there is less understanding of supplier processes and technology. Better component knowledge would address some of those problems, but so far the company has solved the problem by utilising their customers’ knowledge of components. This pooling of capabilities can be termed a collective absorptive capacity.
5. DISCUSSION

The purpose of the thesis is to assess the strategic role of manufacturing capabilities for a product-owning firm by focusing on what impact its internal manufacturing capabilities have on the integration of the manufacturing department with customers, suppliers and the product development department. The results of each of the papers provide some valuable insight into this topic, by focusing on one individual question related to the overall discourse. This chapter will highlight how the papers answer the research questions and also how they contribute to the discussion of the role of manufacturing capabilities in the supply chain. The final chapter, Conclusions, will present what the strategic role of manufacturing capabilities is, when taking the findings of all five papers into account.

5.1 Internal and external integration and its effect on manufacturing firms’ competitiveness

The research questions of paper 1 are:

RQ 1a: How do a company’s competitive priorities influence the level of integration between the manufacturing department and the company’s customers, suppliers and product development department?

RQ 1b: How do competitive priorities influence the outcome of integration between manufacturing and the company’s customers, suppliers and product development department?

Based on the findings outlined in the previous chapter, the answers to the research questions can be summarised as:

Answer 1a: Integration between the manufacturing and the product development department was, as expected, higher for the innovation-focused firms compared to market-responsive or cost-focused firms. Contrary to expectations, supplier and customer integration did not differ significantly between groups. The results show that competitive priorities only influence the level of integration between manufacturing and the product development department and not the level of customer or supplier integration.

Answer 1b: The paper showed that for firms whose competitive priority is innovation, integrating manufacturing with product development is beneficial. Integrating manufacturing with the product development department as well as suppliers and customers is of vital importance for the firms whose competitive priorities are to be market responsive or price focused. Competitive priorities thus have a significant impact on the outcome of companies’ integration efforts.
Competitive priorities thus determine which types of integration are most beneficial for a firm. When the company’s competitive priority is low cost, an efficient supply chain is key (Fisher, 1997), which includes integrating customers and suppliers. When the competitive priority is innovation, a responsive supply chain is more appropriate (ibid.) and the integration between manufacturing and product development departments is most important (Christensen et al., 2002). When the integration efforts are optimal, the outcome mirrors the competitive priority (Boyer, 1998), i.e., more efficient product development or more efficient production for innovation and cost focus, respectively. However, competitive priorities change over time, meaning that solely focusing on improving one performance criterion may lead to relatively lower performance, using other indicators, in the future. The first paper shows that shifts in competitive priorities should be followed by a corresponding shift in integration efforts. The finding is in line with Christensen et al. (2002), who advocate a disintegrated supply chain, in terms of ownership, when the competitive priority is cost and an integrated one when the competitive priority is innovation. When value added is spread among many firms, integrating supplier and customers becomes more important, as is also stated by Lo and Power (2010). A key reason for a firm to own a larger part of the supply chain is to facilitate better product development (Christensen et al., 2002), which includes integrating the manufacturing with the product development department (Ulrich and Ellison, 2005).

Although the level of integration did not differ much between the groups, the outcome of integration did vary depending on the companies’ competitive priorities. In other words, firms integrate with customers and suppliers irrespective of competitive priorities, but they do not get the same benefits. There are two possible explanations for this: either the content of their integration efforts differs in areas that were not picked up by the survey (i.e., product and process development), or their integration efforts are not in line with the demands of their competitive priorities.

The results were somewhat ambiguous and there are numerous potential reasons for that. First, one can raise the usual concerns about how the concepts have been operationalised (see section 3.5.1). Second, an underlying assumption of the paper was that firms behave rationally and that the type of integration was implemented to support their competitive priorities. That may, however, not be the case, as some of these integration efforts may be left over from a previous era where the firms’ competitive priorities were different. The integration mechanisms may have been ideally suited for previous competitive priorities, but may no longer be suitable. This explanation is rather similar to the phenomenon described by Hill (2000), where a firm’s strategy or products have changed but the firm’s manufacturing strategy has not. A third explanation is that the integration does indeed fit the overall competitive priorities of the firm but that the firm lacks the absorptive capacity required for utilising integration effectively. This seems plausible, because Boyer (1998) reported that competitive priorities have little impact on actual implementation of manufacturing practices, meaning that firms may lack the required manufacturing-based ACAP to support the required supply chain integration.

