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MASS CUSTOMIZATION: IMPLEMENTING THE EMERGING PARADIGM FOR COMPETITIVE ADVANTAGE

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In many industries the dominant paradigm, 'mass production,' is being challenged by the emerging paradigm, 'mass customization.' Accordingly, many researchers posit that firms which replace 'mass production' with 'mass customization' will gain a significant competitive advantage. Based on an in-depth study of the National Bicycle Industrial Company (NBIC), this paper explores the dynamics of pursuing both mass production and mass customization strategies simultaneously. At the operational level, the paper discusses the organizational mechanisms instituted by the NBIC in order to benefit from the simultaneous pursuit of both approaches. At the competitive level, it isolates the relative contributions of both approaches to the overall competitive positioning of this firm in its industry. Based on this discussion, it provides a framework that illustrates the dynamics involved in the pursuit of both approaches. Implicitly, the paper argues that for firms competing in rapidly changing environments the ability to maintain a sustainable competitive advantage depends on the firm's capability to create knowledge by interacting both mass customization and mass production approaches. Finally, the paper concludes with managerial and research implications regarding the emerging paradigm of mass customization.

The fundamental nature of competition in many industries (e.g., automobiles, bicycles, computers, machine tools) is being transformed, as are business strategies pursued by firms in these industries. The reasons cited for the transformation often include: (1) the emergence of new manufacturing technologies (such as CAD, CAM, FMS) which have fundamentally altered the economies of manufacturing and removed the factory as a barrier to product variety and flexibility (Jelinek and Goldhar, 1983; Meredith, 1987); (2) the increased pace of technological change and the concomitant shortening of product life cycles that have led to an increased proliferation of product varieties (Sanchez, 1995; Stalk and Hout, 1990; Wheelwright and Clark, 1992); and (3) the shifting nature of customer demand for increased product variety, more features, and higher quality in products and services (Kotler, 1989; Pine, 1993).

Firms competing in industries undergoing such transformation find that they are no longer able to compete on the basis of standardized products or services alone. Moreover, in such environments, being 'world-class' in manufacturing alone is not enough to sustain a competitive advantage (Hayes and Pisano, 1994). As stated by Hayes and Pisano (1994: 78) what is required is 'the capability to switch gears—from, for example, rapid product development to low cost—relatively quickly and with minimum resources' (see also Sanchez, 1995). Hence, the goal of manufacturing strategy in such environments is *strategic flexibility* and, more importantly, the role of manufacturing is to provide the required flexibility (cf. Gerwin, 1993; Hayes and Pisano, 1994; Sanchez, 1995).

Key words: mass customization; learning; new product development and mass customization; Japanese management practices; new knowledge creation

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To an increasing number of researchers, the emerging paradigm of 'mass customization' is a means to attain strategic flexibility (e.g. Goldhar and Jelinek, 1985; Kotler, 1989; Pine, 1993; Pine, Victor and Boynton, 1993). Mass customization is generally described as a process by which firms apply technology and management methods to provide product variety and customization through *flexibility* and *quick responsiveness* (cf. Davis, 1987; Pine, 1993). Although mass production's primary goal is to produce standardized products at a price that everyone can afford, the goal of mass customization is to produce enough variety in products and/or services so that nearly everyone finds exactly what he or she wants at a reasonable price (Pine, 1993). With the growing emphasis on strategic flexibility, mass customization as a strategy approach is emerging as an important research topic (e.g., Gerwin, 1993; Pine, 1993).

This research examines the role played by mass customization in competitive strategy. This is done by examining the *dynamics of implementing a mass customization strategy in a firm that is heavily dependent on mass production for a major portion of its revenues*. Based on an in-depth study of the National Bicycle Industrial Company (NBIC), this paper highlights the dynamics of pursuing both mass production and mass customization strategies simultaneously. My discussion focuses on the operational (internal) and competitive (external) aspects of pursuing mass production and mass customization approaches simultaneously. At the operational level, the paper discusses the organizational mechanisms instituted by the NBIC in order to benefit from the simultaneous pursuit of both approaches. At the competitive level, it attempts to isolate the effect of interactions between the approaches and then examines their impact on the *overall* competitive positioning of this firm.

Similar to Nonaka (1991, 1994) and others (e.g., Garvin, 1993) the paper illustrates that in changing environments a firm's ability to develop and maintain a sustainable competitive advantage lies in its capability to create organizational knowledge, along with strategic flexibility (see also Garud and Kumaraswamy, 1995; Hayes, Wheelwright, and Clark, 1988; Sanchez, 1995). Using the NBIC example, I illustrate how employing both mass production and mass customization approaches simultaneously enables organizational knowledge creation and greater strategic flexibility.

