better service (Simon and Dolan, 1998). On the other hand, mass production can offer greater cost advantages with standard products. Recently, mass customization has emerged as a way to combine the advantages of both customization and mass production (Kotha, 1995, Pine, 1993).

Customization is a widely studied subject. However, there has a notable lack of almost any linking of customization to broader issues of manufacturing, marketing, and research and design (R&D) (Spring and Dalrymple, 2000, Lampel and Mintzberg, 1996). Moreover, it can be said that customization is not a homogenous phenomenon that can be addressed as a whole. The objective of this study is to point out how customization is seen and how it is managed within an organization. The paper starts with a literature review of customization. Some frameworks are presented to identify and classify customizations. The study relies on interviews conducted in four different companies manufacturing capital goods. The rest of the paper discusses key issues identified during this study.

LITERATURE REVIEW

A number of writers have considered product customization. The following discusses some of the frameworks presented in the literature. 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). A customized product can be seen as a generic product which is modified by customer needs, like a car with a list of optional extras. Alternatively, it can be seen as a special product which is made of standard modules combined the way the customer wants, like a prefabricated house.

Different motivations exist for customization (Spring and Dalrymple, 2000). Typically a product is customized to fulfill customers' needs. A customer might need features that are considered as useless or even unattractive by other customers, or are simply not common standard features. Similarly, some customers require higher or lower performance, or the product is to be included as part of the customer's manufacturing process. Furthermore, customization can be a choice for its own sake. Åhlström and Westbrook (1999) studied the benefits, disadvantages, and difficulties of customization. Increased customer satisfaction and increased market share are the most frequently mentioned benefits, while increased material and manufacturing costs are among the most notable disadvantages. Difficulties are most often related to understanding customer wants.

Customization means differentiated products, and typically can increase the variety of products. This can lead to a higher market share and to increased profitability (Kekre and Srinivasan, 1990). However, customization also has its downside, since there is a tendency for

part and process varieties to increase (Yeh and Chu, 1991), low volume and high variety are often associated with customization, and typical manufacturing processes require job-shop and batch processes (Duray et al., 2000, Hayes and Wheelwright, 1979).

Lampel and Mintzberg (1996) have identified five main customization strategies based on the stage of customer involvement. The strategies differ from each other depending on the part of the value chain in which the customization is made: *pure standardization, segmented standardization, customized standardization, tailored customization,* and *pure customization.* Pure standardization refers to a completely standard production in which all the pieces made are similar. In segmented standardization, customers are seen as a cluster of buyers, and each cluster is seen as a whole, as occurs when making different products for different market areas. In customized standardization, a product is customized in an assembly phase using standard components. Tailored customization requires basic design that can be customized in a fabrication phase. In a pure customization strategy, a product can be customized from scratch. However, there has to be some standard configuration, otherwise this strategy should be called prototyping rather than customizing.

Coates and Wolff (1995) approach customization as a manufacturing practice. They define customization as *soft* when the customer is not involved in the manufacturing process, and *hard* when there is customer involvement in the manufacturing process. Gilmore and Pine (1997) have identified four distinct approaches to mass customization: *collaborative, adaptive, cosmetic, and transparent.* In collaborative customization, customers select from predetermined elements their own combination, after which the product is custom-made. In adaptive customization, the product itself is customizable, and the provider does not make any customization. Cosmetic customization is used when a standard product or service satisfies almost every customer. It could be said that the product remains standard and it is the wrapping that is customized. Transparently customized products may look like a standard product to the user. However, the provider has studied customer process or behavior in such a way that the product can fulfill the needs of an individual customer. Typically, this requires long-term customer relationships.

Modularity is used to gain volume in mass customization. It has been suggested that modularity is the key to achieving volume-related advantages, such as low costs. Furthermore, modular assembly is the most frequently used means of customizing (Åhlström and Westbrook, 1999). Duray et al. (2000) combine modularity within the customization framework presented by Lampel and Minzberg (1996). They classify modularity according to the stage at which modularity will be utilized. By doing so, they recognize four different archetypes: *fabricators, involvers, modularizers,* and *assemblers*. Fabricators are willing to use common components, though they may also design unique components to meet customer requirements. Involvers let

a customer to take part in the design and fabrication process. The actual customization is done during the assembly phase by combining standard components, and no customized components need be fabricated. Modularizers use common components in many product lines. Modularity is built into the product structure and is even used without customization, with customer options being chosen in either the assembly or use phase. Assemblers provide segmented standardized products using modular components. Furthermore, customers can customize a product by themselves. It has been found that custom product manufacturers are more likely to be fabricators or involvers (Duray, 2002).

