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The Effects of Customization on Capital Goods Manufacturing Business

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Being a scientist is like any other work. All you have to be is encouraged, hard working, and humble. It is not easy to achieve great results, and the world will not be much of a better place because of your work. Your work may promote our knowledge a little bit, but that's it. Hopefully, your work can help someone to do his part in the further creation of knowledge.

When we five and a half years ago founded Cost Management Center (CMC) we wanted to achieve a little more than what one person can do. I think that we have managed quite well, but still there remains much work to do. We have had to overcome prejudices, as I have done with this work. This dissertation is an example of teamwork, and I want to thank everyone who has been working at CMC during this research process. All the help and encouragement has been needed. I want to present my special thanks to Jari Paranko and Petri Suomala. Jari is deeply responsible for why I even started my work as a researcher. He promised to arrange financial support to carry out my dissertation process. There have been tough times, but here we are. Petri was my first research partner, and our working together has taught me a lot. We were young and inexperienced scientists when we started our work; however, now we both have earned our legitimacy as scientists. Last but not least, Jari and Petri have been my co-authors in four of the articles forming the essential core of this dissertation.

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My final words are reserved for the sponsors, the Tampere City Science Foundation, Tampere University of Technology Foundation, TEKES, and the companies that have collaborated with CMC. Your support has been essential.

Tampere, June 15th 2004

Matti Sievänen

Abstract

Customization has gained much attention during the past decade. In the capital goods industry, customization has always been the dominant paradigm. Capital goods, such as big luxury cruisers, have not only been custom built but even custom designed. However, capital goods manufacturers have been seeking volume-related advantages by standardizing products. Although they have succeeded somewhat in standardizing most of their production, they still manufacture many customized products. Indeed, even so-called standard products are often customized using standard options, with any two of the same standard products quite seldom being alike. This thesis focuses on those products having both standard and customized versions, as well as annual production volumes ranging between ten and several hundred units.

This research studies the effects of customization on capital goods manufacturing in terms of company operations and the extra costs resulting from customization. Compared to previous studies, this thesis takes a broader view of customization by combining sales, engineering, manufacturing, and after sales. Furthermore, the focus on after sales extends the time perspective of this view. The thesis relies on five different case studies, conducted in four companies, all of which manufacture capital goods for industrial customers. Two of these companies are more closely studied to gain a more detailed view of the distinct effects of customization. Studying customization in the capital goods manufacturing industry extends current theory concerning customization, since most of the research has primarily focused on the consumer goods environment.

The thesis shows that customization is a normal procedure in capital goods manufacturing. It is used to avoid price competition and can be seen as a way to justify operating in the markets. Customization has the greatest effect on engineering, while tied-up resources form an important disadvantage. In manufacturing, this disadvantage is perceived as increasing throughput time and thus leading companies to begin manufacturing before determining all customer specifications. However, in terms of after sales the effects are quite minor, because after sales in capital goods is already a low-volume business, which is not significantly lowered by customization. Nevertheless, though after sales is low-volume business, it still has important economic value.

Keywords: Capital goods, Customization, Management accounting, Product variety

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List of original publications

Matti Sievänen, 2003. “Customization in capital goods manufacturing business”, The Finnish Journal of Business Economics. Volume 52, Issue 3, Pages 392-408

Sievänen Matti, Paranko Jari & Suomala Petri, 2001. "Cost of Customization", Proceedings of 16th International Conference on Production Research, Prague, Czech Republic, July 29, - August 3, 2001

Matti Sievänen, Petri Suomala & Jari Paranko, 2004. “Product Profitability: Causes And Effects”, Industrial Marketing Management, Volume 33, Issue 5, Pages 393-401

Petri Suomala, Matti Sievänen & Jari Paranko, 2002. "The effects of customization on spare part business: A case study in the metal industry", International Journal of Production Economics, Volume 79, Issue 1, Pages 57-66

Suomala Petri, Sievänen Matti & Paranko Jari, 2003. “Customization from the After-Sales Point of View - Implications of Product and Item Customizations for Spare-Part Business”, Technovation. Accepted 7.1.2003.

The author’s contribution to the original joint publications was as follows. In publications II and III, he was the first author, being the main study designer and writer of these two publications. In publications IV and V he was participating in the collection and analysis of the data. In publication IV, he wrote the literature review of customization. In publication V, he has been responsible for writing the entire literature review.

1 Introduction

1.1 Standardization vs. customization

The ideas underlying standardization have their roots in the French Revolution and introduction of the metric system. The French decided to have only one measurement system replace the numerous systems that had dominated before the revolution. The meter was defined to be 1/10,000,000 of the distance between the Equator and the North Pole as measured through the quadrant that passes through Paris. Regardless of the irrelevancy of this definition, the advantages of standardization have made the metric system the most used in the world. When considering the development of the manufacturing industry, it can be noted that the past century has been a time of movement toward standardization. Standardization has gained volume in consumers' goods, with McDonald's providing one of the finest examples of this standardization. However, in the capital goods industries, some products have always been craft manufactured and even custom designed. The most extreme examples of customized products include such products as paper machines and luxury yachts. These products are always one-of-a-kind and are typically considered to be projects. In that sense, customization would be the wrong term, since the opposite policy – standardization – is missing. At the other extreme, capital goods produced in high volumes include such products as electric motors. These high-volume capital goods can take advantage of mass production techniques, such as the assembly line, that have been developed for consumer goods. Between these two extremes lie products which are the interest of this thesis. Products like cranes and crushers, which have annual manufacturing volumes ranging from ten to several hundred. These products have a standard configuration which can be order by the customer as a standard product. Moreover, a product can also be considered standard if it can be customized using standard options. On the other hand, customers may desire customized products with options and features that have not been previously designed into the product. Thus, these products can be divided into standard and customized classes, and it is the difference between these two classes that forms the basis of this thesis.

In recent years, customer-focus strategies have become increasingly popular, and customization has thus gained much interest among management scholars. Mass customization has been a popular subject, with most research concerning customization being connected to consumer goods. Two of the most influential writers have been Gilmore and Pine (Gilmore 1993; Pine II 1993; Pine II et al. 1993). However, capital goods have not gained as much interest, despite the important economic value of the capital goods sector. One reason for this may be that capital goods have long been considered to be customized, and those products that are the subject of this thesis have not been recognized as a separate group. Moreover, customization has quite often been connected to either marketing or manufacturing, while studies linking customization to broader issues of manufacturing, marketing, and engineering have remained sparse.

The aim of this research is to describe the effects exerted by customization on the capital goods manufacturing business, how it might affect companies' operations as well as to describe extra costs resulting from such customization. The thesis does not concentrate only on manufacturing but also expands its examination from R&D to also cover after sales. The thesis relies on five different case studies in which the phenomenon of customization is investigated in a real-life context. Studies are conducted in four companies, all of which manufacture capital goods for industrial customers. Two of these companies are more closely studied to gain a more detailed view of the distinct effects brought about by customization.

The structure of this thesis is as follows. The second section briefly reviews the literature on customization. The third section defines the objectives and presents the methods used in the thesis. In the fourth section, original papers are summarized, and the individual objectives, methods, and results are discussed. Finally, conclusions are drawn based on the results of individual papers, and the contribution of the thesis to this field is discussed.

1.2 Concept definitions

Before describing the thesis in further detail, two key concepts, customization and capital goods, should first be defined. Customization itself is quite a new term. The Oxford English Dictionary (2003) dates it to the year 1975. However, the verb to customize is older, dating back to either 1934 (Oxford-English-Dictionary 2003) or 1923 (Merriam-Webster-Dictionary 2003). The verb to customize is defined as "*to make to order or to measure; to model or alter according to individual requirements*" (Oxford-English-Dictionary 2003). Similarly, customization is defined as "*the action or result of customizing; creation or adaptation (of something) according to the customer's requirements*" (Oxford-English-Dictionary 2003). Later, customized products have been defined as "*… slight variations of standard configurations and are typically developed in response to a specific order by a customer*" (Ulrich and Eppinger 1995 p. 22). Thus, there are two conditions which have to be fulfilled. First, there must be a customer order. Second, there needs to be a standard configuration which can be varied.

