Manufacturing strategy and e-business: an exploratory study

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Abstract
Whilst much of the e-business evolution has been referred to as an additional and complementary marketing channel, there has been little concern about the impact on manufacturing. However, since a manufacturing strategy should be closely linked to the marketing strategy, developments in marketing are likely to impact manufacturing. In this paper, we explore the ways in which e-business is impacting the manufacturing strategy in manufacturing firms. We study seven Swedish manufacturing firms and investigate the relationship between e-business and manufacturing strategy. The findings indicate that e-business mainly affects two decision categories – vertical integration, and manufacturing planning and control systems – through new ways to communicate and exchange information between buyers and sellers at both business ends. Improvements in these decision categories lead to potential gains in delivery speed and reliability, but only for make-to-order companies, whereas the impact on quality, price and flexibility is more or less negligible. Make-to-stock firms report only limited impact on manufacturing.

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Introduction

Electronic business (e-business) solutions are currently evolving on a global scale and manufacturing firms are becoming successively more interested, as well as involved, in the features of e-business. The evolution so far can be seen to encompass two stages (Norris *et al.*, 2000); electronic-commerce (e-commerce) and e-business. E-commerce, which is the aspect of e-business that has garnered most attention, is often defined as the buying and selling of goods and services on the Internet, especially the World Wide Web. It includes business-to-business (B2B) and business-to-consumer (B2C) buying and selling, electronic data interchange (EDI), online catalogues, etc. E-business is in turn defined as conducting business on the Internet. In this sense, e-business is not just buying and selling, but also servicing customers and collaborating with business partners. IBM regards e-business as:

> . . . the use of Internet technologies to improve and transform key business processes (IBM, 2001).

Consequently, e-business, in contrast to e-commerce, significantly affects business processes and relationships along the value-chain (Norris *et al.*, 2000). Although there are differences in definition of e-commerce and e-business, the two terms are often used interchangeably.

Whilst much of the e-business evolution has been referred to as an additional and complementary marketing channel (see e.g. Parsons *et al.*, 1998; Bakos, 1998), there has been little concern about the impact on manufacturing. Only in a few and limited cases can "e-manufacturing" become a reality, i.e. where the products can be digitally developed and distributed.

However, since a manufacturing strategy should be closely linked to the marketing strategy, developments in marketing are likely to impact manufacturing. Van Hoek (2001) argues that the most profitable features of e-business centres on the existing companies with a heritage in the "brick-and-mortar" world that are now penetrating the e-business environment. Hence, getting the most out of e-business is rather related to management issues than merely the Internet technology itself. It has therefore been argued that it is of great importance to use existing business models and tools to analyse features of the e-business evolution (King and Clift, 2000; Porter, 2001).

The purpose of this research is to provide exploratory results of how the e-business evolution is impacting the manufacturing strategy. This research is exploratory in nature in order to gain new insights into an as yet incompletely documented phenomenon. Therefore, a qualitative research methodology was used. Data were collected at seven Swedish manufacturing firms that had been working with e-business solutions for some time. The criterion for selection of companies was that they had been operating e-business solutions extensively for some time. The participants were provided with information and terminology on manufacturing strategy in order to provide a basis for comparison. Based on these case studies, we here explore similarities and differences as to the experiences of the introduction of e-business on manufacturing strategy issues.

In analyzing the cases, our main focus is on e-business solutions in B2B environments. We furthermore address both manufacturing (direct) and operating (indirect) inputs, mainly in systematic sourcing and selling (cf. AMR, 2000a, b; Kaplan and Sawhney, 2000). In terms of a manufacturing strategy, we

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distinguish between competitive priorities, such as quality, flexibility, delivery speed and dependability, and cost (price) (see, e.g. Ward *et al.*, 1998), and decision categories, such as process, capacity, facilities, vertical integration, quality, organization, and manufacturing planning and control systems (see, e.g. Hayes and Wheelwright, 1984). In order for a manufacturing strategy to support the marketing strategy of a manufacturing firm, changes in either strategy, or in environmental factors affecting either strategy, must be analyzed in order to maintain alignment and avoid mismatches.