The existing literature on mass customization has mainly focused on manufacturing operations (Da Silveira et al., 2001). Moreover, critical aspects are rarely discussed. Zipkin (2001) points out that there are no mass markets for all customized products. Furthermore, he argues that mass customized products tend to have previously been customized initially on a small scale. It has also been suggested that the era of mass customization may have resulted from the development of flexible manufacturing and information technologies (Da Silveira et al., 2001). Argawal et al. (2001) maintain that mass production is still useful, at least in the car industry, which they use as an example.

RESEARCH ISSUES AND METHOD

Customization is a widely studied subject. However, there are diverse interpretations of what customization means (Spring and Dalrymple, 2000) and how it is conducted. Because customization has typically been used in industrial markets for doing business (Spring and Dalrymple, 2000, Håkansson, 1982, p. 165), it is assumed that companies manufacturing capital goods have a long history of customization. In other words, that there should be an established practice of customization, and workers would have extensive experience in customization. The research questions examined in this exploratory study are the following:

- What does customization mean in capital goods manufacturing business?
- What are the perceived advantages and disadvantages of customization?
- What is the crucial point when customizing?

Answering the first question gives insight into what capital goods manufacturers mean when they talk about customization. Moreover, it clarifies how customizations are conducted and makes it possible to classify customizations based on the presented frameworks. The second question points out the pros and cons of customization. Moreover, it explains why companies are customizing. The final question answers where the pitfalls of customization are.

Semi-structured interviews were chosen as the method to answer these questions, since it enables the researcher to gain a clear understanding of the subjects discussed. When selecting

the case companies, a literal replication was used to ensure that each case would predict similar results (Yin, 1994, p. 46). Moreover, in every case the process of interest (customization) was "transparently observable" (Eisenhardt, 1989). 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. The study was thus able to simultaneously link customization to manufacturing, marketing, and engineering.

DATA COLLECTION

All four companies had a well-established history. Three out of the four companies were among the biggest in their markets. Furthermore, all the companies were part of larger corporations, and manufactured machines used by industrial customers. These machines were either sold directly to the customer or through sales companies, which were typically owned by the company itself. However, one company used dealers significantly more than did the other companies.

The net sales of the companies or business units studied ranged from 25 to almost 100 million euro. In three of the four companies, the sale prices of the machines manufactured averaged over 100 000 euro per unit. However, in one company, the average sale price was less than 10 000 euro. Furthermore, the products of the companies had a lifetime that typically exceeded 10 years. For each company, after-sales activities were significant, and were often noted as being the most profitable part of the business.

The following section provides a short description of each company. Even though there are no confidential data presented herein, the names of the companies are not shown. This was a prerequisite by some of the companies before consenting to participate in the study.

Company A

The annual production volume of Company A was about 550 units. There were three main product lines, in which one was more or less standard, and the other was heavily customized. The production of the company was characterized by heavy machining and assembly, and the production process was designated as job shop. The company manufactured the core components for its products. Furthermore, it used subcontractors intensively to deliver other components. The company products typically formed part of the customers' manufacturing process

and were always made according to customer specifications. Practically every product manufactured was somehow customized. Consequently, the company was used to project work, with the manufacturing time and expenses of each product being closely documented. The number of final customers was limited. However, sales negotiations were typically conducted through a third party, thus making it more challenging to determine actual customer requirements.

The people interviewed included production manager, engineering manager, and area sales manager. All interviewees had similar understanding about customization. A product was considered standard if it could be produced from standard components, though some measures of standard components had to be changed. Customization typically meant that a new component had to be designed or the connections to the customer process had to be designed. Engineering work was needed whenever a product was customized. However, the main component of the product remained practically standard. The company used many standard components to meet the required delivery times. Nevertheless, the company's representatives used the word "standard" to describe the components, since even these components were typically designed and manufactured specifically for this company.

The company had established an approval procedure for customization. The final decision concerning what and how a product was to be customized was made by the technology (R&D) department. The responsibilities for new product development and customization were divided into separate departments. Customization had the highest impact on the engineering department, since the manufacturing effects were minor, and manufacturing time typically varied within ±5%. For the sales department, customization was a normal way of doing business. The most critical aspects in customizing were to know the actual customer requirements and to transfer these requirements throughout the organization. Moreover, meeting short delivery times was considered problematic.