The paper is organized as follows. First, the paper highlights the emerging literature pertaining to mass customization and then discusses the methodology to study the NBIC. Next, it illustrates the interplay between mass customization and mass production using the NBIC's approach to staying competitive in the Japanese bicycle industry. Following this, the paper provides a framework that illustrates the dynamics involved in pursuing both mass production and mass customization strategies simultaneously. Before drawing conclusions, it discusses the implications of pursuing both mass production and mass customization approaches to competitive strategy.

THE EMERGING PARADIGM OF MASS CUSTOMIZATION

There is a growing interest in distinguishing between mass production and mass customization as two distinct approaches to competitive strategy. To appreciate the dichotomy between mass production and mass customization, it is important to highlight briefly the role of manufacturing strategy and technology in constraining the options of a firm's overall strategy.

From mass production to mass customization

The most important stream of work explaining the role of manufacturing in strategy can be traced back to Woodward's (1958, 1965) seminal studies of British firms. Woodward (1965) demonstrated that production technology had a systematic relationship with the organizational structure and the management characteristics of a firm. Although she proposed a framework that included nine different categories based on production technology, a parsimonious classification based on four categories (i.e., job shop, small batch, assembly line, and continuous flow) popularized by Hayes and Wheelwright (1979) has received greater attention.

Hayes and Wheelwright (1979) proposed a dynamic framework for matching a firm's 'product and market evolution' with 'manufacturing process' characteristics. They argued that a customized (i.e., one-of-kind) product was best produced in

a *job shop* environment, whereas standardized products were best produced in an *assembly line* mass production environment. Their rationale for 'matching' product with process characteristics was based on economies of scale and the intensive capital investment required to manufacture products in large volumes. In other words, their framework unequivocally illustrated a trade-off between product variety and production cost. Most importantly, from a strategic standpoint this trade-off involved setting increased *efficiency* (lower per unit cost, greater precision, and higher production volume) against *flexibility* (cf. Hayes and Wheelwright, 1979; Jelinek and Goldhar, 1983).

With the emergence of new manufacturing technologies such as flexible manufacturing systems (FMS), and computer-aided manufacturing (CAM), many researchers have questioned the need for trade-offs between efficiency and flexibility (e.g., Adler, 1988; Kotha and Orne, 1989). Advances in manufacturing automation facilitate the manufacturing of a variety of products in a connected line flow (i.e., mass production) environment and, more importantly, product variety (i.e., flexibility) can now be achieved without the accompanying cost penalty (i.e., efficiency). In contrast to traditional systems based on economies of scale, the new economies of production are based on the concept of *economies of scope* (Goldhar and Jelinek, 1983; Panzar and Willig, 1981) and *substitution* (Garud and Kumaraswamy, 1995).[1]

Flexible automation may have fundamentally altered the economies of manufacturing, but it is by no means a panacea for achieving flexibility. As Jaikumar (1986) has vividly demonstrated, while new flexible automation may be necessary, it is by no means sufficient to realize operational flexibility. In order for firms to achieve flexibility, Jaikumar (1986) and others (e.g., Garud and Kotha, 1994; Walton and Susman, 1987) suggest that changes in management practices (i.e., job design, management organization, work-team structure, selection and training, and compensation and appraisal) are required to obtain the benefits of flexible automation. Still other researchers have argued that only a system that supports learning and development can help firms attain strategic flexibility (e.g., Adler, 1988; Garvin, 1993; Nonaka, 1991).

Emerging literature on mass customization

It is in this context that Pine (1993) and others (e.g., Davis, 1987; Kotler, 1989) have popularized the term 'mass customization' to discuss flexibility and quick responsiveness. Not unlike previous discussion pertaining to flexibility, Pine argues:

> In Mass Production, low costs are achieved primarily through economies of *scale*—lower unit costs of a single product or service through greater output and faster throughput of production process. In Mass Customization, low costs are achieved primarily through economies of *scope*—the application of a single process to produce a greater variety of products or services more cheaply and quickly. (1993:43, italics original)

Pine (1993) observes that advances in manufacturing and information technology (e.g., CAD, CAM, FMS) as well as new management methods (e.g., JIT, reductions in setup and changeover times) enable firms to pursue mass customization in many industries.

A brief review of this emerging literature suggests that much research has focused on contrasting mass production with mass customization approaches to competitive strategy. For example, Pine *et al.* (1993: 108) illustrate that these paradigms require different organizational structures, management values and roles, systems, learning methods, and ways of relating to customers. Therefore, he and his co-authors (1993) conclude that mass production and mass customization are fundamentally different and incompatible paradigms because of their different, yet pervasive impacts on the way work is organized within a firm (see Table 1).[2]

The normative proposition that emerges from

[1] Garud and Kumaraswamy (1995) have suggested that 'economies of substitution exist when the cost of designing a higher performance [technological] system through the partial retention of existing components, is lower than the cost of designing the system afresh.' They note that in dynamic product markets technological progress may be achieved by substituting certain components of a technological system while retraining or reusing others. Additionally, see also Sanchez (1995) for a discussion of economics of scope as it pertains to dynamic product markets.