The other concept, capital goods, dates back to the 1890's (Merriam-Webster-Dictionary 2003; Oxford-English-Dictionary 2003) and is defined as "*commodities forming capital; economic goods (e.g. railways, ships, machinery, buildings) destined for use in production, opposite to consumers' goods*" (Oxford-English-Dictionary 2003). Capital goods are not consumed immediately and can produce income for many years to come. Due to their nature, capital goods cannot be studied unless attention is given to the life cycle of the product extending from R&D to after sales.

Concepts like mass customization and product variety are quite often associated with customization. However, there are distinct differences between the terms that should be noted. The term mass customization has raised much attention since the late 1980's. Mass customization can be defined as a process by which firms apply technology and management methods to provide product variety and customization through flexibility and quick responsiveness (Pine II 1993; Kotha 1995; Da Silveira et al. 2001). In mass customization, the paradigm shift is from mass production to customization. Quite often in mass customization the first condition of customization, a customer order, has not been fulfilled as in the case of customizable (Logman 1997) or self-customizing (Åhlström and Westbrook 1999) products. Furthermore, the lack of mass markets for capital goods limits the use of mass customization frameworks (Zipkin 2001).

Similarly, obvious differences exist between product variety and customization as a manufacturing strategy (Ross 1996). The former is a push strategy offering a wide variety of products to the customer, while the latter is a pull strategy wherein a company can still offer a wide variety of choices, and the products are manufactured according to the customer's requirement. However, the importance of the research related to product variety and mass customization cannot be neglected when studying customization.

2 Literature review

2.1 Customization frameworks and capital goods manufacturing

The following chapter presents some of the most common customization frameworks. The idea is not to give a comprehensive picture of all possible frameworks but rather to present those frameworks most adaptable to capital goods manufacturing. One of the most influential frameworks for customization is that presented by Mintzberg (1988) and further developed by Lampel and Mintzberg (1996). The latter framework includes five customization strategies based on customer involvement in a value chain of a firm. Two of the strategies, pure standardization and segmented standardization, are not customization strategies. The remaining three are customized standardization, tailored customization, and pure customization. In pure customization, the customer influences the entire production process. A product can even be designed from scratch. In a tailored customization strategy, a generic prototype is altered according to the customer's needs. A tailor-made suit is a good example of such a strategy. In customized standardization, the customer selects from predefined options to manufacture the product using standard components.

Amaro et al. (1999) use the previous framework and combine it with possible non make-to-stock strategies (MTS). Although their actual aim is to classify non-MTS companies, they also provide a classification for customization. They define four product types using the three customization strategies presented by Mintzberg (1988) and add one, a standardization strategy. Then, they combine these four product types with engineering-to-order, manufacturing-to-order, and assembly-to-order strategies to form 11 different categories, which they use for classifying non-MTS companies. Even with this detailed classification, they cannot classify all the case companies in their study. Moreover, quite many companies end up being classified into more than one category, and thus their classification fails. However, their classification has contributed to the theory of customization by showing that the customization strategies of Mintzberg can be executed in more than one way. For example, a company can make purely customized products that do not require any designing work.

Duray et al. (2000) combine modularity within the customization framework presented by Lampel and Mintzberg (1996), thus increasing the validity of the framework. They classify modularity according to the stage at which modularity will be utilized. In doing so, they recognize four different archetypes: fabricators, involvers, modularizers, and assemblers. Moreover, a later study by Duray (2002) finds that companies which consider themselves to be customized producers are typically fabricators or involvers. Both of these classes include customer involvement in the design and/or fabrication stage. Thus, companies can use either a pure or tailored customization strategy. Similarly, Bouwens and Abernethy (2000) classify products as customized when they are either basic models that are customized according to the client's specifications or

completely customized. Moreover, they further specify that the firm must add to the customized product features that have not been designed in advance.

2.2 Motivation for customization

Capital goods have a long history in terms of customization (Håkansson 1982 p. 165; Spring and Dalrymple 2000). However, some authors (Boddewyn et al. 1986; Jain 1989) argue that industrial goods are more suitable for standardization than consumer goods. Jain (1989) even uses products like heavy equipment and machine tools as examples. Boddewyn et al. (1986) argue that industrial buyers are more rational which explains the standardization of industrial goods. Moreover, their data show that industrial goods manufacturers have standardized the most, compared to consumer non-durables and durables manufacturers. This data appears to contradict the long history of customization in capital goods. The problem might be that neither standardization nor industrial goods are well defined. Moreover, authors might mix marketing and product standardization, and companies can use global brand strategies even with customized products.

Since standardization offers advantages (see e.g. Rommel 1991), we have to point out the motivation for customization. Such theories as consumer psychology, behavioral decision and neoclassical economics indicate that different customers can give different value to the same product (Bolton and Myers 2003). Customers require different performance and features. Moreover, some features can even be unattractive to other customers (Spring and Dalrymple 2000). Some customers may want a customized product because they perceive it as a status symbol (Evarts 1999). Furthermore, a customization can also be a choice for its own sake, with the process of customization being more important than the customized product itself (Spring and Dalrymple 2000).

Furthermore, what are the advantages that a producer can achieve by customizing a product? Custom-orientated strategies have been shown to be advantageous in industrial markets (Balakrishnan 1996). A firm can increase market share by customizing products (Sriram and Sapienza 1991; Åhlström and Westbrook 1999). Customization can be seen as better service, thus having a positive effect on profit (Balakrishnan 1996; Simon and Dolan 1998) while, simultaneously, improving customer satisfaction (Fitzgerald 1995; Åhlström and Westbrook 1999; Zairi 2000). It has also been argued that a customized product can form an entry barrier (Spring and Dalrymple 2000). Although the product itself may be unprofitable, it could help to exclude competition. Similarly, a customized product can, in the short term, be unprofitable while still serving as a vehicle for learning (Spring and Dalrymple 2000). Quite often, this is connected to a new product or process design in which customization is seen as an information source for customer requirements. Another advantage closely connected with these entry-barrier and

vehicle-for-learning functions is that the customization process itself promotes stable relationships by closely involving customers with manufacturers, as is often the case in capital goods markets (Håkansson 1982). Furthermore, a customized product can provide a means to show off — we can do something that requires something special (Spring and Dalrymple 2000). Thus, a customized product can support a company's brand image. On the other hand, some companies see customization as a way to qualify them to operate in their markets and not solely as a means to gain competitive advantage (Amaro et al. 1999). The list of motivations is long, but the motivation for customization is ultimately linked to a practical belief that it will be profitable in the long term. Whatever the motives for customization, one thing is said to be sure: the demand for customized products is rising (Lampel and Mintzberg 1996; Amaro et al. 1999; Evarts 1999; Spring and Dalrymple 2000). However, capital goods have always been customized, and the trend can be the opposite, from customization to standardization, especially with global brands (Jain 1989). Nevertheless, there will always be a demand for customized capital goods that will enable small and medium size manufacturers to survive in these markets.