In summary, it could be said that customization was a normal way of doing business. A customer-focused strategy was evident and the company's way of doing business seems to reflect the normal procedure within this industry. It could be said that customization was a prerequisite for success.

Company B

The unit analyzed in Company B was the Assembly Business Unit. The company also had another business unit where the core component was manufactured. These two business units interacted closely, and the core components were designed, in some cases, based on the need of the Assembly Business Unit. The assembly used job shop production. The annual production volume was about 250 units. The company manufactured only one type of product, which

differed typically in size. The company used subcontractors to deliver standard components which could be shared across different products. The company product typically formed part of the customer's process or could be the process itself. The smaller products were quite standard, and the heavy end was always customized. The number of potential customers was considerably large. The company had close customer relationships because of the long after-sales period and direct sales efforts. In addition to interviews, more detailed, analyzed data concerning customizations were available. The data were used to triangulate interviews and to place customization within the larger context of the company.

The people interviewed were workshop manager, two design managers and product manager. The reason for interviewing two persons from the design and engineering department was to study the organizational change which had occurred about two months before the interview. This made it possible to obtain a comprehensive picture of how customization had affected the engineering. The company was currently implementing a process-management project and had already designated its manufacturing customized product as a core process. As a result, the R&D department had been divided into new product design and customization departments. One design manager interviewed was the head of customization engineering and the other had long experience in design work throughout the company.

All the people interviewed had similar opinions on customization as well as the reasons for using it. Customization was seen to have occurred when customer features that did not form part of the catalogue features were introduced into the product. In other words, customization was typically done when the standard configurations did not fulfill customer requirements. Sometimes, customization meant component sharing across a product range, which typically involved adding a new feature to the product. Frequently, a customer option would become a standard option. The company had a configuration tool, and over 70% of the products corresponded to standard configurations. Customizing a product inevitably required engineering work, though the core component of the product could be customized using standard consumable parts. Otherwise, the core component was usually based on a standard configuration. Similarly, most of other components were standard, and customization was accomplished by adding optional components to the standard configuration.

Because the company had defined customization as one of the core processes, answers were well structured and the company had recognized the need to develop the customization process. The company had a configuration tool in use, and at the moment a mass-customization project had just been started. The aim of the project was to shorten the throughput times. The means to achieve this included both modular design and component sharing. However, it seemed that mass customization would affect most products that were currently manufactured based on standard configurations. Engineering and transferring customer requirements to the

product features were crucial factors in the customization process. It was also mentioned that mistakes in engineering were expensive, as they increased manufacturing time and typically raised expenses for after sales.

The company had recognized many advantages in customization. Somehow, they felt that it was the most effective way of doing business. Customization had increased sales volume and customer satisfaction. After-sales markets were important to this company, creating about one third of the sales volume. Increased sales volume created even more business in the long run. The negative effects of customization were that it significantly used up engineering resources and increased manufacturing time by 20 to 30%. The increased sales price typically covered any increased direct expenses. However, the overall effect on profitability remained unclear.

Product management and engineering decided together whether customization should be done. The company had an A–B–C–D classification for customization, where A is standard and D is new product. In addition to customized products, the company also offered "specials." These were actually new products, which were made according to customer order and designed by customization engineering. These products could also be referred to as a failures of the normal process, since they should have actually comprised part of new product development.

Company C

Like Company B, Company C had two manufacturing departments. The assembly department was chosen as the unit for analysis. The machining department manufactured the core component of the product. Most of these components were sold to other manufacturers as a standard component. The assembly department produced the final products, and the sales companies or dealers sold these products to the customers. The product most often comprised a separate piece of the customer's manufacturing process and as such was easily replaceable. The company manufactured about 2 500 products annually, with the size of the product varying from the size of a washing machine to the size of a container. Small machines were typically considered as the standard, and large ones as customized. Moreover, the company manufactured some of its products under another trademark. The production process involved a disconnected line for the smaller products, and job shop for the larger products. Compared to other companies, this company was the smallest, and the sales price on its machines was the lowest. Moreover, the company was able to use commercial standard components more than did the others. With a higher volume, the company was more a standard product manufacturer than were the other case companies. However, the assembly of larger machines followed the logic of the other case companies, and thus gave similar results.

The people interviewed were production manager, engineering manager, and sales manager. Customization was recognized at two levels. It either consisted of combining standard modules or designing and manufacturing customer options. The reason given for customization was that the standard configuration could not fulfill customer requirements. It was typically possible to fulfill these requirements with standard components, though these products were sometimes used in environments that required new designing. Moreover, market area configurations were not recognized as customization.