[2] Other researchers (e.g., Piore and Sabel, 1984; Cusumano, 1991) have discussed similar developments in other settings. Piore and Sabel (1984) have used the term 'flexible

Table 1. Mass production versus mass customization

	Mass production	Mass customization
Focus	Efficiency through stability and control	Variety and customization through flexibility and quick responsiveness
Goal	Developing, producing, marketing, and delivering goods and services at prices low enough that nearly everyone can afford them	Developing, producing, marketing, and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want.
Key features	• Stable demand • Large homogeneous markets • Low-cost, consistent quality, standardized goods and services • Long product development cycles • Long product life cycles	• Fragmented demand • Heterogeneous niches • Low-cost, high-quality, customized goods and services • Short product development cycles • Short product life cycles
Product	Standardized products built to inventory	Standardized modules assembled based on customer needs
Structure	Mechanistic, bureaucratic and hierarchical	Organic, flexible, and relatively less hierarchical

Source: Adapted from Pine *et al.* (1993) and Pine (1993).

Pine (1993) and others (e.g., Kotler, 1989) is that mass customization is the only viable strategic option for the 1990s. This is exemplified by Pine (1993: 264) who noted:

> In industries struck by increased market turbulence, the system of Mass Production that made America great has become outmoded and is no longer effective. Worse, it is detrimental to the companies that practice it, to their workers, and to America...But a new frontier in business competition, the paradigm of Mass Customization, is at hand...The time has come to shift to Mass Customization...

Although this emerging literature is helpful in drawing attention to mass customization as an important strategic option in rapidly changing environments, it has failed to address many important details. First, a critical examination of the literature suggests that the general prescription that mass production is not a viable strategy in many industries is perhaps too extreme an assessment, because theoretically a firm could pursue a mass customization strategy in one segment of its market and a mass production strategy elsewhere. In other words, *are mass production and mass customization strategies really as incompatible as suggested in the literature*? Also, because many firms are likely to be pursuing a business strategy based on mass production and, perhaps, deriving a majority of their revenues from mass markets, suggestions that they should abandon a mass production approach in favor of mass customization is unrealistic. Therefore it would be interesting to explore *how a firm that derives a major portion of its revenues from mass production implements a strategy of mass customization.*

Second, although flexible automation and computer technologies enable the pursuit of mass customization, technology alone is insufficient to achieve flexibility. Achieving flexibility requires an organizational climate that nurtures learning and knowledge creation (cf. Adler, 1988; Garud and Kotha, 1994; Garvin, 1993; Nonaka, 1994).

specialization' to describe a system of production that certain industrial communities employ to compete and respond to change. According to these authors, flexible specialization is the descendant of the system of craft production (job-shop environment) and is 'based on flexible—multi-use—equipment, skilled workers, and the creation through politics of an industrial community that restricts the forms of competition to those favoring innovation' (1984: 17). Cusumano (1991) has discussed the strategy of certain large Japanese software firms which have effectively combined 'craft' and 'mass production' modes of production to produce incremental product variety and customization in computer software development.

However, little research has been expended in the context of mass customization on highlighting organizational mechanisms that foster knowledge. Specifically, it is not clear *how knowledge creation enables strategic flexibility in the context of mass customization*.

Finally, while the theoretical premise for pursuing a strategy emphasizing flexibility and mass customization is based on economies of scope, the literature provides little evidence that pursuing such a strategy does in fact lead to superior returns. In other words, *what are the broad performance implications of implementing a mass customization strategy*?

In sum, this study attempts to address these questions that the literture on mass customization has so far failed to discuss.

METHODOLOGY

Recently, Bettis (1991) observed that the majority of researchers in strategic management use outdated concepts, are driven by multivariate statistical methodology, and they often fail to suggest prescriptions that are relevant and practical to managers. Consequently, he urges strategy researchers to employ more unstructured and exploratory research that looks at outliers, as opposed to statistical averages, to develop useful prescriptive implications of the strategy process. In line with these suggestions this research provides an in-depth case study of the NBIC, one of Japan's premier mass customizers, and its position within the Japanese bicycle industry (JBI). The paper uses the NBIC's approach to competitive strategy to illustrate the interplay between this firm's approach to mass customization and its overall strategic positioning.

Choice of the firm

I chose the NBIC because of: (1) its pioneering role in introducing mass customization strategy in the JBI; and (2) the extraordinary attention that this small firm has attracted in the media for pioneering a unique approach to mass customization. Moffat (1990: 132) in describing the NBIC's introduction of mass customization noted that: 'The concept has so intrigued executives and engineers that they have been flocking from as far away as Italy to this factory in Kokubu, in Western Japan, to study it.'