The contribution to the overall topic of the thesis is that manufacturing capabilities may play an important role in the supply chain and in product development, but the role differs depending on what the competitive priorities are.
5.2. Beyond Fisher’s product-supply chain matrix: Illustrating the actual impact of technological maturity on supply chain design

The research question for paper 2 is:

RQ 2: How do competitive priorities influence the design of the overall supply chain?

Based on the findings outlined in the previous chapter, the answer to the research question can be summarised as:

Answer: Competitive priorities have a clear impact on the design of the supply chain. The case study company, Ericsson, which until recently has been focused on innovation, focuses more on the integration of internal departments than on customers or suppliers. However, as the telecom equipment industry is maturing, implying a gradual shift in competitive priorities, Ericsson is gradually giving more attention to its supply chain. The change can be observed as increased outsourcing, more responsibilities for capable suppliers and a more cost-efficient distribution system.

Earlier studies suggested that the level of innovation and the predictability of demand are the main determinants of supply chain design. The proposed solution is to have an efficient or a responsive supply chain, depending on the demands of the most important product. Paper 2 pointed out three weaknesses with this argument. First, the link between innovative products and responsive supply chains is not as strong as Fisher (1997) suggests. Factors beyond the innovativeness of products also place requirements on responsiveness. Second, highly innovative products demand supply chains that support product development rather than just responsiveness. Third, the demands are changing due to both product life cycle and technological dynamics. The problem is compounded by the fact that most firms sell multiple products at different stages of the product life cycle. These three factors mean that supply chains have to be progressively redesigned or the firm must settle for a compromise between opposing demands. This finding expands the arguments of Fisher (1997), who highlights the need for innovative firms to have supply chains capable of responding to the rapid changes in demand typical of innovative products.

A one-size-fits-all supply chain strategy is inadequate when the opposing demands grow too large, as this case study shows. Christopher (2000) suggested either a hybrid approach or a separate supply chain for each product. The latter solution was also advocated by Aitken et al. (2003). The Ericsson case reveals evidence of both approaches: two partially separate supply chains. One of them can be described as truly responsive, whereas the other is more cost efficient. In the Ericsson case, technological change entails that a large and growing share of their products compete on price, increasing the need for supply chain efficiency.

The development of supply chain design at Ericsson in the last decade differs significantly from that at Nokia Networks (Collin et al., 2009), a firm operating in the exact same
segments and markets as Ericsson. There are thus multiple solutions to the dilemma faced by companies in the telecom equipment sector. Which solution is the best remains unresolved: although Ericsson has been successful lately in terms of market share and profitability, particularly compared to Nokia Networks, this may be due to other factors.

The paper fits into the overall topic of this thesis by providing a more detailed picture of contemporary global supply chains, and to a lesser extent product development. Although the role of internal manufacturing capabilities was not initially in focus, it soon became clear that the role was indeed of prime concern. Productivity in the manufacturing department had improved dramatically for Ericsson in recent years, driven both by the establishment of lean principles but perhaps even more importantly by changing characteristics of the product. The product had become increasingly modularised, with fewer parts (which are also interchangeable) that could be rapidly and easily assembled (for a description of modularisation, see Ulrich, 1995). In fact, production costs were now lower than the cost of logistics. Manufacturing still retains its role as a consolidation point for the flow of modules from supplier to customers. However, that role is also diminishing as modules are getting more standardised, which allows for assembly closer to customers. The future role of manufacturing capabilities must therefore be extended to the supply chain. When the management of manufacturing is no longer confined to individual firms, the role of supply chain management replaces the role of managing internal manufacturing capabilities. An important task is thereby to harness manufacturing and product-related capabilities, through appropriate integration mechanisms, wherever they reside in the supply chain.
5.3. Manufacturing competence – A key to successful supplier integration

The research question for paper 3 is:

RQ 3: Do internal manufacturing capabilities make supplier integration more efficient in terms of increased performance for the focal firm?

Based on the findings outlined in the previous chapter, the answer to the research question can be summarised as:

Answer: Internal manufacturing capabilities make supplier integration more efficient. The combined effect of supplier integration and manufacturing capabilities such as the use of advanced machinery and the efficient utilisation of these, contribute to increased performance, particularly in terms of increased flexibility and reduced lead times. The combined effect of supplier integration and the use of cross-functional teams in manufacturing operations contribute to increased product development efficiency and better financial results.