The company had established an approval process for customization and an A–B–C–D classification similar to that used in Company B. There were no "specials," and the approval process was strictly followed, even though the production manager was able to recall one exception. Modularized product structure was a critical success factor for cost-effective customization. Moreover, customer specifications had to be right from the start. The interviewed managers listed among the disadvantages of customization that it tied up resources and disturbed other projects. This was particularly a problem for the engineering department. Customization and especially mass customization were said to be the only way to successfully compete. The company implemented more customization than did its competitors, a fact that had helped it carve out new niches.

Company D

With an annual production volume of about 500 units, the production of company D was mainly devoted to product assembly that made use of disconnected line, batch and job production processes. Similar to other companies, Company D manufactured the core component of the product itself. Furthermore, this component was quite standard.

The company had two product lines. The first one was typically standard, manufactured on the disconnected line, and assembled using standard components. However, about 10% of these products were customized. The design of these products was market-driven, and in domestic markets the company was a market leader. However, the total market for these products was fragmented with many competing players on the market. The second product line involved batch and job production processes. Customized products accounted for nearly 25% of these products. In fact, practically all the products were manufactured based on customer requirements, though not all products were considered to be customized. Moreover, the offering process typically took quite a long time and required close cooperation with the customer. The production volumes for these products were low, and the price of a single machine could reach up to one million euro. The company was also a market leader in these products.

The people interviewed were purchasing manager, R&D manager, and business line manager. The company had had many projects concerning customization and modularization. A

common view of customization was held by all in the company. If standard options fulfilled customer requirements, the product offered was a standard. If engineering was needed, the product was customized. Moreover, there were standard options which were specified, but not designed until the first customer order. Furthermore, the company products had to fulfill regulations which differed according to the market area. These regulations resulted in customizations, even though the customer regarded these products to be standards. Similarly, the manuals for the product had to be translated into different languages.

The perceived advantages of customization were increased sales volume and market share. Moreover, this allowed the company to receive important market information about customer needs. The downside was that customization tied up resources and significantly disturbed other operations. In this company, disturbance stood out more than in the other companies. Similarly, the chain effects caused by customization were noted, though the effects were unclear. Customization looked profitable when measured in terms of gross margin. Nevertheless, all interviewed persons said that this was not an accurate yardstick for success. Instead, they felt that if the opportunity costs were calculated, the profitability was significantly worse.

CUSTOMIZATION BY FUNCTION

Manufacturing

All the companies studied manufactured multiple products with low volumes. The manufacturing process was either job shop or disconnected line. Customization was seen as manufacturing customer features that were not offered as standard options. In addition, one interviewee considered modular assembly from standard options as customization. Typically, it was options that were customized. At the moment, two of the companies were involved in mass customization projects that had already had some effects on the manufacturing processes, such as modular assembly.

Due to customization manufacturing time increased from 0 to 50%, though the increase was typically less than 20%. However, the increase in the throughput time was more critical. Quite often the throughput time doubled. The most often mentioned disadvantage was the increase in inspections needed. When short delivery time was critical, a company had to start to manufacture before all customer requirements were known, an occurrence that quite often led to rework. However, if the product was well designed and extra time was available for manufacturing, customization had only minor effects. As one interviewee said: ”If the product is well designed and documented, the manufacturing is peanuts.” The most often mentioned advantage of customization was increased sales volume.

Engineering

How customization was organized differed significantly. Two companies had organized separate subdivisions for customization engineering, thus ensuring more effective management of customization. In one of the companies, the use of subcontractors was under consideration for customization engineering. By contrast, in another company, a new product design was partly outsourced because it was felt that customization needed more experienced engineer designers.

The time needed for customization varied between 5 and 100% of the designers' time even within a single company. In some cases, the design work needed for offering bids took up to one-third of the designers' time. In all companies, the greatest disadvantage was that customization tied up resources. Quite often this meant the most experienced designer, and what made it more challenging was a significant variation in the demand. Among the advantages was that customization served as an information source for customer requirements. Even though customization had the greatest effects on engineering, the attitude towards customization was positive. A crucial factor affecting customization was that there should be no misunderstandings concerning customer requirements, otherwise useless work or even greater harm could occur.

Sales

The meaning of customization varied the most within sales representatives. This might have been due to significant variation in the responsibilities of the interviewees. For this group, a customized product was either specially custom made or a combination of standard options. In general, customization was seen as a way to increase customer value. It was said that customization was done either to avoid price competition or as a way to attain a better price. Moreover, customization was felt to comprise a normal part of the interviewees' daily work.