The three research questions that we address in this paper are:

1 which competitive priorities are affected by e-business initiatives and how;
2 which decision categories in a manufacturing operations strategy are affected by e-business initiatives and how; and
3 will e-business be considered a competitive priority or decision category in itself or lead to the creation of new competitive priorities or decision categories?

This paper is outlined as follows. We first present the contents of a manufacturing strategy to provide the basic theoretical foundation for the exploratory study, focusing on competitive priorities and decision categories. Thereafter the seven case companies are presented in some detail. We then explore how the manufacturing strategy is affected by e-business in the seven cases. Finally, we provide a summary and some concluding remarks. We hope that this research will contribute to the understanding of how a manufacturing strategy is affected by, and could be restructured with respect to the opportunities provided by e-business solutions.

Manufacturing strategy

The content of manufacturing strategy is traditionally built around two broad groups: competitive priorities and decision categories (Rudberg, 2002). The competitive priorities are defined as a set of goals for manufacturing (Leong *et al.*, 1990; Dangayach and Deshmukh, 2001), which is used to align the business strategy and market requirements with the manufacturing task. The decisions made to fulfill the manufacturing task are often grouped into a number of decision categories (Hayes and Wheelwright, 1984). Wheelwright (1984) defines a manufacturing strategy by the patterns of decisions actually made within these categories. The more consistent the pattern of decisions is in supporting the competitive priorities and the manufacturing task, the more effective the manufacturing strategy. Interrelationships among decision categories are analyzed in, e.g. Olhager *et al.* (2001), Olhager and Rudberg (2002), and Rudberg and Olhager (2003). Together, competitive priorities and decision categories form the theoretical foundation for our exploratory study, in that we relate the impact of e-business on manufacturing strategy to specific competitive priorities and specific decision categories.

Competitive priorities

Competitive priorities are normally defined as a consistent set of goals for manufacturing. When determining the manufacturing task it is vital to define what the manufacturing function must accomplish in terms of providing competitive priorities. In doing this, one must realize that all priorities cannot be provided at the highest level, since no single manufacturing system can provide all priorities to be competitive in all dimensions (Skinner, 1969). Trade-offs must be made. Wheelwright (1984) declares that it is extremely difficult for a company to try to compete by offering superior performance along all of these dimensions simultaneously. Consequently, it is obvious that the choice of manufacturing task will position a company relative to its competitors in terms of its competitive advantage. Competitive priorities as means to structure and operate manufacturing have been used extensively in the manufacturing strategy literature (see, e.g. Hayes and Wheelwright, 1984; Miltenburg, 1995; Hill, 2000). When the business has decided upon the choice of competitive priorities and defined the company's manufacturing task, it is time to make the right decisions to fulfill that task. These decisions are often divided into a number of decision categories.

Decision categories

The essence of a manufacturing strategy could be characterized as consisting of a pattern of decisions within certain categories, affecting the ability of the manufacturing function to meet the long-term objectives and the manufacturing task. The decision categories noted in a manufacturing strategy somewhat differ from author to author, but there seems to be an essential agreement on areas that really matter for manufacturing (see, e.g. Skinner, 1969; Hayes and Wheelwright, 1984; Fine and Hax, 1985; Samson, 1991; Miltenburg, 1995).

The categories, generally ranging from six to ten in number, are usually divided into structural (related to long-term commitments and heavy investments) and infrastructural (related to support functions where changes may be incorporated in a shorter time perspective) decision categories, as proposed by Hayes and Wheelwright (1984). A review of a typical set of decision categories and the associated major types of policy areas is presented in Table I (cf. Hayes *et al.*, 1988).