2.3 The effects of customization

In the capital goods markets, customization is linked to a customer's problem solving (Håkansson 1982 p. 165). Quite often, a customer is not only seeking a customized product but is simultaneously looking for a solution, technical advice, or joint development. The producer must have good knowledge of customer requirements (Åhlström and Westbrook 1999). Practically the only way to gain such knowledge is through continuous feedback from the customer and close customer relationships, at least with some of the customers (Håkansson 1982 p. 163). However, close connections with customers are not enough. The company must also have intimate connections between departments to be able to transfer customer requirements throughout the organization (Bouwens and Abernethy 2000; Spring and Dalrymple 2000). Sales, product design and production departments should be totally interdependent. Thus, the sales and manufacturing process requires a skilled workforce and the interactions can be of a high-cost nature (Berman 2002). Moreover, customization can increase complexity within the organization by bringing about activities that have never before been carried out (Bouwens and Abernethy 2000).

Typically, customization is associated with low volumes and high variety (Hayes and Wheelwright 1979), while capital goods can be associated with low volumes. In that sense, low volumes may or may not be the result of customization. However, low volumes and high variety can also require flexible job-shop and batch manufacturing processes (Hayes and Wheelwright 1979; Duray et al. 2000). It has been said that a company must make a trade-off between efficiency (low cost) and flexibility (high

variety) which can be explained by the economics of scale (Hayes and Wheelwright 1979). However, this trade-off can be challenged by flexible manufacturing techniques and the economics of scope (Kotha 1995). There are numerous writings showing that product variety can increase costs (Hayes and Wheelwright 1979; Yeh and Chu 1991; Mughal and Osborne 1995; Stalk 1998; Darlington 1999; Åhlström and Westbrook 1999; Svensson and Barfod 2002), as well as many writings showing that there is no increase, or that the increase is not significant (Kekre and Srinivasan 1990; Kotha 1995; Ross 1996; Tang and Yam 1996). For example, the article by Stalk (1998) is contradictory. First, he divides costs into variety-related and scale-related costs, in which variety-related costs increase with increasing variety. He even presents figures indicating that when variety is reduced by half, costs fall by 17% and productivity rises by 30%. However, the article does not show where he obtained his data. He then offers time as a competitive advantage that explains everything, and claims that expanding variety is a time-based strategy in which the cost penalty is negligible. In that sense, variety is a good thing and can increase profitability. Similar ideas concerning small batch sizes and time-based management can be found in the theory of constraints (Goldratt and Cox 1987). Furthermore, lean manufacturing (Womack and Jones 1994; Amaro et al. 1999), mass customization (Pine II 1993), and agile manufacturing (Brown and Bessant 2003) promise the same types of advantages with high variety and a batch size of one. Thus, almost any modern manufacturing strategy would promise high variety with low cost or no added cost.

Frequently, increases in manufacturing costs can be explained by increased setup costs (Yeh and Chu 1991; Darlington 1999). Similarly, direct labor and material costs have been blamed for the increase (Åhlström and Westbrook 1999). Moreover, it has been claimed that the increase is due to overhead and support costs (Hayes and Wheelwright 1979; Yeh and Chu 1991; Mughal and Osborne 1995). It has been argued that problems related to increased overhead and setup costs can be solved with new production technology and a focused factory (Kotha 1995; Stalk 1998). This, however, can increase capital-related costs, and the costs savings may not always be obvious. Similarly, the number of components or stock-keeping units is a cost driver in many organizations (Mughal and Osborne 1995; MacDuffie et al. 1996; Mévellec and Sievänen 2003). This leads us to component sharing and modularization, which are said to be effective methods for customization (Åhlström and Westbrook 1999; Duray et al. 2000). Modularity has been presented as a way to achieve short delivery times simultaneously with high product variety. This has been referred to as a customization-responsiveness squeeze (McCutcheon and Raturi 1994). It should also be noted that there are opportunity costs associated with customization (Stump et al. 2002). Resources allocated for customization thereafter become unavailable for other purposes. Unfortunately, there are no reliable data showing the amount of opportunity costs.

The cost savings resulting from customization are justified by the decrease in finished goods and work-in-process inventory (Kotha 1995). Similarly, there should be neither

obsolete nor redundant products in the production. It has been argued that carmakers could save $65 to $80 billion annually by reducing this obsoleteness (Agrawal et al. 2001). This decrease may not be as dramatic with capital goods, since most of the products are already manufactured based on customer orders. Thus, the reduction gained may be next to nothing. Furthermore, no manufacturing process is totally flexible and there will always be some fixed costs. How these fixed costs vary in terms of product variety and customization remains unclear. Customization or increased variety might increase total sales volume, thus decreasing the amount of fixed cost per unit. However, there is no solid theory which would support the contention that customization decreases costs. Indeed, customization might even require new supportive resources, thus leading to an increase in fixed costs. Similarly, most theories addressing cost penalty are fragmented and have led to contradictory conclusions.

It is good to keep in mind that overhead and supportive costs are typically allocated to the product as a general overhead, thus making marginal costing systems unsuitable for measuring cost effects when dealing with diversity in products, volumes, and processes, as is the case in customization (Cooper 1988a, b). Abernethy et al. (2001) have challenged the rationale of investment in activity-based costing systems within high diversity environments. They argue that a more sophisticated version of traditional costing systems is enough. At this point, it should be noted that the division between traditional costing and activity-based costing systems is somewhat unclear (Gosselin and Mévellec 2003). Furthermore, Bouwens and Abernethy (2000) have studied the consequences of customization on management accounting systems, though they were unable to find any direct relations. Despite this criticism, this thesis assumes that activity-based costing is more accurate in pointing out the differences between standard and customized products.

In summary, though customization is a widely studied subject, most of the studies have been narrowly focused, mainly on manufacturing or marketing. Moreover, few studies have focused on the role of customization in the manufacture of capital goods. Thus, customization and the motives for it need to be more closely defined in the capital goods environment. Furthermore, there is a considerable amount of contradictory evidence, especially concerning the cost effects. Although the literature has primarily concentrated on describing the cost effects, this thesis takes a broader view and aims to expand this research to include the product life cycle, from R&D to after sales.

3 Research objectives and method

As shown by this literature review, no solid theories have been devised to describe customization when connected to broader issues affecting capital goods manufacturing. Thus, new evidence is required. This thesis addresses the question of how a company's operations and costs can be affected by customization. The aim of the thesis can be divided into the following questions that are answered in the five separate studies (Table 1).

Table 1. Secondary research questions

Research question	Case study
1. What does the concept of customization mean in capital goods manufacturing?	**I** Customization in capital goods manufacturing business
2. What is it that practitioners mean when they refer to customization?	**I** Customization in capital goods manufacturing business
3. What are the perceived advantages and disadvantages of customization?	**I** Customization in capital goods manufacturing business
4. What new activities are required for customization?	**II** Cost of customization
5. Does customization increase costs – how much?	**II** Cost of customization
6. Does customization explain differences in product profitability?	**III** Product profitability: Causes and effects
7. How can customizations be classified in terms of after-sales?	**IV** The effects of customization on spare part business **V** Customization from the after sales point of view
8. How does customization affect the number and the sales volume of product items in after-sales	**V** Customization from the after sales point of view
9. What is the effect of customization on the value of spare-parts inventory?	**V** Customization from the after sales point of view

As shown in Table 1, this thesis consists of five case studies that are reported in separate papers. The first paper is an exploratory case study, which describes the phenomenon of customization in a capital goods manufacturing environment. The second paper builds a novel theory describing the cost effects of customization, which have not been reported previously in a similar environment. The third study focuses on the overall profitability

of the products. The study tests the applicability of the whale curve (Cooper and Kaplan 1991; Kaplan and Atkinson 1998; Kaplan and Cooper 1998) to the case environment. Simultaneously, the study contributes new evidence to the discussion of product variety and profitability, and seeks to determine whether any factors, like customization, may help explain differences in profitability. The fourth and fifth papers concentrate on after sales, an important business area for capital goods manufacturing. The fourth paper is an exploratory case study that examines the effects of customization in general and provides a framework for classifying customizations in a technical sense. In the fifth paper, after sales is studied in greater detail. The five studies together provide a comprehensive picture of customization in the capital goods manufacturing business. Figure 1 shows how these five studies are connected. This dissertation is represented by the gray rectangular area.