The findings of the paper were in line with Cohen and Levinthal (1990), as well as with the other empirical studies that had indirect operationalisation of ACAP (see chapter 2). The indirect operationalisation means that R&D or manufacturing spending can be used as a proxy for absorptive capacity. This study shows that an increased level of manufacturing capabilities does have a similar effect, and the absorptive capacity that has been gained can be exploited by integrating suppliers.

The results confirmed the presence and effect of ACAP, but did not provide much detail about how manufacturing capabilities contribute to increased efficiency of supplier integration. Also, only one out of many types of integration, supplier integration, was tested. Moreover, the results of the third paper were not as clear as hoped for, although there are more significant positive correlations for the firms deemed to have a higher manufacturing capability compared to the firms with lower capability. However, for a number of factors no significant correlations for either group were detected. There can be a number of explanations for this; the next few paragraphs mention some of them.

First, according to both Cohen and Levinthal (1990) and subsequent authors like Zahra and George (2002) or Lane and Lubatkin (1997), absorptive capacity is a rather complex construct. It involves not only the level of previous investments, although that is in focus in Cohen and Levinthal (1989, 1990), but also factors such as the relatedness of the knowledge, the type of knowledge, as well as the type of communication with the external environment, to mention a few. In this paper we adopted the rather simple approach used by Cohen and Levinthal (1989), Veugelers (1997) and Stock et al. (2001), and simply considered absorptive capacity a result of previous investments in manufacturing. It may, however, not be sufficient in order to capture the full diversity of the concept (see also Mowery et al., 1996).
Second, as absorptive capacity is path dependent (Cohen and Levinthal, 1990), there must be a fit between a firm’s absorptive capacity and the knowledge it seeks from external sources as well as the mechanisms it uses. ACAP was measured using eight items (see section 3.4.3), but did not include the type of knowledge the firm is attempting to acquire. It is possible that there is a mismatch between these in some companies. Supplier integration is bound to fail no matter how much absorptive capacity they have in the domain we have measured, if it does not correspond to the knowledge the firm is seeking.

Third, Lane and Lubatkin (1998) emphasised the relative level of knowledge between the two firms, and Mowery et al. (1996) showed that related capabilities enhance absorptive capacity. However, only the level of capability of the focal firm was measured, not the level of its suppliers. This means that there is no way of telling if the capabilities the firms have invested in are related to those of its suppliers. Ideally the investment in manufacturing capability should have been measured at both firms. Only if they invest in similar capabilities can the absorptive capacity be expected to improve. But in practice that measurement is very difficult to perform using survey methodology.

The papers’ contribution to the topic of the thesis is that manufacturing capabilities do play an important role in a supply chain context. Integrating suppliers into product and process development is a key part of supply chain management (Ragatz et al., 2002), and paper 3 demonstrates that the ability do so effectively is to some extent dependent on the level of manufacturing capabilities.
5.4. **Do customers improve new product development efficiency? Revealing the impact of manufacturing-based absorptive capacity**

The research questions for paper 4 are:

**RQ 4a:** Do internal manufacturing capabilities make customer integration more efficient in terms of more efficient new product development?

**RQ 4b:** Do internal manufacturing capabilities make the integration of manufacturing and product development departments more efficient in terms of more efficient new product development?

Based on the findings outlined in the previous chapter, the answers to the research questions can be summarised as:

**Answer 4a:** Internal manufacturing capability increases the company’s ACAP and makes customer integration more efficient. The efficiency can be measured as shorter time to market and a lower cost of new product development.

**Answer 4b:** This study does not find any evidence of internal manufacturing capability having an impact on the efficiency of integration between the manufacturing and the product development department in terms of shorter time to market or lower cost of new product development.

The results of this paper were clearer than the results of paper 3, meaning that it is reasonably certain that manufacturing capabilities do have an impact on new product development efficiency, which was the key question of the paper. The contribution of each integration mechanisms is, however, less certain, as there were numerous instances where the contribution was not significant. Testing whether (and which) integration mechanisms contribute to NPD efficiency was not the original aim of the paper, although the research questions of this thesis, in order to be coherent with the other papers, are phrased as such.