More than in the other departments, the sales representatives emphasized equated customization with knowing their company's own capabilities and combining these with customer requirements. Similarly, the interviewees were able to classify both customer requirements and customers. Typically, new customers wanted features which were offered by competitors, and customers with long relationships required more specific features. One disadvantage was that customization demanded a great amount of resources. The profitability of customization was unclear, though it was said that customization was profitable in terms of gross-margin, but no further conclusion could be made. Nevertheless, the belief was that customization was less profitable than standard production.

TABLE 1. Effects of customization.

	Manufacturing	Engineering	Sales
Advantages	**Increased sales.**	**Information source of customer requirements.**	**Avoiding price competition. Increased customer value.**
Disadvantages	**Increase in throughput time. Extra inspections needed.**	**Tied up resources.**	**Tied up resources.**
Crucial point	**Good design. Time.**	**Understanding of customer requirements.**	**Knowing own capabilities and customer requirements.**

Comparison between the functions

Manufacturing considered the effects of customization to be minor. Typically, these effects were related to the extra work required or to throughput time. These companies were used to manufacturing unique pieces, and customization was thus nothing new. Similarly, sales staff saw customization as forming a normal part of their daily business. Customization had the biggest impact on engineering. In every case, customizing engineering was needed. However, each function saw customization as the normal way of doing business and said that it was unavoidable. A short comparison is shown in Table 1.

CLASSIFYING CUSTOMIZATIONS

In the following sections, customization is classified according to the frameworks presented below (Table 2), and the suitability of the frameworks is discussed in terms of capital goods manufacturing.

Although the customization strategies of Lampel and Mintzberg (1996) can be used to classify capital goods manufacturing, pure standardization and segmented standardization are practically useless. Only a few products from one of these company can fit into the segmented standardization class. Moreover, products assigned to the customized standardization class were considered by the interviewees to be standard. Customized products can typically be grouped under tailored customization. These are characterized by a standard core design which is not altered, though some peripheral design changes can be made. Even though pure customization was not the preferred strategy, a capital goods manufacturer sometimes had to choose it.

Although these strategies describe strategies along the operating process, they can be used to classify products. As noted by Lampel and Mintzberg (1996), there exists a continuum of strategies, and thus the line between two classes can be fuzzy. These results suggest that the companies wish to move from tailored customization towards customized standardization.

TABLE 2. Classification of customizations.

		Company A	Company B	Company C	Company D
Lampel & Minzberg	Pure standardization	None	None	None	None
	Segmented standardization	None	None	Market area customization	None
	Customized standardization	Typical standard production	Typical standard production	Typical standard production	Typical standard production
	Tailored customization	Typical customization	Typical customization	Typical customization	Typical customization
	Pure customization	Practically none	Specials	Practically none	Specials
Coates & Wolff	Soft	"Standard production"	"Standard production"	"Standard production"	"Standard production"
	Hard	"Customized production"	"Customized production"	"Customized production"	"Customized production"
Gilmore & Pine	Collaborative	Typical with some limitations	Typical with some limitations	Typical with some limitations	Typical with some limitations
	Adaptive	None	None	None	None
	Cosmetic	None	None	None	None
	Transparent	None	None	Combined with collaborative	Combined with collaborative
Duray et al.	Fabricators	Typical customization	Typical customization	Typical customization	Typical customization
	Involvers	Typical standard production	Typical standard production	Typical standard production	Typical standard production
	Modularizers	None	Aim of mass customization	Aim of mass customization	None
	Assemblers	None	None	None	None

The division of customization into soft and hard is too aggregate of a classification for capital goods. Indeed, most of the products are results of hard customization. Soft customization, choosing from predetermined options, is considered as standard production. However, quite often in these companies these choices have effects on manufacturing processes and thus the division becomes blurred. It is good to keep in mind that the division might not be made to classify customization but rather to show the emergence of hard customization.

The mass customization framework presented by Gilmore and Pine (1997) is not suitable for classifying capital goods. Collaborative customization best defines what these manufacturers are doing. However, predetermined options are not enough. There are some transparent

customizations, such as safety regulations, but these typically go hand in hand with collaborative customizations. Even though writers say that they have identified four distinct approaches to customization, these approaches are actually suitable only for classifying mass customization because the most of customized product could not classified in any of the classes. With respect to capital goods markets, there are in many cases no mass markets, and thus products have to be craft manufactured.