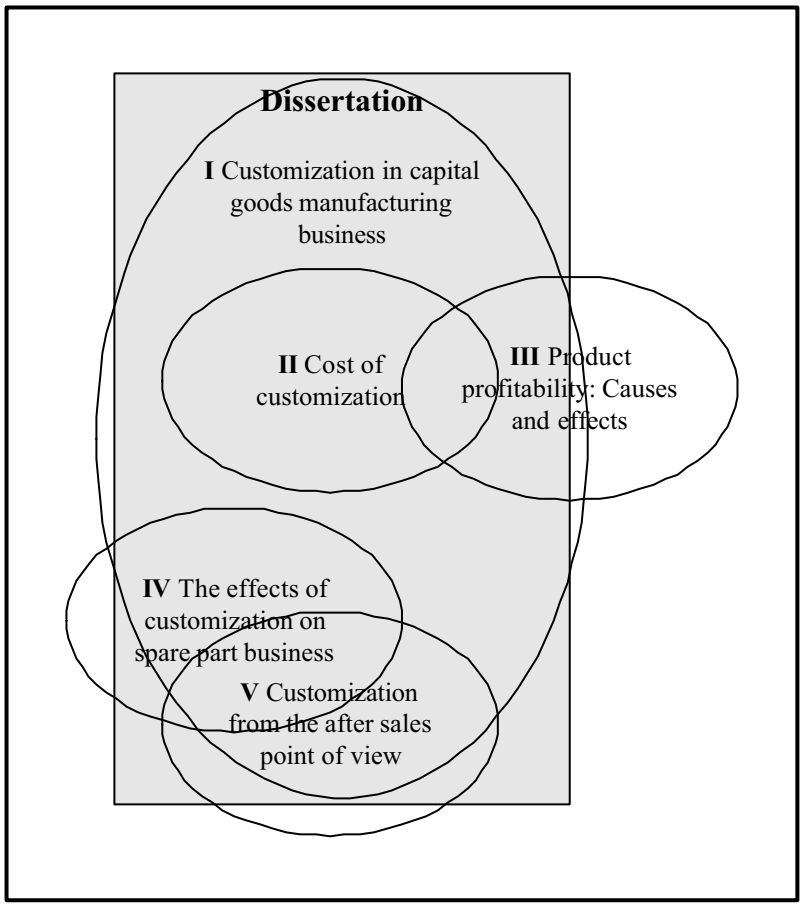

Figure 1. The composition of the case studies

Unfortunately, some important aspects have remained beyond the scope of this study, including organizational issues and the effects of customization on sales volumes and sales prices. Similarly one element closely connected to customization – customer costing or profitability – has not been a subject of study, since the appropriate data could not obtained from the case companies, due to decisions made by representatives

of the companies. However, taking customer profitability as part of the study would not have been a simple task, as the division between customer and product costs is somewhat unclear (Seppänen and Lyly-Yrjänäinen 2002).

Because the aim of this thesis is to increase our knowledge and understanding, hermeneutics offers a valid methodology (Burrell and Morgan 2000 pp. 235-238; Gummesson 2003). A business environment is by nature ambiguous, thus making it exceedingly difficult to find unambiguous cause-and-effect relationships. Instead, the business environment needs to be interpreted and softer, more transient explanations have to be provided for practitioners. Hermeneutic research involves constant oscillation between what is known and what is learnt. Furthermore, meaning for a part can be only given within a holistic context, demanding consistency and coherence between the parts and the whole. Finally, research is a never-ending process toward improved understanding and must reach a conceptualization or condensation in order to contribute to theory. (Gummesson 2003)

It has been argued that in the study of business-to-business environments, qualitative methods, such as case studies, are necessary to develop new theories (Wilson et al. 1986; Lichtenthal and Long 1998). A case study is useful when the phenomenon investigated is complex, the current theoretical base is thin, or the phenomenon is difficult to study outside its natural environment (Bonoma 1985; Eisenhardt 1989). Moreover, case study is sympathetic to the ideas of hermeneutics (Gummesson 2003). Case research has been shown to be powerful in developing new theory (Eisenhardt 1989; Voss et al. 2002). One of the advantages of a case study is that it allows the use of multiple data collection methods, such as archives, interviews, and questionnaires. The data can be either qualitative, quantitative, or both (Bonoma 1985; Eisenhardt 1989; Voss et al. 2002). This enables a fuller picture of the subject of the study. Furthermore, multiple data sources provide a base for triangulation, which in turn increases the construct and internal validity of the study (Bonoma 1985; Leonard-Barton 1990; Voss et al. 2002).

Typically, case research has high validity with practitioners (Eisenhardt 1989; Voss et al. 2002). The empirical validity is also likely to be high because theory building is closely tied to empirical evidence. Bonoma (1985) uses the term “has currency” with the same meaning, and simultaneously combines that with external validity. However, external validity is most often related to the generalizability of the results, which is also a weakness of single case studies (Leonard-Barton 1990; Voss et al. 2002). Other possible weaknesses of a case study are that the theory can become either too complex, because of the intensive use of empirical evidence, or too narrow and idiosyncratic, resulting from the inability of the researcher to raise the level of generality of the theory (Eisenhardt 1989).

In this study, each case has involved the collection of both qualitative and quantitative data. The study relies strongly on interviews, as well as detailed data collected from such sources as financial statements, quality manuals, as well as sales, engineering, and manufacturing documents. The data is collected from four different companies, all of which are capital goods manufacturers. Two of these companies were studied more closely, and an activity-based costing model was constructed for both companies to provide detailed cost information about the cost effects. Moreover, these two companies were examined by at least three investigators, which enhances confidence in the findings (Eisenhardt 1989). When selecting the last two case companies, a literal replication was used to ensure that each case would predict similar results (Yin 1994 p. 46).

4 Summaries of original papers

4.1 Customization in capital goods manufacturing business

The objective of the first paper was to define the concept of customization in a capital goods manufacturing business, as well as study the perceived advantages and disadvantages of customization. Four different customization frameworks (Coates and Wolff 1995; Lampel and Mintzberg 1996; Gilmore and Pine 1997; Duray et al. 2000) were presented and tested to determine their suitability for classifying customization in a capital goods manufacturing business. The study focused on the engineering, manufacturing, and sales functions of the companies, since customization was not seen as a homogenous phenomenon that could be addressed as a whole.

Semi-structured interviews were chosen as the method to answer these research questions, since interviews enable the researcher to gain a clear understanding of the subjects discussed. Four capital goods manufacturers were selected based on their having the following functions: engineering, manufacturing, and sales. All four companies represented manufacturers in the metal and machine industry and had been well-established for over 30 years. Furthermore, all four companies manufactured the main component of the product itself. From each company, at least one person representing each function was interviewed to determine whether their answers would differ based on the function represented. Thus, the study was simultaneously able to link customization to manufacturing, marketing, and engineering.

The results of the study show that customization was a normal procedure for conducting business in the capital goods industry. All companies in this study had well-established approval procedures for customization. Customization was seen as satisfying customer requirements with non-standard components. Typically, the core component and design remained standard, with only the options being customized. The perceived advantages of customization were linked to increased sales volume and customer intimacy. Extra work and tied-up resources were among the major disadvantages. Crucial factors included the ability to understand and transfer customer requirements into product features.