Although the focus has been on the NBIC's approach to mass customization, there is usually no mention of the fact that the NBIC is also a *mass producer* of bicycles. In fact, over 90 percent of the NBIC's sales revenues are derived from mass production. Although other researchers cite the NBIC's approach to mass customization, they have neglected to highlight its mass production capability, its organizational structure, and its unique approach to mass customization in a context emphasizing mass production. Understanding the NBIC's approach to mass customization may be helpful in answering issues that the received theory on mass customization has failed to address.

Data collection

Data on the NBIC were collected through a series of semi-structured interviews over an 18-month period during 1992 and 1993. Numerous in-depth interviews were conducted with six of the firm's senior executives, including the firm's managing director, Mr. Hata, who has over 25 years of experience in this industry and has been with the firm from its inception.

With the help of two research assistants fluent in Japanese, I interviewed senior executives at the Bridgestone Cycle Company, Japan's largest bicycle manufacturer and the NBIC's rival, and the Cat Eye Corporation, one of Japan's leading suppliers of bicycle parts. To gather industry-related background information, we held a series of semi-structured interviews with members of the Japan Bicycle Promotion Institute, Tokyo, Japan, including Mr. Hiroshi Ise, director of the Overseas Division. We collected additional information about the JBI from the offices of the Japan External Trade organization (JETRO) in Tokyo. Data collected from these sources served as the basis for our own detailed case study on the JBI and the NBIC's role in it (see Kotha and Fried, 1993 for more details).

OVERALL COMPETITIVE POSITIONING OF THE NBIC

The NBIC was Japan's second largest manufacturer of bicycles in 1992 with sales of about ¥20 billion. The firm markets bicycles under three different brand names: Panasonic, National, and Hikari. The NBIC targets each of its brands at

a unique market segment, and together, the three brands cover a broad spectrum of the bicycles sold in Japan. They range from high-quality, high-priced sports and fashion bicycles (i.e., Panasonic brand) to bicycles that are used primarily for transportation from home to the nearest train station or supermarket and back (i.e., Hikari brand). The National and Hikari brands together constitute the bulk of the NBIC's production and sales. Panasonic, the company's most expensive line, accounted for slightly less than 20 percent of total production in 1992.

At its current location the NBIC has two factories: one that focuses on mass production and the other on mass customization, located next to each other. The mass custom factory, initially conceptualized as a pilot plant, was built in 1987. High-end Panasonic bicycles are produced in *both* the mass production factory (mass-produced Panasonic bicycles) and the mass custom factory (custom-made Panasonic bicycles) and shipped to dealers for delivery to customers. Whereas more line workers are employed by the mass production factory, the NBIC's best skilled workers produce bicycles at the mass custom factory. Operating on a single-shift basis throughout the year, they produce a small fraction of the firm's total production. To better appreciate the conditions under which the NBIC developed its mass customization strategy, it is necessary to understand the industry conditions the firm faced during the 1980s and early 1990s.

The Japanese bicycle industry

Industry demand

Starting in the early 1970s, Japan's bicycle industry grew rapidly due to robust growth in the economy and the resulting strong consumer demand. Several environmental changes, including the growth of suburban residential and shopping areas, contributed to higher demand for bicycles, as bicycles were used mainly for commuting to and from railway stations and shopping areas (JETRO, 1990). Additionally, with the introduction of small or 'miniwheel' bicycles, women became an important market segment. In response to women consumers, the firms in the industry introduced a greater variety of colors and models to appeal to these consumers. The growing demand for bicycles resulted in product standardization and increased adoption of mass production techniques by manufacturers in industry.

The 1973 'oil-shock' had a chilling effect on Japan and bicycle production dropped over 18 percent to 7.6 million units. The industry hoped that demand for bicycles would rise under a 1973 energy savings plan, but this did not occur and demand plateaued around 7 million units. Domestic production and shipment of bicycles remained stable through the late 1980s and early 1990s. Meanwhile exports of Japanese bicycles have gradually declined as the Japanese yen has strengthened and imports from Taiwan and China have grown (see Kotha and Fried, 1993).