The theoretical aim of the paper was to test whether the ACAP framework, with an explicit operationalisation (see section 2.5.3), is valid for this context. The answer to that question is affirmative, although there are some questions regarding the constructs. The integration mechanism component of ACAP was measured at three different levels: acquisition, assimilation and exploitation. The first two are fairly straightforward and can be relatively easily operationalised. Exploitation, on the other hand, posed a serious challenge. Previous empirical research is not always a good guideline as there has been considerably leeway in the ways ACAP in general (Lane at al., 2006), and exploitation in particular (Lane and Lubatkin, 1998; Zahra and George, 2002), has been operationalised. The main question is: what is a typical integration mechanism used in later stages of NPD, i.e., when external knowledge is put to practical use? This paper used the extent of the use of cross-functional teams in process, supply chain and market development as the
integration mechanism. Cross-functional team integrate knowledge from different departments, hence it is a type of integration. Process, supply chain and market development are when new products are being prepared to be exploited for commercial success.

The conceptual framework developed in this paper was to a large extent based on previous work, most notably Lane et al. (2006) and Zahra and George (2002). The results of this study are in line with their work and thus support previous findings. However, previous studies did not focus on manufacturing or make a clear distinction between knowledge resources (capabilities) and integration mechanisms. Consequently, this paper provides an extension of the conceptualisation of absorptive capacity.

For efficient NPD, resources should be allocated in a manner that lowers NPD cost and time to market. Investments in manufacturing result in a considerable cost for firms and cannot easily be justified on the basis of increasing innovation capability. This paper shows that investments in manufacturing will have no direct effect on either TTM or cost of NPD. However, the paper shows that the interaction effect of manufacturing capabilities and integration is significant and both shortens TTM and lowers NPD cost. In other words, by broadening the resources to areas that allow a firm to acquire, assimilate and exploit knowledge, i.e., supply the company with adequate ACAP, NPD can be made more efficient. The rationale for manufacturing investments should thus not only be based on direct effects but also on the ACAP it provides. This absorptive capacity gives the company the capability to more quickly and cheaply acquire, assimilate and commercialise external knowledge. This finding is clearly in line with Cohen and Levinthal’s (1989, 1990) original propositions.

Paper 4 showed that manufacturing capabilities increased the focal firm’s ACAP, which resulted in better NPD efficiency. When product development is deemed more important than manufacturing efficiency, the natural tendency is to prioritise investments in the former. The results of this paper show that this may be a mistake, since investment in manufacturing capabilities will not only increase manufacturing efficiency, but also NPD efficiency. Naturally, NPD efficiency is not important, or even relevant, for firms whose competitive priority is low cost.
5.5. Manufacturing competence and external integration: Absorptive capacity in a first-tier supplier

The research question for paper 5 is:

RQ 5: How do manufacturing capabilities influence integration mechanisms in practice?

Based on the findings outlined in the previous chapter, the answer to the research question can be summarised as:

Answer: The results show that some of the manufacturing-related capabilities are required for effective external integration. For the case study company, the most important one is what has been termed ‘combinative capability’ (Kogut and Zander, 1992), i.e., the ability to combine different capabilities in order to produce value. Other important capabilities that have an impact are the ability to achieve short changeover times and design for manufacturing. The company employs many different mechanisms with its customer and suppliers, e.g., customer selection and segmentation, alignment of manufacturing strategies, supplier evaluation, as well as comparing their own manufacturing operation with that of their suppliers. The effectiveness of many of these mechanisms depends to a large extent on manufacturing-related capabilities.

Similarity of capability, in this case between the customers and the focal firm, gives a high level of relative absorptive capacity (Lane and Lubatkin, 1998). Both the focal firm and its main customers have broad capabilities that allow them to integrate various internal and external sources. However, the focal firm has a lower level of absorptive capacity relative to its suppliers, because the latter have focused on developing niche skills not possessed by the focal firm.

The results of the paper should not be viewed as a definite answer as to what actually constitutes ACAP. This is a single case study, and the results serve to highlight some of the manufacturing-related capabilities and mechanisms that make up a manufacturing firm’s ACAP. For other firms, other manufacturing capabilities or integration mechanisms may be more relevant and for different reasons. ACAP, and relative ACAP even more so, is context specific and unique to each firm (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998). To map the full list of manufacturing capabilities and mechanisms that contribute to ACAP would require a very large study indeed. This also shows why survey-based studies of ACAP, such as papers 3 and 4, by necessity must measure ACAP at a very general level.