Case studies

We study seven Swedish manufacturing firms[1] and investigate the relationship between e-business and manufacturing strategy. The firms are:

- Arla Foods (dairy);
- Seco Tools (industrial tools);
- Atlas Copco Tools (heavy equipment);
- SKF (ball bearings);
- ABB Robotics (industrial robots);
- Nobel Biocare Procera (dental components); and
- Strålfors (printing devices and services).

Based on these cases we explore similarities and differences, in order to analyze and generalize the impact of e-business on a manufacturing strategy.

Firm 1: the manufacturer of dairy products

Established on 17 April 2000, Arla Foods is the result of a merger between the Danish MD Foods and the Swedish Arla, the first merger between two co-operatives from two different countries. Arla Foods is owned by some 17,000 Danish and Swedish milk producers who supply milk to the group. With approximately seven billion kilograms of milk received and a turnover of $4.4 billion, Arla Foods is Europe's largest dairy group.

E-business and the Internet are of high strategic importance to Arla Foods, which aims at being the leader within these areas in its business segment. A large amount of resources and money is spent on e-commerce and e-business solutions. Arla's B2B activities are on the one hand aimed at supermarkets and grocery shops, where not only ordering activities are supported but also future events, campaigns and new product introductions are posted. Here the stores get full information on Arla's forecasts, sales plans, and also exception messages if a store deviates from its normal buying behavior. On the other hand, Arla is also under way to implement a B2B solution towards the milk producers to provide them with accurate information concerning demand, quality and environmental issues. Arla is furthermore heavily involved in B2C activities with a Web-based cookery book linked to an automatic grocery list and the possibilities of home delivery of the goods if an order is placed. A similar portal for catering companies is under development.

Arla believes that e-business will change the way of making business in the dairy industry to a great extent. They are working with some future scenarios to be prepared for what is likely to come. Yet, there are still no indications of any major change in competitive priorities, although there are obvious changes in the ways of making business. This will in turn lead to changes in the decision categories, especially concerning organization and control systems.

Firm 2: the manufacturer of industrial tools

Seco Tools is one of the world leading producers of cemented carbide tools for cutting in metal turning, milling, drilling and threading. The firm operates in 50 countries, the sales turnover is $320 million, and there are 3,900 employees. They introduced on-line ordering for customers in 1999, and have continuously improved the system. The purpose of introducing e-business was to improve competitiveness and order administration, and to provide better service to existent customers. Another objective was to try to increase the number of customers by offering an efficient way of placing orders.

Table I
Decision categories and associated policy areas within a manufacturing strategy

Decision category	Major types of manufacturing choices
Structural categories:	
Process	Process choice, technology, integration
Capacity	Amount, timing, increment size
Facilities	Size, location, specialization and focus
Vertical integration	Direction, extent, balance
Infrastructural categories:	
Quality	Definition, role, tools
Organization	Organizational design, selection, competence development
Manufacturing planning and control systems	System design, decision support, system integration

Today, 25 per cent of all orders are managed through the e-business solution, and the company envisions a rapid increase in the number of orders in the near future.

E-business as such is considered a new competitive priority that has rapidly turned into an order qualifier. Apart from this, the impression at the company is that e-business has had no effect on manufacturing strategy, mainly because they operate on a make-to-stock basis to a central warehouse. For the global distribution they also employ two distribution centers. Since customers require a delivery lead-time of 48 hours, products must be kept in stock in anticipation of product demand. They typically run large batches on dedicated lines. In order to improve customer service in case of shortages, the e-business system will be integrated with the master scheduling system to speed up the information flow from shortage acknowledgement to the automatic master scheduling of a replenishment order, and to generate current delivery lead times.