Firms in the industry

Bicycle producers in Japan can be subdivided into two groups: manufacturers and assemblers. As their name denotes, the assemblers purchase all their components from outside parts suppliers and only assemble bicycles. Historically, manufacturers accounted for most bicycles produced. Starting in the 1980s, shipments of bicycles became evenly split between the manufacturers and assemblers, with each accounting for approximately 50 percent of the industry's output.[3]

During the latter 1980s, the JBI was maturing rapidly. Moreover, the average unit price customers were willing to pay for a 'standard' bicycle was dropping. As the demand for bicycles plateaued, there was increasing competition among the manufacturers and assemblers. To gain market share, manufacturers introduced many new models. For example, the NBIC offered over 250 different models in 1987 and within each model type customers had a choice of color and other options. The NBIC's management changed about 80 percent of the models yearly. Not to be outdone, the industry leader, Bridgestone, offered over 300 models during the same period. Though the average price of a sporting bicycle was increasing, this segment was not

[3] In 1992, the JBI consisted of over 80 bicycle manufacturers and a few large assemblers. The top five manufacturing firms were Bridgestone, NBIC (National), Miyata, Maruishi, and Nichibei Fuji. Bridgestone Cycle Co. was the industry leader with 18 percent of the domestic market. The top five assemblers were Yokota, Deki, Hodaka, Saimoto, and Wani. Yokota led the group of assemblers with 9 percent of the market.

growing as anticipated by manufacturers. It was under these conditions that the managing director along with other senior managers at the NBIC decided to change the firm's strategy (Hata, 1993).

The emergence of mass customization

According to the firm's managing director, Mr. Hata, the original idea for customizing bicycles came as the NBIC's president visited a famous department store in Osaka. The president noticed that women could custom order dresses which were then delivered by the store in 2 weeks, and he wondered if it was possible for the NBIC to produce bicycles in this way. He mentioned the idea to Mr. Hata. Recalls Mr. Hata:

> At that time, we were used to making a few specially designed bicycles for some customers, like Olympic racers, but offering a custom-made bicycle to everyone was a different matter altogether. We were manufacturing bicycles in lot sizes greater than 50 in our factory. Now we were challenged by our President to produce bicycles in lot sizes of one. More importantly, the orders received were to be completed and delivered within two weeks. We not only had to convince ourselves that this was possible, but also had to convince our design people, our manufacturing people and our line workers that this was a *good* and *feasible* idea.

Mr. Hata began giving serious thought to the notion of mass customizing bicycles. Initially, not everyone at the NBIC supported this idea for bicycle production. Some senior members of the NBIC argued that it would require a large investment and entail a tremendous risk for the firm. They asked, 'What if NBIC fails in this attempt?' They also pointed out that the market for 'sports' type bicycles was shrinking, though admittedly at a slower pace that that of other segments. Further, when the NBIC's managers consulted some industry analysts, they were told that such a strategy would be impossible to develop and implement. According to some senior executives at the NBIC, many of the firm's managers had their own doubts about the feasibility of such an approach. However, despite their skepticism, they were willing at least to try and see if this project might work (Hata, 1993).

The NBIC had two broad objectives when it began mass customization of bicycles: (1) the firm wanted to double the amount of high value-added products sold by accommodating the *individual* needs of the customer, and (2) it wanted to devise a 'system' of production and delivery that clearly differentiated its high-end Panasonic brand from competitors' products, meanwhile meeting the growing need for variety in the marketplace.

The project leader, Hata, assembled a team that consisted of members of his management team, a product designer, a few process engineers and some highly skilled and experienced line workers. In discussing the project implementation he recalled (Hata, 1993):

> We worked long hours. We proposed and debated many new ideas for days. We started with a few people, but as the project began to progress, more people were added. Within a few weeks we established a pilot plant in a large empty warehouse next to the factory. Still, numerous issues had to be addressed and solved, but as time went on we were convinced that the project was doable. We knew we had the capability, because many of us had spent most of our professional lives making bicycles.

Under Mr. Hata's stewardship, the team completed the project in a mere 4 months, and by July 1987 they had converted the pilot plant to one that was fully operational. It was exactly 7 months since the firm's president had visited the department store in Osaka. The new system the NBIC had devised was aptly named the Panasonic Ordering System (POS).

According to the general manager of sales at the NBIC, customer service, 'appropriate' pricing, and extensive communication were all an integral part of the NBIC's mass-customization strategy. Domestic customers were guaranteed a delivery time of 2 weeks, not a day more, but also not a day less. He pointed out, 'We could have made the time shorter, but we wanted people to feel excited about waiting for something special' (quoted in Moffat, 1990). According to the firm's officials, custom-made Panasonic bicycles were priced only about 20–30 percent higher (depending on the particular model and features selected) than 'comparable' Panasonic bicycles produced at the mass production factory. In 1989, it received orders for approximately 12,000 bicycles, an increase of 20 percent over orders in the previous 2 years. A significant portion of these orders were from customers in Japan.

The NBIC's strategy of offering a truly custom-made bicycle surprised all of its major competitors. Within months, the two other leading manufacturers of bicycles scrambled to develop and implement their versions of mass customization. Within a year, both offered their own versions of mass customization. However, they were less successful in exploiting this approach in this industry, relative to NBIC, for reasons discussed later.