The findings were not particularly extensive; many of the rather common capabilities and activities that may take place in most manufacturing firms do contribute to the absorptive capacity. Perhaps most firms and individuals do not regard these as absorptive capacity, due to their everyday nature as well as the fact that they were originally developed to take care of a specific task and not to build up absorptive capacity. However, this only confirms the very nature of absorptive capacity, as Cohen and Levinthal (1990) noted that absorptive capacity is typically obtained as a side effect of investment in a particular area.
However, at times firms may not have the absorptive capacity required to develop their businesses, and this is particularly true when the market experiences rapid technological change (ibid.). In these cases it is prudent to invest in knowledge that may not produce immediate benefits, but will still build up absorptive capacity. The case study firm was in the midst of industry-wide restructuring, where suppliers are asked to take ever more responsibility for product development as well as other additional services. Perhaps this is one of those times where a shift in the market should be accompanied by more investment in absorptive capacity?

With respect to the discussion of the strategic role of manufacturing capabilities, the findings of paper 5 do not deviate from the findings of papers 3 and 4. Manufacturing was indeed a strategic resource for the case company, which is not really surprising considering that its business is to manufacture components for other large companies, components that are often designed by the customer. However, the strategic role of manufacturing capabilities was wider than just optimising in-house production for high efficiency, fast and secure delivery, and high quality. The case company’s manufacturing capability had been leveraged for both supply chain efficiency and product development efficiency. The supply chain efficiency was increased by working closely with suppliers, as well as auditing and developing their capabilities. This task was very much dependent on the company’s own capabilities. Product development efficiency was increased by suggesting amendments to the components that would increase quality, cut costs and ease assembly.
6. CONCLUSIONS

This chapter will first, based on the findings of the five papers, conclude what the strategic role of manufacturing capabilities is. This is achieved by focusing on what impact internal manufacturing capabilities have on the integration of the manufacturing department with customers and suppliers, as well as with the product development department. Subsequently, the chapter will outline the theoretical contribution, managerial implications and suggestions for further research. As an epilogue, the chapter will finish by elaborating on how the findings of the case can be applied to the cases mentioned in the introduction, Nokia and Apple.

6.1. The Strategic Role of Manufacturing Capabilities

The purpose of this thesis is to assess the strategic role of manufacturing capabilities, by focusing on what impact internal manufacturing capabilities have on the integration of the manufacturing department with customers, suppliers and the product development department. The thesis has argued, and shown, that in order to evaluate the strategic role of manufacturing capabilities, it is important to look beyond manufacturing capabilities’ direct contribution to performance, and to look at how they can assist the supply chain in improving performance in line with competitive priorities.

Papers 1 and 2 showed that the role manufacturing capabilities can play is dependent on firms’ competitive priorities. When the technology is new, the competitive priority tends to be innovation, and the role of manufacturing capabilities is to facilitate more efficient NPD. As products mature, low cost is the dominant competitive priority, and the role of manufacturing capabilities is to facilitate a high operational efficiency of the supply chain. The strategic role of manufacturing capabilities is thus dependent on the maturity of the products, but as the maturity of the product changes over time (by its very definition), the role of manufacturing capabilities will change too. When making strategic decisions regarding manufacturing it is important to take into account its dynamic nature.

Although the potential role of manufacturing capabilities is dependent on the firms’ competitive priorities, just possessing manufacturing capabilities will not automatically translate into high performance, as was shown in paper 4. Instead, the performance outcome is dependent on both the level of manufacturing capabilities, but even more importantly how they are leveraged through various integration mechanisms. The results show that a high capability in manufacturing makes customer (paper 4) and supplier (paper 3) integration more efficient, and results in both higher operational efficiency as well as faster and more cost-efficient NPD. The impact on the integration of the product development department is less conclusive, as shown by paper 4. In practise, paper 5 showed that many of the integration mechanisms a firm can employ, such as supplier audit or helping customers with design for manufacturing, are indeed dependent on manufacturing capabilities.