Firm 3: the manufacturer of heavy equipment

Atlas Copco is a global industrial group headquartered in Stockholm, Sweden. The Group, which was founded already in 1873, employs more than 26,000 people today and manufactures products in 14 countries on four continents, with a turnover of $4.6 billion. Atlas Copco companies develop and manufacture electric and pneumatic tools, compressed air equipment, construction and mining equipment, assembly systems, and offer related service and equipment rental. The products are sold and rented under different brands through a worldwide sales and service network reaching 150 countries, half of which are served by wholly or partly owned sales companies. The group operates through a number of divisions within four business areas:

1 compressor technique;
2 construction and mining technique;
3 industrial technique; and
4 rental service.

Here we have focused on the industrial technique business area and Atlas Copco Tools, which develops, manufactures, and markets pneumatic and electric power tools as well as assembly systems for industrial customers. The business area serves the needs of the machine industry, the automotive after-market, light construction, and OEMs.

So far, B2B activities within Atlas Copco Tools have mainly focused on the marketing channels. Today industrial customers can order products via an on-line product catalogue at Atlas Copco's portal. Atlas Copco Tools has somewhat of a reactive position towards e-business. They expect e-commerce to be a major force in the future, but they do not actively approach the subject and do not have an e-business strategy. Hence, it is no surprise that the company only sees minor effects from e-business on its manufacturing strategy.

Firm 4: the manufacturer of ball bearings

SKF is world leader in ball bearings. This large global corporation operates in more than 150 countries around the globe with approximately 41,000 employees. The sales turnover was approximately $3.7 billion in 1999. Quality and innovation have always been guiding principles for SKF, based on heavy investments in theoretical research, applied simulation and advanced testing. Most products are produced in make-to-stock production lines, while some large products are customized in make-to-order functional layout systems.

In the fall of 1999, SKF launched its e-marketplace (www.endorsia.com) linking SKF to both suppliers and customers. The idea is to reduce costs by improving information management related to order administration, inventory management, and logistics. The primary use has been for purchasing of maintenance, repair and operating supplies, i.e. non-supply chain materials.

A central aspect of quality assurance is the quality of the e-business application itself. The customer order information is digital all through the order process. Delivery speed is difficult to improve, since most products are made-to-stock. Also, VMI (vendor managed inventory) is used in some instances. However, customer delivery lead times have been reduced for make-to-order items, since order administration activities are more or less eliminated. With reducing administrative costs, there are opportunities to reduce the product price, which is important since price is the most important order-winning criterion. With the use of e-business, information becomes more direct, both relative suppliers and customers. Simpler and more direct information has improved forecasting and the quality of information. Customer service has improved simultaneously with reduced inventory levels.

Firm 5: the manufacturer of industrial robots

ABB Robotics, the world's leading supplier of industrial robots with more than 80,000

robots installed world-wide, is a part of ABB Asea Brown Boveri, formed in 1987 out of the merger between the Swedish Asea and the Swiss BBC Brown Boveri. ABB provides various industrial services such as; power generation and transmission, oil and gas systems, semiconductors, industrial automation, robotics, etc. through a highly decentralized organization. ABB Robotics has an annual turnover of $200 million with some 600 employees. Its major customers are within the automotive, metal fabrication and plastics industries.

ABB runs a corporate project aiming at enhancing the relationships with customers and suppliers with the aid of e-business. During this project ABB plans to invest some $1 billion within IT infrastructure and e-commerce. The goal is to offer all standard products within ABB on the Internet by the end of 2001. ABB builds their e-business solution on three main areas; operating (indirect) inputs, direct inputs, and customers. Regarding the operating inputs ABB already has a portal called "easy-to-buy" up and running since 1999. For the direct inputs an e-business system is under way, with possibilities to integrate the users' ERP systems. ABB has no plans to implement an e-business system for their main customers since they build their businesses on personal contacts with customers. However, smaller customers will be offered standard products via the Internet, and information and service will be offered as a complement to the traditional customer channels. ABB Robotics has been experimenting with e-business solutions since 1996 and uses a global ordering system (GOS) where customers can configure a robot and place an order. ABB Robotics has the "SupplierWeb" for upstream operations where a couple of hundred suppliers can access forecasts, quality records, etc. The next step is to introduce self-billing within the SupplierWeb.