Customization had the greatest impact on engineering, in which it not only tied up resources but most often also demanded the most experienced resources. Typically, every customization required engineering work. The effects on manufacturing were minor. Increased throughput time and extra inspections were the most frequently mentioned disadvantages. The increase in manufacturing time was typically less than 20%. For the sales departments, customization was simply a normal part of business that enabled the company to avoid price competition. However, customization needs to have strict rules, and those rules must be followed. Otherwise, a company could end up making products unsuitable for that business.

Comparing the presented frameworks allowed the following conclusions to be made. The division into soft and hard customization (Coates and Wolff 1995) was too general and therefore not suitable for classifying capital goods. Similarly, the framework of Gilmore and Pine (1997) was not suitable for capital goods. The mass customization approach did not appear to work because customer requirements differed so much that in many cases, there were no mass markets. The customization strategies presented by Lampel and Mintzberg (1996) were, however, suitable for classifying capital goods. Typically, manufacturing was either a customized standardization or tailored customization. Nonetheless, the division between classes was at times somewhat unclear. The idea of combining modularity and customer involvement (Duray et al. 2000) worked fine, because at least in these companies modular design and manufacturing were well adopted and typically used.

4.2 Cost of customization

The second paper studied the cost effects of customization in capital goods manufacturing. The objective of the study was to show how customization affects the use of activities and the cost of products. Customization was seen as a phenomenon that to some extent changes or influences the present structures of business processes and activities. The underlying hypothesis was that customization would increase the number of activities needed and, furthermore, increase the use of those activities.

The descriptive case study was conducted in a metal and machine industry company which manufactures and assembles capital goods for industrial customers. The production consisted mostly of assembly work, and material expenses accounted for nearly 60% of all expenses. Three products were chosen as the subject of the study, since they were considered to be representative of the company's production, covering a little over 50% of the company's total production volume. Moreover, all three products had a significant number of both standard and customized models. The data was collected through interviews and from the company's sales and manufacturing documents, and an activity-based costing model was created.

The results of the study showed that customization slightly increased the number of activities required to manufacture and sell the product. The increase in the use of activities was more significant. Customization had the greatest effect on engineering activities, where the increase was on average about 300%. Similarly, the increase in sales activities was significant. It was found that translating customers' needs into product features was an expensive part of customization. Another significant increase was in manufacturing costs. The increase was higher when the production process was conducted on a disconnected line. A job-shop process seemed to be more suitable for manufacturing customized products. The increase was not because of increased set-up

cost, but mostly because of the increase in direct assembly work. Assembling non-standard components required extra time and inspections. On average, the cost of a customized product was 17% higher than the cost of a standard product. However, the difference in the total cost of activities was 67%.

4.3 Product profitability: Causes and effects

The objective of the third paper was to analyze the phenomenon of product profitability and to investigate the causes of the differences in profitability between products. The aim was to determine if there are systematic reasons that could explain the phenomenon demonstrated by the whale curve. The whale curve demonstrates the effect of plotting a company's cumulative profits as a function of products ranked by their profitability (Cooper and Kaplan 1991; Kaplan and Atkinson 1998; Kaplan and Cooper 1998). Typically, both the most profitable products and the least profitable products are among the best performers in sales volume. It is said that companies encounter a whale curve for cumulative product profitability especially in activity-based cost systems constructed for companies or business units that meet two main conditions: expenses in indirect and support resources are high, and a great diversity exists in products, customers, and processes (Kaplan and Atkinson 1998).

The case study was conducted in the same company as that researched in the second study. The company's annual production was approximately 2,700 end products. About 10% of the products were customized for special environments, such as hazardous areas, thus adding to the requirements of the products. These customized products were known to be time and activity consuming, but the higher profit margin was expected to make them profitable. Moreover, the company also manufactured the main components for the end products. These main components were also sold to other end product manufacturers at a production volume of about 10 000 pieces per year. The profitability and cost structure of all products and models were studied using the same data as in the second study. Furthermore, sales documents were studied more closely to determine actual sales prices and volumes of the products. Since the prices of the products fluctuated, the study used average prices.

The results of the study showed that the profitability of the products varied greatly even though the company did not fill two main conditions (high indirect expenses and great diversity of products and processes). However, the difference in profitability between standard and customized end products was not statistically significant. Furthermore, the results for profitability and product variety suggested that it was more profitable to broaden existing product lines than to introduce a completely new product. Results related to product life cycle revealed that products in the decline production life cycle were the most unprofitable, mainly due to high product sustaining costs.

4.4 The effects of customization on spare part business - A case study in the metal industry

The objective of the fourth paper was to identify the consequences of customization in spare part operations. The spare parts business involved the purchasing, warehousing, selling and delivering of spare parts. In addition, customer service, such as handling warranty issues, was seen as a part of the spare part business. The aim of the paper was to classify different customizations from the perspective of the spare part business. Furthermore, the study aimed to build a framework to assist R&D and product management in decision-making related to alternative customization policies.

The research was based on an analysis of the selected customized case items and products of the case company, which was a large worldwide operating metal and machine industry company. The company representatives composed the list of items to be studied. The selected items represented typical examples of customized products, as well as products that allowed comparison of the significance and nature of customization with items representative of standardization, the directly opposite policy. The items selected comprised one spare-part assembly, three types of wear (consumable) parts, and one complete end product.

Data gathering was initiated by interviewing R&D and after-sales employees. The interviews in the R&D department provided information about technical background, processes leading to customization, and R&D workload caused by customizations. In the spare part business, the sales volumes of the customized case items were examined using company statistics. In addition, costs associated with the case items such as warranty, delivery, revision and model costs were studied, along with the cost structure of the spare part business. After-sales staff was interviewed, and process models were built based on the interviews and company quality manuals. The process model and knowledge of the time allocation allowed an activity-based cost model to be created based on the spare part business. This model was used to answer the question how did the cost effects of customization vary in relation to a particular type of customization.

The results of the study enabled customizations to be categorized from a technological perspective. A customized item could either be a spare or a consumable part. A third possibility involved applying the customization to an end product without having any effects on either spare or consumable parts. Spare-part customization could be divided into three subgroups; removal, change, and addition. In a technical sense, each customization required electrical, hydraulic, mechanical or some other design. Assessing the impact of the changes on the spare part business suggested that mechanical customizations had only negligible consequences, because they were typically incorporated into the permanent structure, such as the frame of a machine.

Once the change was implemented, no spare parts were likely to be needed in the future. Customizations of consumable parts were – in a technical sense – divided into two subcategories. One could focus on either changing the shape or the material of the standard consumable part. However, from the perspective of the spare part business, technical categorization had only a tenuous link to the actual effects of customization on the business.

The primary effect of customization in the spare part business was to increase the number of spare part items. Moreover, the personnel costs had a significant role in determining the cost effects of customization, while warehousing costs seemed to be minor. When customization led to an increase in the number of seldom sold items, its affect on the working time spent in different activities was considerable. Difficult and unfamiliar items typically required, in such cases, 10 times more effort in after sales than those more familiar items.

4.5 Customization from the after sales point of view -Implications of product and item customizations for spare part business

The fifth paper tackled the same problem as the fourth, after sales. However, the data was analyzed at a more detailed level and the study attempted to provide a set of explanations to assess the relationship between product customization and the costs of after-sales activities. The scope of the study was to evaluate the effects of customization on the number and the sales volume of after-sales product items. In addition, the impact of product customization on spare-part inventory value was also of interest. The categorization developed in the fourth paper provided a framework for assessing the implications of customization on after sales.

The case study was conducted in the same company as in the fourth paper. It relied on a single product and a single consumable part. The rationale for selecting these two cases was that both the product and the part represent a critical case. The case product was seen by the company representatives as a typical example of a substantially customized product. The consumable part was one of the most extensively customized items in the company's product line. Taken together, these two cases made it possible to construct a fairly representative picture of after-sales business.