Figure 1 provides an illustration of the production processes and the various computer-assisted numerical control (CNC) machines used by the NBIC at its mass custom factory (for a detailed description of the manufacturing processes see Kotha and Fried, 1993). This group of CNC machines forms an information network comprised of sophisticated machines that enable the pursuit of mass customization.[4] Craftsmen on the factory floor, using information input into the system, are able rapidly to 'set up' each machine to perform the tasks required to complete each order individually.

THE NBIC's UNIQUE APPROACH TO MASS CUSTOMIZATION

To highlight the NBIC's approach to mass customization it is necessary to discuss the firm's overall approach to competitive positioning within the bicycle industry. In 1992, the NBIC produced 700,000 bicycles, 90 percent of which were produced by the mass production factory and shipped to Matsushita's (the NBIC's parent corporation) sales subsidiaries. In contrast, as noted above, about 12,000 of these bicycles were produced at the firm's mass custom factory. Furthermore, the majority of the firm's 470 workers are employed in the mass production factory and not the mass custom factory. Of these 470 employees, slightly more than 66 percent are classified as direct or line workers and the rest as indirect workers. More than half of the indirect workers were in the production engineering and design departments of the firm. Hence, the managers at the NBIC recognize that the firm is heavily dependent upon the mass market for the bulk of its revenues (and profits). According to the firm's managers, this situation is unlikely to change in the near future given that the market for custom-made bicycles has experienced less than the expected rapid growth.

How does the NBIC's approach to competitive positioning differ from the descriptions provided in the emerging literature on mass customization? A careful study of the NBIC's approach to mass customization illustrates many of its distinctive aspects.

Based on the recognition that the mass production and mass custom factories can serve different segments, the firm is pursuing both approaches to strategy simultaneously in its industry. This implies that the firm did not view the paradigms of mass customization and mass production as an 'either–or' proposition. This recognition is a critical issue for both researchers and practitioners interested in the strategy of mass customization, because the literature on the topic has focused mainly on enumerating the differences between the two approaches, thereby suggesting that they are incompatible.

In order to pursue simultaneously both strategies, NBIC managers have intentionally created two separate manufacturing facilities. This separation is akin to what Skinner (1974) has termed 'factory focus.' Skinner observed that no single factory can do all things (e.g., quality, cost, flexibility, and delivery) equally well. Therefore, he argued that factories which are focused on a narrow, internally consistent, set of performance objectives would outperform conventional plants which attempted a broader mission. Focused factories perform better because (1) narrowing the range of demands placed on a factory permits its technological and human resources to focus on few priorities (Abegglen and Stalk, 1985; Gerwin, 1993) and (2) focusing on a limited set of manufacturing priorities enables the strategy and the design of the manufacturing system to be fitted together by making appropriate trade-offs in certain key factory tasks (e.g., plant and

[4] The importance of a dynamic information network for the pursuit of mass customization or a strategy based on product variety has been underscored by Pine *et al.* (1993), Sanchez (1995), and others (e.g., Jelinek and Goldhar, 1983). The recent attempts by Levi Strauss & Company to offer 'custom-fit' blue jeans for women was made possible due to a computer information network system developed by an independent computer consulting firm (Rifkin, 1994). Also, Pine *et al.* (1993) in their discussions of Bally Engineered Structures Inc., a mass customizer for refrigeration products, point out that a sophisticated information-management system called 'computer-driven intelligence network' was at the heart of this firm's approach to mass customization.