ABB has a structured approach towards its use and implementation of e-business solutions, but it is still too early to see the results of all investments. It is however already clear that the technical support of ABB's technically customer specific products has increased. E-business solution handles a major part of the support activities regardless of geographical location. Furthermore, ABB Robotics uses e-business and enhanced collaboration as an alternative to vertical integration, wherefore they focus more on their core businesses.

Firm 6: the manufacturer of dental components

Nobel Biocare is among the world's leading producers of innovative dental implants and industrialized dental prosthetics. Operations are run in two business areas – dental implants and Procera. Nobel Biocare had a turnover of $170 million in 1999. The company has 1,100 employees in 23 countries, most of whom work outside Sweden. Company headquarters are located in Gothenburg (Sweden). Here, we have focused on Procera, which is the area where Nobel Biocare develops, produces and markets dental copings; and dental bridges, as well as what are known as individual abutments for implant treatment. According to Nobel Biocare, Procera is the world's first and, to date, only industrialized process for the production of individually adapted dental copings in other words, the supporting core of an individually produced dental crown. The company also develops and markets the scanning equipment and software that laboratories need in order to register the shape of the tooth and digitally design the individually adapted products. Production takes place in Stockholm (Sweden) and New Jersey (USA).

Procera is a unique, fully digitized customized manufacturing and business process of prosthetic components. The Procera technology replaces a craft dating back more than a century with a modern industrial process for producing dental copings with individual designs made from biocompatible materials with high precision at a reduced cost. The CAD/CAM process for producing dental crowns in Procera was introduced into the Swedish market at the end of 1994. In this sense Nobel Biocare Procera has implemented a whole new B2B process from the dentist, to the production and procurement, and back to the dentist, all based on e-business solutions.

New technology together with an innovative e-business solution has created the platform for a new business area and a new manufacturing strategy for this area. Thus, all aspects of competitive priorities and decision categories have been developed with respect to the new product. The fully automated line process uses the digitized scan to produce the dental crown at both lower cost and higher flexibility than the traditional manufacturing process. The e-business solution furthermore offers shorter delivery lead times. Hence, the resulting product-process relationship is best characterized by the concept of mass customization; see, e.g. Pine (1993) and Duray *et al.* (2000).

Firm 7: the manufacturer of printing devices and services

Strålfors is an IT-focused B2B company with a print heritage, and provides turnkey solutions within the field of information transfer. The company is based in Sweden, and operates in 11 countries, including the Nordic countries, Switzerland, Russia and the USA. There are 1,600 employees and the net sales amounted to $280 million in 2000. The business is divided into seven business areas: InfoConcept, card solutions, IT development, graphical, labels, lasermax, and IT supplies, grouped in three business sectors: information logistics, graphics products and services, and system and product-oriented information transfer. The company has previously been a large user of EDI, but is successively moving towards Web-based e-business solutions. They have established an electronic marketplace called Trade-it (www.tradeitstralfors.se) that is open to contract customers only, i.e. B2B. They deal with 400 of the 500 largest customers. The initiative came from the marketing department in collaboration with the customers, recognizing a need for reducing the delivery lead time, i.e. increasing the delivery speed.

New digital printing technology has, together with e-business communication, created a platform for a new product: print-on-demand business cards. The customer provides the information and approves the layout. All data are handled electronically and a digital file is sent to the printer, which drastically reduces lead times and batch sizes that can be managed economically. Routines that previously took many weeks and many proof readings, now take only a few days. The internal administration and handling costs for customers have almost been eliminated.