The idea of combining modularity and customer involvement works when classifying customizations of capital goods. All companies are fabricators when customizing and involvers when they are manufacturing what they call standard products. However, there is a shift from involvers towards modularizers. Companies want to postpone the time of customer involvement as late as possible, as this allows them to aim for shorter delivery times. Modular product structure and component sharing are already typical habits in these companies.

Regrouping customer involvement into two classes makes classifying easier. Quite often, it is difficult to make a distinction about when customer involvement actually takes place. As in these cases, engineering is needed for all customizations. However, the core design typically remains standard.

CONCLUSION

The data show that customization was a normal procedure for doing business in the capital goods industry. All the 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, but the options were customized. In almost all cases, engineering work was required. The advantages of customization were connected to increased sales volume and customer intimacy. Moreover, customization was seen as a way to obtain valuable customer information. Extra work and tied up resources were major disadvantages. Crucial factors included the ability to understand and transfer customer requirements into product features. Modular design was mentioned as a prerequisite for successful customization.

Customization had the biggest 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. In the most extreme cases, the time required could extend to over 2 500 hours. In such cases, the division between customization and new product design was unclear. Moreover, the offering bids took a significant amount of the designers' time, up to 40%. Consideration of the time required for customization and offering design would seem to suggest that the effect of new product design would be unfavorable. As noted

in Company D, chain effects might lead customization to have a negative total impact on profitability. However, if customization is well managed, these negative effects can be avoided. In these companies, two had established separate customization and new product design departments; whereas, in the other two companies, the same engineers had to do both tasks.

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%. However, this should be taken into account when setting delivery times and also when making offers. An increase of 20% in labor expenses can easily make a product unprofitable. Moreover, those customizations, which can increase manufacturing time well over 20%, should be recognized and managed more carefully. It appears that it would be beneficial for these customized products to have a dedicated designing and manufacturing process.

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 ends up making products that are not suitable for the business. In three of the four companies, at least one case of such products was mentioned. Although the general opinion of these products was that they were unprofitable, no data were found to confirm this view.

Comparing the frameworks presented allows the following conclusions to be made. The division into soft and hard customization (Coates and Wolff, 1995) is too general and is therefore not suitable for classifying capital goods. Similarly, the framework of Gilmore and Pine (1997) is not suitable for capital goods. The mass customization approach does not appear to work because customer requirements differ so much that in many cases, there are no mass markets. The customization strategies presented by Lampel and Mintzberg (1996) are, however, suitable for classifying capital goods. Typically, manufacturing is either a customized standardization or tailored customization. Nonetheless, the division between classes is at times somewhat unclear. The idea of combining modularity and customer involvement works fine. That is because, at least, in these companies modular design and manufacturing are well adopted and typically used. Moreover, regrouping customer involvement into two classes would make classifying easier.

The findings of this study are supported by previous studies indicating that customization can increase market share and customer satisfaction (Kekre and Srinivasan, 1990, Åhlström and Westbrook, 1999, Simon and Dolan, 1998). A typical difficulty is understanding customer requirements (Åhlström and Westbrook, 1999). However, increased manufacturing and material costs were not mentioned as a disadvantage of customization. A common disadvantage is that customization ties up resources, especially in engineering.

The use of the mass customization framework is of limited value in the capital goods industry. At least, in companies described in this study, there are no mass markets for their customized products. Moreover, these capital goods have always been customized. These finding are supported by Zipkin (2001). However, modular design and assembly is typically used to achieve cost advantages when customizing (Åhlström and Westbrook, 1999, Duray et al., 2000). Moreover, the finding that capital goods manufacturers are typically either fabricators or involvers is also consistent with other recent work (Duray, 2002).

All four case companies represented capital goods manufacturers in the metal and machine industry. Similarly, all companies had industrial customers, and the lifetimes of their products well exceeded ten year. As expected, all the cases yielded similar results, a point worth keeping in mind when generalizing from these results. However, it would be beneficial to study other companies, as well. Such extreme cases as large-scale construction projects, including paper mills or nuclear power plants, would certainly provide valuable new evidence. Similarly, the shipbuilding industry would be an interesting subject for study.

Many questions remained unanswered and further research is needed. There were two different ways to organize customization design. The pros and cons of both methods should be studied. Moreover, it would be rewarding to study how the customization process could be optimized. To aid in optimizing customization processes, there should at least be a classification for recurring and non-recurring customizations. Moreover, companies should avoid non-recurring customizations or at least these ”special offers” should have their own design and manufacturing process. ■

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