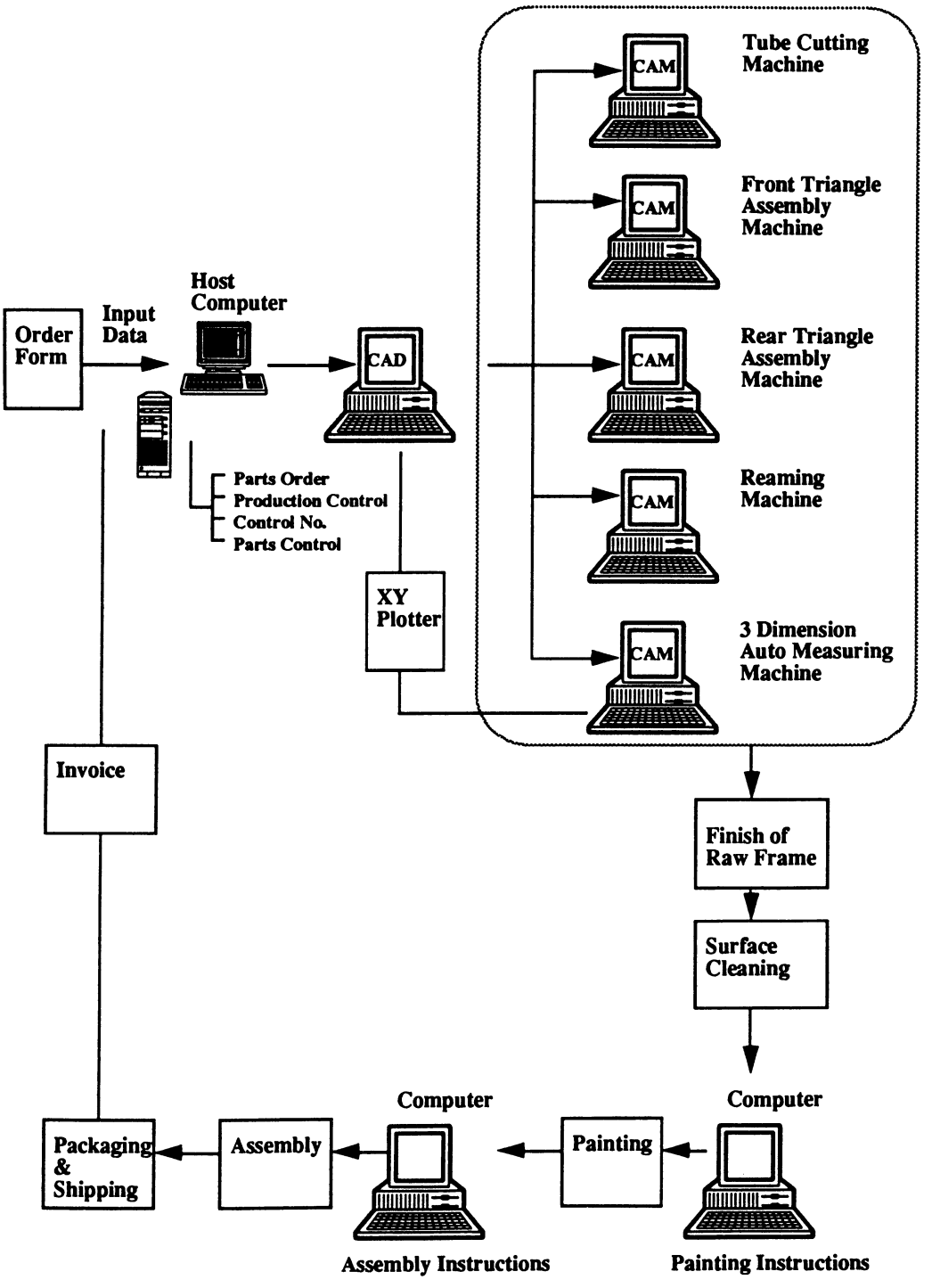

Figure 1. The production process at the custom factory

equipment selection, production planning and control, labor and staffing, product design and engineering, and organization and management). By employing two separate factories to pursue different levels of customization (i.e., 'mass-produced' Panasonic bicycles with limited options) and 'mass custom' Panasonic bicycles (based on anthropometric dimensions of customers), the NBIC has taken the concept of Skinner's factory focus to a new level.

Examining the NBIC's competitive approach in the Japanese bicycle industry suggests that the mass-production factory caters to a large market segment and is organized along traditional lines of efficiency. In other words, the NBIC is pursuing a low-cost strategy using its different product lines at the mass production factory (Porter, 1980). The strategic emphasis in manufacturing is driven by efficiency considerations such as achieving economies of scale through long production runs. The bicycles are produced to inventory based on predetermined forecasts. This factory is *indirectly* linked to the final customers: information on customer preferences for popular bicycle models and color/patterns is gathered at various retail outlets and fed back via sales and marketing to manufacturing.

In contrast, the mass custom factory attempts to target a smaller segment of the market via a differentiation strategy (Porter, 1980). In this approach, the factory is *directly* linked to customers via retail outlets. For example, under the POS, it is the mass custom factory that assumes responsibility for communicating with customers. A customer's selection of options, colors, patterns, and models is directly received by the factory. The firm estimates that when ordering a custom-made bicycle, *a customer can choose from about eight million possible variations based on model types, color, frame size, and other features* (cf. Kotha and Fried, 1993).[5] Shortly after the factory receives the customer's order, a personalized computer-generated drawing of the bicycle is mailed to the customer with a note thanking him or her for choosing a bicycle built under the POS.[6] In this factory, the production process begins only after *the arrival of the customer's order and specifications*. Once the individualized bicycle order is produced, it is shipped the same day.

Finally, not only is the NBIC pursuing both approaches simultaneously, the same product line (i.e., Panasonic) is available as either a mass-produced bicycle or a mass-customized product. At first glance, such redundancy seems unwarranted and wasteful and, moreover, from a strategic perspective, it suggests that perhaps the firm lacks proper focus (cf. Nayyar, 1993). However, given that one of the main objectives for introducing the POS was to increase their market share of high-end product line (i.e., Panasonic bicycles), it can be inferred that the NBIC's managers have implicitly recognized that the benefits of attempting mass customization transcend the market segment especially as it relates to knowledge creation, as discussed below.