Even though the average order is small and made-to-order, the manufacturing system is a dedicated line. The set-up time is minimized since the whole process is digitalized. The printing of business cards was new to Strålfors. Therefore, a new manufacturing system and a new manufacturing strategy had to be developed. The resulting product-process relationship is best characterized by the concept of mass customization; see, e.g. Pine (1993) and Duray *et al.* (2000). The order winner has moved from price for the previous analogue technology to delivery speed and volume flexibility for the digital technology. The e-business solution has improved customer collaboration for pre-press activities. Internal lead times have been reduced, a reduction that has been transferred to shorter delivery lead times. However, a capacity slack has to be maintained in order to cope with variations in demand volumes over time, resulting to a lead capacity acquisition strategy (cf. Hayes and Wheelwright, 1984).

Manufacturing strategy and e-business findings

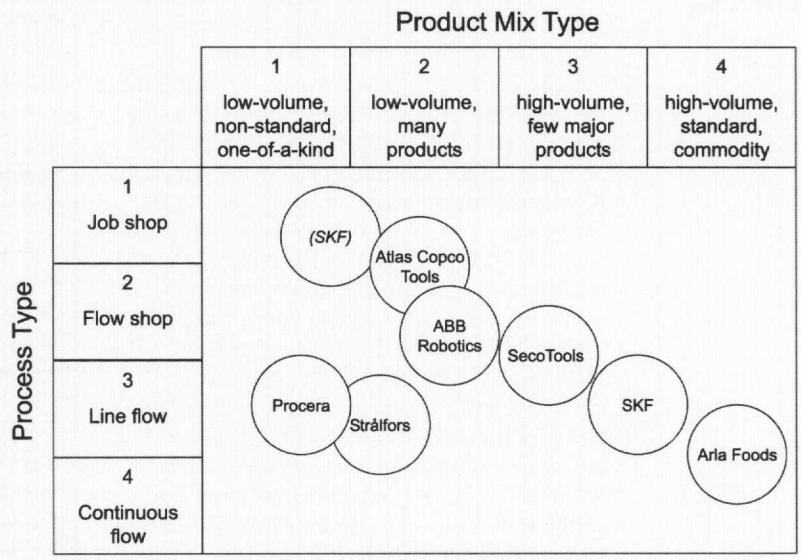
In this section we first characterize the companies in terms of products and processes. Then we explore the effects of e-business on competitive priorities and decision categories within a manufacturing strategy. Of special interest is to note if there are some relationships between the type of manufacturing and the effects of e-business on manufacturing strategy.

Characterizing the participants

In Figure 1, the companies are positioned in the product-process matrix (Hayes and Wheelwright, 1979; 1984) to get an overview of the seven companies and to understand the similarities and differences in terms of products and processes.

Firms are typically positioned along the diagonal (Hayes and Wheelwright, 1979; 1984). With increasing product volume and standardization, it is possible to maintain an increasing degree of flow orientation of the process. The concept of mass customization can be positioned at the lower left corner of the product-process matrix (cf. Figure 1), where a large variety of products are to be manufactured in the same flow-oriented process. This is the opportunity that the manufacturers of dental components (Firm 6: Procera) and printing devices and services (Firm 7: Strålfors) approach, facilitated by new product technology. In general, short or non-existent set-up times are required for the operations to run smoothly; requirements that a digitized product fulfill. The other five companies are distributed along the diagonal; in the case of SKF, they use quite different processes for make-to-stock versus make-to-order items. The majority of products are made to stock, for which the process is line flow. However, make-to-order items are produced in a job shop environment. Different positions in the product-process matrix are typically associated with different order penetration points. In a job shop, low-volume, non-standard, one-of-a-kind products are typically engineered to order (ETO). With increasing product demand, product standardization and the process flow orientation, the order penetration point

Figure 1
Position of the case companies in the product-process matrix



Source: Based on Hayes and Wheelwright (1979; 1984)

successively moves towards the final goods inventory, i.e. towards make-to-stock (MTS). In between, make-to-order (MTO) and assemble-to-order (ATO) situations are found. Thus, there is a continuum along the ETO-MTO-ATO-MTS scale associated with the product-process position, from the upper left-hand corner down the diagonal to the lower right-hand corner. The two mass customization firms depart from the typical relationship in that they operate on an MTO basis in a dedicated process.