The collection of data related to the case product consisted of three phases. First, all the sales documents regarding the product were studied to identify the individual customizations made during the life cycle of the case product. The second phase involved interviews with the R&D engineers responsible for the product. Each customization was separately studied, and the engineers were asked to comment on the technical nature of the customizations in detail. Moreover, the engineers' opinions about

the effects of the customizations on after sales (in terms of new items) were collected. Finally, the last phase was conducted in cooperation with the after-sales department. Two after-sales managers were interviewed to determine the general implications of the customizations that had been made. The managers were questioned about whether a customization creates a new item to be added to after sales or not. Further, the respondents were asked if a customization creates a new item that was a) critical, b) kept in regional inventory, or c) kept in local inventory. All the customizations that caused new items to be kept in stock were analyzed in detail, and the total impact of customizations on inventory value was calculated. The total number and the sales volume of different versions of an item were investigated, and the costs connected with engineering, molding, manufacturing, and warranties of the item were assessed and calculated.

The result of this study showed that customization had very little direct impact on after sales business. In general, customization increased the number of items stored in information systems. However, only a minority of items was kept in stock. Furthermore, a many of the customizations were implemented by altering or adding a fairly simple mechanical structure to the product. In such cases, spare-part support was rarely needed for after sales. It could be said that the sales volumes of spare parts in this capital goods business were low and that they remained low regardless of the customization. In addition, cost analysis indicates that the costs of customization (within the scope of the study) were not excessive.

5. Results and general discussion

5.1 Discussion

The aim of this thesis was to show how customization affects capital goods manufacturer's operations and costs. As this question is too general, more detailed research questions were presented and examined in the separate studies. The following section presents the results and connects them to previous research. Furthermore, other findings relevant to customization and product variety theory are presented and discussed.

The first two questions are connected to defining the concept of customization. What does the concept of customization mean in the capital goods manufacturing business, and what is it that practitioners mean when they refer to customization? As expected, customization is a normal way of doing business in capital goods markets (Håkansson 1982 p. 165; Spring and Dalrymple 2000). Indeed, all the case companies had a long history of customization. Customization is seen as fulfilling customer requirements with non-standard options. Typically, these options or features are not designed in advance. Thus, customization in the capital goods business requires engineering. However, the core component and design always remain standard. If the core component or design is modified, then it is no longer reflects customization, but instead becomes a new product design.

The third question is connected to the motives of customizations. The results were similar to those found in previous studies. Increased market share and customer satisfaction were among the advantages of customization previously identified in other studies (Sriram and Sapienza 1991; Fitzgerald 1995; Åhlström and Westbrook 1999; Zairi 2000). The finding that customization could increase the sales of consumable spare parts is in line with previous findings. Customization in that case can be seen as both a vehicle of learning (Spring and Dalrymple 2000) and a means to increase customer satisfaction, thus binding customers to the manufacturer and helping to establish a stable relationship (Håkansson 1982). In at least one case, a certain type of pride could be noted when an engineer mentioned that they had made the world's largest product of its type. In that sense, a customized product supports the image that a company can do almost anything (Spring and Dalrymple 2000).

All manufacturing departments considered increased throughput time to be the major disadvantage of customization. This finding is similar to the so-called customization-responsiveness squeeze (McCutcheon and Raturi 1994), for which modularity has been suggested as one possible solution (Åhlström and Westbrook 1999; Duray et al. 2000). Short delivery times forced companies to start manufacturing before all customer specifications had become known. In some cases, this required rework. Thus, this thesis does not support previous findings indicating that customization decreases work-in-

process inventory or reduces obsolete and redundant products in production (Kotha 1995; Agrawal et al. 2001). However, it should also be noted that previous findings have focused almost solely on consumer goods. Typically, capital goods manufacturing has always been based on customer orders, and the advantages of customization cannot thus be justified by a decrease in inventory. In the engineering and sales departments, the most often mentioned disadvantage was that customization ties up resources. Often customization required the most experienced engineers and sales persons. This finding can be attributed to the typical difficulty in understanding customer requirements, since customization requires a skilled workforce, is high-cost in nature, and increases supportive costs.

The fourth question remains somewhat unanswered. The study shows that customization requires new activities as has been noted earlier (Bouwens and Abernethy 2000). However, far-reaching conclusions cannot be made based on these results, due to the manner in which the activities were defined. Although two new activities were recognized in this study, the nature of other activities may have changed because of customization. For example, the bidding process and transferring customer requirements have become more complicated.

The fifth question reveals new evidence when the effects of customization were studied in terms of costs. It was found that customization increases total costs, a finding which is quite obvious. The increase is greatest in engineering, thus leading to an increase in supportive and overhead costs (Hayes and Wheelwright 1979; Yeh and Chu 1991; Mughal and Osborne 1995). The results related to direct manufacturing expenses are also somewhat contradictory. Although manufacturing does not consider the increase to be significant, the figures show that the increase can be as high as 20%. It should be kept in mind that the manufacturing time for standard products can vary. Thus, any increase due to customization can simply be seen as part of the normal fluctuation that is typical for low volume manufacturing. Furthermore, in capital goods manufacturing, increased setup costs are not significant. This finding contrasts with previous studies (Yeh and Chu 1991; Darlington 1999). This difference may also be related to low volumes, in which batch sizes are always small.

The sixth question studied the profitability of the products. These findings did not show that customization led to any differences in profitability. In fact, customized products were found to be as profitable (or unprofitable) as standard ones. This finding may appear to contradict the ideas of activity-based costing (Cooper 1988a, b). However, there is nothing contradictory about it, because activity-based costing is only interested in costs, not profits. Moreover, the comparison between high and low volumes is fruitless since capital goods are typically manufactured in only low volumes. In the case company, higher expenses were covered by higher sales prices. Furthermore, the study revealed other findings concerning the profitability of customization and product variety, suggesting that it is profitable to increase product variety by creating more

models from a single product. However, it is not profitable to increase variety by creating new similar products. The former finding can be explained by the higher total volume (Kekre and Srinivasan 1990), and the latter by higher supportive costs (Hayes and Wheelwright 1979; Yeh and Chu 1991; Mughal and Osborne 1995).

The last three questions were connected to the after-sales function. The study presents a new taxonomy for customization based on a technical perspective. Even though the classification has been created for spare parts, it can be altered to cover customization in general. Overall, similar classifications are sparse (Suomala 2001). Furthermore, the findings based on these spare-parts businesses were somewhat unexpected. At least, the company representatives were convinced that customization had a negative financial effect on the business. However, the results show exactly the opposite to be true. The effects were minor. Quite often, customization was made to the permanent structure and no new spare-part items were created. Furthermore, only a minority of the items was kept in stock. Moreover, the sales volumes in the capital goods spare-parts business are always low, and customization does not make them any lower.

This research revealed other findings concerning customization and product variety. It was reported in more than one case that companies manufactured customized one-of-a-kind products called “specials” that consumed enormous amounts of time and resources. Furthermore, these “specials” were considered to be unprofitable, though no data were found to confirm this view. Nevertheless, these “specials” were in some cases classified as a symbol to the industry in support of the brand image (Spring and Dalrymple 2000). Unfortunately, this was not true in all cases, and in some cases the rationale for customization was difficult, at least for outsiders, to determine. If “specials” do not support the strategy and the brand image, they would only drain resources, and the opportunity costs could become be too high. Spring and Dalrymple (2000) have reported similar findings. Thus, it would be beneficial if there were a classification for recurring and non-recurring customizations, as this would enable a company to improve its engineering and manufacturing process and avoid such “specials”.

Using modularity allows the case companies to achieve volume-related advantages in customization. In the spare-parts studies, it was found that once designed, the customized option frequently became the standard in the future, since modular design incurs no extra penalties. These findings are similar to previous studies (Åhlström and Westbrook 1999; Duray et al. 2000; Duray 2002).