Previous studies have shown that the integration of customers (Gruner and Homburg, 2000) and suppliers (Primo and Amundson, 2002) are beneficial when developing new
products. Paper 4 has shown that high capabilities in manufacturing can make customer integration more efficient and thus reduce the cost of NPD and reduce the time to market. The third and fifth papers investigated how manufacturing capability makes supplier and customer integration more efficient, respectively. The third paper shows that proficiency in the use of advanced machinery and the use of cross-functional teams make supplier integration more efficient in terms of delivery performance, but also innovation and financial results. The fifth paper lists some of the manufacturing-related capabilities and how they can improve both customer and supplier integration. Papers 3-5 all agree that it is the combination of internal manufacturing capabilities and integration that gives firms a competitive advantage, whereas the value of both manufacturing capabilities and integration is considerably less when measured individually.

The impact of manufacturing-based ACAP is particularly strong for performance criteria such as flexibility, and they are important for innovation-focused firms as they contribute to a responsive supply chain (Fisher, 1997). According to Boyer (1998), firms that focus on cost efficiency are the ones most likely to invest in efficient manufacturing, whereas the findings of the thesis show that innovation-focused firms are even better positioned to take advantage of the ACAP the investment provides.

However, as pointed out earlier, competitive priorities are not static. Companies that today compete on innovation may be competing on low cost tomorrow, or vice versa, which means that assessing the long-term strategic importance is far from easy.

The findings of the thesis imply that manufacturing capabilities may well seem expendable, but only if they are assessed in isolation and when evaluating them by their direct contribution to firm performance. If suppliers offer superior performance, the best choice may well appear to be to outsource manufacturing. Arnold (2000) suggested that complete outsourcing of manufacturing is optimal; no competitive advantage can be gained from possessing manufacturing capabilities. In his view the firm’s main role is to integrate a number of external partners. Similarly, McCarthy and Agnastosou (2004) argued that the relative decline of manufacturing is not a cause for concern since it is compensated for by the increased importance of purchasing brought about by outsourcing. The findings of this thesis suggest that the arguments of Arnold (2000) as well as McCarthy and Agnastosou (2004) are fallacious; the advantages these authors attribute to the efficient utilisation of external sources cannot be realised without possessing adequate internal manufacturing capabilities. This becomes evident when looking at how manufacturing capabilities influence the efficiency of integration. When looking at manufacturing through an “ACAP lens”, manufacturing capabilities are almost inevitably seen as indispensable. This is true because the ACAP it provides helps firms integrate external sources more efficiently and thereby achieve performance improvement both in terms of operational efficiency and in terms of efficient product development. When the performance improvement corresponds with the prevailing competitive priority, the supply chain can be said to be effective. Manufacturing capabilities can thus act as a catalyst for effective supply chain management.
6.2. Contribution
The thesis contributes to the discourse on the role of manufacturing capabilities by focusing on their impact on the effectiveness of supply chain management. One of the main parts of optimising the supply chain is to ensure that suppliers and customers are integrated in an efficient manner, and papers 3-5 showed that manufacturing capabilities play an important role in this process. Manufacturing capabilities, in combination with integration mechanisms, increase operational and product development efficiency. The operationalisation of ACAP in a manufacturing setting is the first theoretical contribution of the thesis.

Operational efficiency is more important for firms focusing on cutting costs, whereas the latter is of prime interest for innovation-focused firms. Competitive priorities have not previously been linked to the role of manufacturing capabilities in the supply chain. Previous studies have instead focused on whether manufacturing is a strategic function or whether, and how, manufacturing capabilities can directly contribute to performance. This is the second theoretical contribution of the thesis.

6.3. Managerial Implications
The findings of this thesis have implications for managers contemplating whether to outsource manufacturing due to a perceived high cost/benefit ratio of such a decision. The thesis argues that an assessment of the strategic role of current manufacturing capabilities must be based on the current and future competitive priorities. If a firm’s main competitive priority is, or will be, high-level innovation, the contribution of manufacturing capabilities to NPD efficiency needs to be assessed. This thesis has shown that manufacturing capabilities, in combination with customer integration, can make NPD more efficient. If the firm’s main competitive priority is low cost, the contribution of manufacturing capabilities towards meeting cost reduction targets needs to be assessed. But this assessment should not solely be based on the direct contribution of manufacturing capabilities. The findings of this thesis suggest that manufacturing capabilities in combination with supplier integration can increase operational performance and thus save money. Managers need to assess the supply chain effects of manufacturing capabilities before making hasty, and potentially irreversible, outsourcing decisions.