Summary of firms' experiences

The experiences of the seven manufacturing firms in terms of the effect of e-business on competitive priorities and decision categories are summarized in Table II and Table III, respectively. The effects on competitive priorities (cf. Table II) differ considerably. No noticeable effect on quality, price (cost) or flexibility can be found. Even though costs have been reduced for the order administration process this has not been transferred to lower prices for the customers. Two firms report effects on volume flexibility; however, these effects are in reverse directions. One firm indicates that improved information leads to less need for volume flexibility, whereas the other firm focuses on the increased pace of business and a corresponding need for more slack capacity. Delivery speed and reliability are however positively affected for MTO products, since the reduction of order administration activities can be transferred into shorter delivery lead times. It should be noted that MTS products can gain from improved information in terms of better fill rates, i.e. improved stock availability.

The effect on decision categories within a manufacturing strategy (cf. Table III) indicate a similar pattern, i.e. some issues are unaffected and some are dependent upon the order penetration point. Process, capacity and facilities remain rather unaffected. For new product technologies, the strategic policy areas for these issues (cf. Table I) must be addressed and resolved, especially if a move towards mass customization is desirable. The effect on vertical integration is large, irrespective of type of product, process and order penetration point. Customer communication is improved in many ways. For MTO products, even suppliers may be actively involved. Processes such as product development and product customization are improved; again, especially for MTO products. Quality initiatives include quality assurance of the e-business information and of the process of conducting e-business. Some organizational changes are noticed as a direct result of a new order administration process. Finally, manufacturing planning and control systems are generally linked to the order administration process of the e-business solution. The administrative lead-time can thus be reduced, leading to improved delivery speed for MTO products.

The most important findings of this exploratory study are summarized in Table IV. The effect on manufacturing

strategy is basically limited to vertical integration and manufacturing planning and control systems, leading to competitive gains in delivery speed and reliability. These effects are especially noticeable for make-to-order environments, whereas the effect on make-to-stock products is limited.

Concluding remarks

In this paper we have explored the ways in which e-business affects the manufacturing strategy based on the experiences at seven Swedish manufacturing firms. These firms have been operating e-business applications for some time. The findings indicate that e-business mainly affects two decision categories in general; vertical integration, and manufacturing planning and control systems, through new ways to communicate and exchange information. Such improvements in information availability and quality lead to gains in delivery speed and reliability in general, whereas the impact on quality and price is negligible.

Even though there are fewer customer order process activities, the corresponding cost reduction is not transferred to lower prices. However, a reduction in the total purchasing cost for the customer is noticeable.

Improvements in delivery speed and the corresponding improvements in delivery reliability are only noted for make-to-order companies. For these firms, the removal of some customer order handling activities leads to a direct reduction of the customer order lead time which is transferred to a shorter and more reliable delivery lead time. Make-to-stock companies have been able to streamline and dedicate the delivery and distribution processes to specific high-volume products, wherefore these already operate efficiently. The effect on e-business is reduced to improved customer communication. Still, the customer's purchasing process may improve and lead to cost reductions for the customer. The overall impression at the two pure make-to-stock companies in this study is that the introduction of e-business has not affected manufacturing strategy at all. In two cases,

Table II
Summary of firms' experiences of the impact of e-business on competitive priorities