5.2 Conclusion

The results of the study show that in the capital goods business, customization was a normal procedure for doing business. All the case companies had a long history of

customization. Customization was seen as adding non-standard features to a product, typically requiring further engineering work. Common to all cases was that the core product itself always remained standard. If the core product was customized, a new product was created.

In the sales department, customization was seen as a normal part of daily business and was motivated by the need for increased sales and avoiding price competition. Furthermore, customization was seen as a valuable information source concerning customer requirements. A significant increase was observed in sales activities, since translating customers' needs was seen as a crucial point in customization.

The greatest effect of customization was found in engineering. It was noted that customization tied up resources and, typically, the most experienced resources. Furthermore, there is a notable difference between two of the customization strategies. Tailored customization required typically less than 150 hours of engineering work, whereas pure customization were reported to take, in most extreme cases, over 2500 hours. However, even tailored customization can increase engineering activities as much as 300%, as reported in the second paper.

Within manufacturing, customization was perceived as having only minor effects on the manufacturing process. However, this view was contradicted by other findings. In some cases, customization did not require any additional work, nor did it increase manufacturing costs. In other cases, however, manufacturing time was seen to increase by up to 50%. The result of the second paper shows that customization increased manufacturing activity costs on average by 26%. The increase in manufacturing time was explained by extra inspections and rework. The perceived disadvantage of customization was related to throughput time. Short delivery times required a company to start manufacturing a customized product before all customer requirements had become known.

When considering spare parts, in a technical sense, each customization could require electrical, hydraulic, mechanical, or other design work. Mechanical customization seemed to have the least effect on spare parts, since customization was most often made to the permanent structure and did not lead to new items. Closer study of the effects of customization on the spare-parts business revealed that customization had only a minor effect on inventory value. Furthermore, seldomly sold items required more resources than did the more familiar items in terms of after sales. However, it could not be shown that customization increased seldomly sold items. In the case of consumable items, customization could even increase the sales volume of these items.

Other findings show that in one of the case companies, customization required two new activities. Both of these new activities involved inspection and were found to increase the total cost by less than 2%. The increase in other activities, however, was more

significant, with the total costs of customized products averaging 17% higher than the standard products. With regard to the profitability of the product, customized products were as profitable as the standard ones, at least at the level measured, indicating that the increased costs were covered by higher sales prices.

5.3 Limitations and further research

Unfortunately, the study does not answer the question of opportunity costs. In one company, it was noted that the resources used for customization are thereafter not available for other purposes. Thus, the total effect can be negative, even though it appears to be positive in the short run. Furthermore, the study gives no evidence concerning advanced manufacturing technology. However, there is always a penalty for customization either in direct or indirect costs. The question is whether this increase can be covered by higher sales prices. At least, the activity-based costing systems in the companies studied show greater differences in costs and profitability than do any of the previously used marginal costing systems. Moreover, the results for product profitability also show wide variations. These findings corroborate previous studies in justifying the use of activity-based costing (Cooper 1988a, b).

Before generalizing these results, it is worth noting that this thesis relies on case studies, in which external validity is a typical weakness (Leonard-Barton 1990; Voss et al. 2002). In that sense, no grand theory can be built based on these results alone. However, the study creates new knowledge that could be applicable to the environments described. All four case companies represented capital goods manufacturers in the metal and machine industry. Most of the customizations studied can be classified as tailored customization, and the standard products as customized standardization (Lampel and Mintzberg 1996). Thus, it could be concluded that there is, at least to some extent, an analogy that could be drawn between the standard production of capital goods and mass customization (Pine II 1993; Amaro et al. 1999). Moreover, it is interesting to note that production volumes for these products were low, typically less than one hundred but more than ten units per year. In that sense, the generalizability of these findings is limited. The results might have been completely different if the companies studied had had very low volumes, as is the case with paper mill production or shipbuilding. Similarly, these results cannot be generalized to any high-volume capital goods manufacturing, where the production volumes are at least one decade higher, like tractors or electric motors. In such cases, mass customization frameworks may prove to be more beneficial. Nevertheless, most of the findings are supported by previous studies, thus increasing confidence in the findings and improving the external validity of the results (Eisenhardt 1989).

To be able to generalize the findings, further research is needed. Similar studies have to be conducted with multiple cases, in which literal replication should be used for case selection. The theory could also be extended if polar types of cases were selected. For example, similar studies should be conducted that focus on extremely low-volume and relatively high-volume environments. Furthermore, a longitudinal case study would be beneficial when studying the cost effects of customization. The life cycle aspect, which has barely been scratched in this study, could show different figures. For examining the profitability of customization, measurements at a single customization level are not enough, and the total profitability of each customer relationship should also be known. Building a customer relationship is an investment and should thus be studied over a longer period. A single sale can be uneconomical, but after sales can make it profitable. Similarly, further research is needed to determine whether there is some critical size for a population of machines that would serve as a break-even point for after sales profitability.

Although many classifications exist for customization, classification is not enough for managerial purposes. It would also be useful to explore how customization should be conducted for each class, and what the advantages and disadvantages are for each strategy. Other important subjects for future studies would include the effects of customization on organization structure and management control systems. The aim of this thesis was to determine how customization affects a company's operations and costs. New evidence was gained, and new directions have been indicated by this research. For example, in capital goods manufacturing, mass customization does not mean a shift from mass production to customization but, rather, a shift from craft manufacturing towards mass production. Similarly, the competitive situation between standard and customized products would offer an interesting research topic. After all, much further research is needed to gain a fuller picture of customization.

References

Abernethy, M. A., A. M. Lillis, et al. (2001). "Product diversity and costing system design choice: field study evidence." Management Accounting Research **12**(3): 261-279.

Agrawal, M., T. V. Kumaresh, et al. (2001). "The false promise of mass customization." McKinsey Quarterly **2001**(3): 62-71.

Amaro, G., L. Hendry, et al. (1999). "Competitive advantage, customisation and a new taxonomy for non make-to-stock companies." International Journal of Operations & Production Management **19**(4): 349-371.

Balakrishnan, S. (1996). "Benefits of customer and competitive orientations in industrial markets." Industrial Marketing Management **25**(4): 257-269.

Berman, B. (2002). "Should your firm adopt a mass customization strategy?" Business Horizons **45**(4): 51-60.

Boddewyn, J. J., R. Soehl, et al. (1986). 'Standardization in International Marketing: Is Ted Levitt in Fact Right?" Business Horizons **29**(6): 69-75.

Bolton, R. N. and M. B. Myers (2003). "Price-Based Global Market Segmentation for Services." Journal of Marketing **67**(3): 108-128.

Bonoma, T. V. (1985). "Case Research in Marketing: Opportunities, Problems, and a Process." Journal of Marketing Research **22**(2): 199-208.

Bouwens, J. and M. A. Abernethy (2000). "The consequences of customization on management accounting system design." Accounting, Organizations and Society **25**(3): 221-241.

Brown, S. and J. Bessant (2003). "The manufacturing strategy-capabilities links in mass customisation and agile manufacturing - an exploratory study." International Journal of Operations & Production Management **23**(7): 707-730.

Burrell, G. and G. Morgan (2000). Sociological paradigms and organisational analysis: Elements of the sociology of corporate life. Aldershot, Ashgate.

Coates, J. F. and M. F. Wolff (1995). "Customization promises sharp competitive edge." Research Techno logy Management **38**(6): 6-7.

Cooper, R. (1988a). "The Rise of Activity-Based Costing - Part One: What is an Activity-Based Cost System?" Journal of Cost Management **2**(Summer): 45-54.

Cooper, R. (1988b). "The Rise of Activity-Based Costing - Part Two: When Do I Need an Activity-Based Cost System?" Journal of Cost Management **2**(Fall): 41-48.