6.4. Suggestions for Further Research
The main concepts of this thesis were manufacturing capabilities, integration, competitive priorities and ACAP, where the last one in particular is in need of more research. Multiple case studies, or perhaps ethnographies, would provide a deeper understanding of what actually constitutes absorptive capacity and how it causes the effects observed in papers 3 and 4. Paper 5 provided some insights into this, but only one company was studied, and the observations may not apply to all companies in all industries. The survey data used for papers 3 and 4 was not originally designed for measuring ACAP; a new more detailed survey specifically focusing on measuring ACAP in a manufacturing setting would also be
welcome. The findings of the thesis suggest that ACAP should be taken into account when making investment decisions, but the relation between ACAP and other economic parameters has not been explored. Future research could focus on measuring how the economic impact of ACAP relates to the other factors that investment decisions need to take into account. Finally, the development of Ericsson’s supply chain should be compared to other firms in order to find out to what extent the factors and effects described in paper 2 are firm- or industry-specific.

6.5. Epilogue

In the introduction of this thesis, two entirely different strategies were briefly described to illustrate the breadth of the choices managers face when designing their supply chains. Although these case companies were not further explored in the thesis, the results of the thesis may indicate the reason behind the choice and the effectiveness of their strategies. The contrasting cases mentioned were Apple, which relies on complete outsourcing of manufacturing, versus Nokia, which sees its manufacturing operations as a competitive advantage. One of the key factors that determine the optimal supply chain is product characteristics, and here we can see a remarkable difference between the companies. The average selling price of Apple’s iPhone was €430 ($620) at the end of 2009 (according to Macnewsworld.com), whereas the average selling price for Nokia was €63 (Nokia annual report 2009). Customers buy the iPhone for its design, its user interface and the abundance of downloadable applications. Although Nokia offers similar features in their most advanced phones, the majority of customers still opt for a basic low-cost phone. Moreover, Apple sold only one model in 2009, whereas Nokia had more than 50. In other words, Nokia and Apple have entirely different competitive priorities.

Since Apple can charge so much more for their product, cost-efficiency in the supply chain or in product development is not their main concern. Nokia, on the other hand, has thinner profit margins (gross margin 34%), and as the largest player with 39% market share (Nokia annual report 2009), relies on cost efficiency to defend their position. At the same time Nokia still relies on innovation, as does most of the technology industry. In other words, Nokia is well placed to take advantage of the operational and product development efficiency that can be gained through leveraging manufacturing-based ACAP. Supply chain efficiency is critical for Nokia’s success, particularly in the low end of the market. Apple’s success can, on the other hand, be explained neither by efficient operations nor efficient product development. Instead, the ability to design innovative and user-friendly products that can command a price premium is their competitive advantage. The relative lack of efficiency is compensated by higher pricing power that has been gained by redefining competition, in line with Christensen (1997). Both supply chain strategies are therefore viable, and the optimal choice depends to a large extent on the characteristics of the products. If a company has high pricing power, and high efficiency is not a prime concern, the relatively less complex outsourcing strategy can be worth pursuing. Companies facing more margin pressure can only ignore the role of manufacturing in product development and in the supply chain at their own risk.
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Appendices

Appended papers

1. Internal and External Integration and its Effect on Manufacturing Firms’ Competitiveness
   The Proceedings of the 2006 EurOMA conference, Glasgow, United Kingdom
   Page 75

2. Beyond Fisher’s Product-Supply Chain Matrix: Illustrating the Actual Impact of Technological Maturity on Supply Chain Design
   International Journal of Logistics Systems and Management (Forthcoming)
   Page 93

3. Manufacturing Competence – A Key to Successful Supplier Integration
   Page 113

4. Do Customers Improve New Product Development Efficiency? Revealing the Impact of Manufacturing-Based Absorptive Capacity
   Submitted to the International Journal of Business Performance Management
   Page 133

5. Manufacturing Competence and External Integration: Absorptive Capacity in a First-Tier Supplier
   The Proceedings of the 2007 EurOMA conference, Ankara, Turkey
   Page 151

Other appended material

Survey instrument for papers 1, 3 and 4 (in Swedish)
Page 169