Firm	1	2	3	4	5	6	7
Product	Dairy products	Industrial tools	Heavy equipment	Ball bearings	Industrial robots	Dental components	Printing
Order penetration point	MTS products only	MTS products only	Both MTO (25 per cent) and MTS (75 per cent)	Both MTO and MTS products	MTO products only	MTO products only	MTO products only
New technology						New product technology	New product technology
Product quality						New technology gives quality leap	
Delivery speed			Improvement for MTO items	Improvement for MTO items	From three weeks to 24 hours, due to faster and more accurate information	Improvement (compared to traditional technology)	Much faster than for traditional technology
Delivery reliability	Improvement			Improved fill rate	Improvement (order tracking system)		Great improvements relative traditional technology
Price				Potentially lower prices	Potentially lower prices	Lower unit cost, but initial investment in equipment	
Volume flexibility	Reduced need for volume flexibility due to improved information					Increased need for capacity slack to cope with demand volume changes	
Product mix flexibility							

Table III
Summary of firms' experiences of the impact of e-business on decision categories

Firm	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Product	Dairy products	Industrial tools	Heavy equipment	Ball bearings	Industrial robots	Dental components	Printing
Order penetration point	MTS products only	MTS products only	Both MTO (25 per cent) and MTS (75 per cent)	Both MTO and MTS products	MTO products only	MTO products only	MTO products only
New technology						New product technology	New product technology
Process					Need for more flexibility (mass customization type process)	From manual to automated mass customization (line) process	
Capacity						Lead strategy	Lead strategy to provide for volume flexibility
Facilities						Consolidation and centralization of manufacturing sites	
Vertical integration	New ways to communicate with customers. Greater focus on consumers instead of 1st tier customers	New ways to communicate with customers. Increased use of consignment inventories	Improved cooperation with both customers and suppliers, especially for customized products	Closer interaction with customers and suppliers	Enhanced collaboration with both suppliers and customers	Focus on core business with e-business solutions mainly downstream	Improved collaboration with customers; new digital process
Quality	Quality assurance of e-business		Enhanced interaction in product development phase for MTO items	Quality of the e-business process and information	Enhanced quality assurance system (pre-production and after sales)	Quality assurance within e-business solution	

(continued)

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Table III

Firm	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Organization	Change in employees' competence profiles		Some change concerning marketing			Higher degree of centralization	
Manufacturing planning and control (MPC) systems	Integrated e-business and MPC system	Link to MPC system when stock-outs occur, for master scheduling and available-to-promise	E-orders via the portal, integrated with existing MPC system	Reduced order administration lead time Increased use of VMI	Starting to integrate own MPC system with suppliers and customers	Fully automated MPC system linked to the CAD/CAM and FMS systems. Automated call-off via e-mail	Digital planning and control process, from order to invoice

Table IV
A summary of the major effects of e-business on manufacturing strategy

Manufacturing strategy issue	Order penetration point: Make-to-order	Order penetration point: Make-to-stock
Competitive priority:		
Delivery speed	Delivery lead time reduction, due to a reduction in order administration activities	No effect
Delivery reliability	Improved reliability, due to shorter delivery lead times	Improved fill rate, due to improved order data access
Decision category:		
Vertical integration	New ways of communicating with customers and suppliers: product development product configuration order placement	New ways of communicating with customers and suppliers: order placement
Manufacturing planning and control systems	Integration with e-business. Faster access to order data. Reduced lead time	Integration with e-business. Faster access to order data

e-business has together with new technologies formed a basis for entirely new products and new business models. Both these firms have assumed a mass customization approach to manufacturing make-to-order products in a flow-oriented system, where e-business is an integral and vital part of the business model.

Even though this study is based on seven companies only, these are early adopters of e-business applications and represent a wide spectrum of different types of manufacturing. Therefore the results may be interpreted with some generality.

Note

1 Case companies' Web sites are:
ABB Robotics: www.abb.com, www.abb.se
Arla Foods: www.arlafoods.com
Atlas Copco Tools: www.atlascopco-group.com/tools
Nobel Biocare Procera: www.nobelbiocare.com
Seco Tools: www.secotools.se
SKF: www.skf.com, www.endorsia.com
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