Cooper, R. and R. S. Kaplan (1991). The Design of Cost Management Systems - Text, Cases and Readings. Englewood Cliffs, Prentice Hall.

Da Silveira, G., D. Borenstein, et al. (2001). "Mass customization: Literature review and research directions." International Journal of Production Economics **72**(1): 1-13.

Darlington, J. (1999). "Lean Thinking and Mass Customisation." Management Accounting: Magazine for Chartered Management Accountants **77**(10): 18-21.

Duray, R. (2002). "Mass customization origins: mass or custom manufacturing?" International Journal of Operations & Production Management **22**(3): 314-328.

Duray, R., P. T. Ward, et al. (2000). "Approaches to mass customization: configurations and empirical validation." Journal of Operations Management **18**(6): 605-625.

Eisenhardt, K. M. (1989). "Building Theories From Case Study Research." Academy of Management Review **14**(4): 532-550.

Evarts, E. C. (1999). More power to get what you want. Christian Science Monitor. **91:** 16.

Fitzgerald, B. (1995). "Mass Customization - at a Profit." World Class Design to Manufacture **2**(1): 43-46.

Gilmore, J. H. (1993). "Reengineering for mass customization." Journal of Cost Management **7**(3): 22-29.
Gilmore, J. H. and B. J. Pine (1997). "The four faces of mass customization." Harvard Business Review **75**(1): 91-101.
Goldratt, E. and J. Cox (1987). Tavoite: tehtaan johtajan kamppailu tehtaansa ja avioliittonsa pelastamisesta. Espoo, Weilin+Göös.
Gosselin, M. and P. Mévellec (2003). Development of a Cladogram of Cost Management Systems. 6th International Seminar on Manufacturing Accounting Research, Twente, The Netherlands.
Gummesson, E. (2003). "All research is interpretive!" Journal of Business & Industrial Marketing **18**(6/7): 482-292.
Hayes, R. H. and S. C. Wheelwright (1979). "Link manufacturing process and product life cycles." Harvard Business Review **57**(1): 133-140.
Håkansson, H., Ed. (1982). International marketing and purchasing of industrial goods: an interaction approach. Chichester, John Wiley.
Jain, S. C. (1989). "Standardization of International Marketing Strategy: Some Research Hypotheses." Journal of Marketing **53**(1): 70-79.
Kaplan, R. S. and A. A. Atkinson (1998). Advanced management accounting. Upper Saddle River, Prentice Hall.
Kaplan, R. S. and R. Cooper (1998). Cost & Effect - Using Integrated Cost Systems to Drive Profitability and Performance. Boston, Harvard Business School Press.
Kekre, S. and K. Srinivasan (1990). "Broader product line: a necessity to achieve success?" Management Science **36**(10): 1216-1231.
Kotha, S. (1995). "Mass customization: Implementing the emerging paradigm for competitive advantage." Strategic Management Journal **16**(Summer 1995): 21-42.
Lampel, J. and H. Mintzberg (1996). "Customizing Customization." Sloan Management Review **38**(1): 21-30.
Leonard-Barton, D. (1990). A Dual Methodology for Case Studies. Longitudinal Field Research Methods. Studying Processes of Organizational Change. G. P. Huber and A. H. Van de Ven. Thousand Oaks, Sage Publications**:** 373.
Lichtenthal, J. D. and M. M. Long (1998). "Case study: service support and capital goods - dissolving the resistance to obtaining product acceptance in new business markets." Journal of Business and Industrial Marketing **13**(4/5): 356-369.
Logman, M. (1997). "Marketing mix customization and customizability." Business Horizons **40**(6): 39-44.
MacDuffie, J. P., K. Sethuraman, et al. (1996). "Product variety and manufacturing performance: Evidence from International Automotive Assembly Plant Study." Management Science **42**(3): 350-369.
McCutcheon, D. M. and A. S. Raturi (1994). "The customization-responsiveness squeeze." Sloan Management Review **35**(2): 89-99.
Merriam-Webster-Dictionary (2003). OnLine. **2003**.
Mévellec, P. and M. Sievänen (2003). ABC, Process-Oriented Systems: a comparative study. 6th International Seminar on Manufacturing Accounting Research, Twente, The Netherlands.
Mintzberg, H. (1988). "Generic strategies: toward a comprehensive framework." Anvance in Strategic Management **5**: 1-67.
Mughal, H. and R. Osborne (1995). "Designing for profit." World Class Design for Manufacture **2**(5): 16-26.
Oxford-English-Dictionary (2003). OED Online. **2003**.

Pine II, B. J. (1993). Mass customization: the new frontier in business competition. Boston, Harvard Business School Press.
Pine II, B. J., B. Victor, et al. (1993). "Making mass customization work." Harvard Business Review **71**(5): 108-119.
Rommel, G. (1991). "The secret of German competitiveness." McKinsey Quarterly **1991**(3): 40-54.
Ross, A. (1996). "Selling uniqueness." Manufacturing Engineer **75**(6): 260-263.
Seppänen, M. and J. Lyly-Yrjänäinen (2002). Vague Boundaries of Product and Customer Costs. 46th Annual Meeting of AACE International, Portland, Oregon, USA.
Simon, H. and R. J. Dolan (1998). "Price customization." Marketing Management **7**(3): 11-17.
Spring, M. and J. F. Dalrymple (2000). "Product customisation and manufacturing strategy." International Journal of Operations & Production Management **20**(4): 441-467.
Sriram, V. and H. J. Sapienza (1991). "An empirical investigation of the role of marketing for small exporters." Journal of Small Business Management **29**(4): 33-43.
Stalk, G. J. (1998). "Time -- The Next Source of Competitive Advantage." Harvard Business Review **66**(4): 41-51.
Stump, R. L., G. A. Athaide, et al. (2002). "Managing seller-buyer new product development relationships for customized products: a contingency model based on transaction cost analysis and empirical test." Journal of Product Innovation Management **19**(6): 439-454.
Suomala, P. (2001). Asiakasräätälöinnin vaikutukset varaosaliiketoimintaan. Teollisuustalous. Tampere, Tampereen teknillinen korkeakoulu**:** 122.
Svensson, C. and A. Barfod (2002). "Limits and opportunities in mass customization for "build to order" SMEs." Computers in Industry **49**(1): 77-89.
Tang, E. P. Y. and R. C. M. Yam (1996). "Product variety strategy - an environmental perspective." Integrated manufacturing systems **7**(6): 24-29.
Ulrich, K. T. and S. D. Eppinger (1995). Product design and development. New York (NY), McGraw-Hill.
Wilson, D. T., J. D. Lichtenthal, et al. (1986). Grounded theory in organizational buying behavior: back to the past. The American Psychological Association Conference, Washington, DC, Lammers, H. Bruce.
Womack, J. P. and D. T. Jones (1994). "From lean production to the lean enterprise." Harvard Business Review **72**(2): 93-103.
Voss, C., N. Tsikriktsis, et al. (2002). "Case research in operations management." International Journal of Operations & Production Management **22**(2): 195-219.
Yeh, K.-H. and C.-H. Chu (1991). "Adaptive strategies for coping with product variety decisions." International Journal of Operations & Production Management **11**(8): 35-47.
Yin, R. K. (1994). Case study research: design and methods. Newbury Park, CA, Sage Publications.
Zairi, M. (2000). "Managing customer satisfaction: a best practice perspective." The TQM Magazine **12**(6): 389-394.
Zipkin, P. (2001). "The limits of mass customization." Sloan Management Review **42**(3): 81-87.
Åhlström, P. and R. Westbrook (1999). "Implications of mass customization for operations management." International Journal of Operations & Production Management **19**(3): 262-274.

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