Knowledge creation through interaction

The NBIC's managers seem to recognize the critical aspects of knowledge creation (cf. Garvin, 1993; Nonaka, 1991, 1994; Senge, 1990, among others): (1) new knowledge is created by skilled individuals (Nonaka, 1991; Senge, 1990); (2) generally such knowledge is *tacit* and therefore needs to be tapped and made *explicit*; and (3) moreover, knowledge created by one part of the organization can trigger changes in the firm's wider knowledge system (cf. Garvin, 1993).[7]

[5] Due to the scale required for efficient operations, offering numerous options (i.e., type, frame, color, and patterns) can be counterproductive at the mass production factory. It is also likely to increase greatly the complexity involved in managing the operations. In other words, managing manufacturing tasks such as product mix, scheduling, aggregate planning, inventory management, and workforce management can become unwieldy. On the marketing side, predicting customer–product mix requirements with reasonable certainty takes on added complexity given that numerous product combinations are possible. Without a reasonably accurate product mix forecast manufacturing bicycles for inventory can be risky. In contrast, given the smaller scale of mass customer factory, such concerns are less critical because it is the customer who chooses from the numerous options provided. Moreover, it is the customers' orders that initiate the manufacturing process at this factory.

[6] This is followed up with a second personal note, usually 3 months later, inquiring about the customer's satisfaction with his or her bicycle. Finally, a 'bicycle birthday card' is sent commemorating the first anniversary of the bicycle.

[7] Explicit or codified knowledge refers to knowledge that is transmittable in formal, systematic language. In contrast, 'tacit' knowledge has a personal quality, which makes it hard to formalize and communicate because it is deeply rooted in action, commitment, and involvement in a specific context.

Individuals and knowledge creation

At the fundamental level, NBIC managers implicitly recognize that it is individuals that create knowledge in firms and therefore it is important that a firm provides a context for individuals to create knowledge. Also, actions taken by NBIC managers suggest that they understand that knowledge creation requires the tapping of tacit knowledge and often highly subjective insights, intuitions, and ideals of the firm's employees (Nonaka, 1991). In general, this assertion is consistent with Florida and Kenney's (1990: 39) speculation that 'perhaps the key element of the Japanese industrial system lies in its ability to harness workers' knowledge as a source of value directly at the point of production. This occurs through many mechanisms including team-based quality circle efforts and work place suggestion systems and the everyday involvement of workers in Kaizen or continuous improvement activities.' Not unlike other Japanese workers, NBIC factory employees belong to the company union and actively participate in 'quality circle' programs. They meet once a month to discuss quality and safety issues. Additionally, the workers are periodically tested and ranked based on their skills. The highest-ranked workers are provided with the opportunity to work at the mass custom factory where the wages are higher. As the process employed in the production of custom-made bicycles requires a blend of human skills and computer-integrated manufacturing, a higher skill base is necessary to work in the mass custom factory than in the mass production factory.[8]

By establishing different organizational settings (i.e., factory focus) for both the mass production and mass custom factories, the NBIC has sought to maximize the effectiveness with which different types of knowledge are created. For example, many of the process-related skills required in complex manufacturing situations at the mass custom factory fit Nonaka's definition of tacit, rather than explicit, knowledge. The knowledge generated at the point of production is tacit because highly skilled craftsmen translate unique customer specifications into finished products using prior experience and expertise. The craftsmen are responsible for overseeing the manufacturing process from the start to finish, and although robots and semi-automated machines perform the rougher and more routine tasks, it is the craftsmen that complete the finest details (Bell, 1993). In contrast, in the mass production factory, where the efficiency of its routine operations is determined by bureaucratic principles of division of labor, specialization, and high-volume production, the focus is on knowledge that is explicit (i.e., formal and codified) because such knowledge can then be embodied in specialized machines that help lower costs through increased efficiency.

Tacit to explicit knowledge

NBIC managers have instituted some simple, but effective organizational mechanisms to foster interaction between the mass-production and mass-customization factories. From a knowledge-creation perspective this is important because 'knowledge creation centers on the building of both tacit and explicit knowledge and, more importantly, on the interchange between these two aspects of knowledge through internalization and externalization' (Nonaka, 1994: 20).

NBIC managers recognize that in order to create new knowledge its individual workers' tacit knowledge must be tapped and made *explicit*. NBIC managers have established a system where top-rated and highly skilled workers are rotated between the two focused factories. This policy is insightful when you consider that it is one of most powerful methods of transferring knowedge within a firm (Garvin, 1993). As mentioned earlier, the highest-skilled workers (craftsmen), using advanced computer-controlled machines, work on unique customer requirements at the mass custom factory. In doing so they are challenged to manufacture products to very demanding specifications and quality levels. It is in this production setting that these workers both create and internalize their tacit skills in bicycle

According to Nonaka (1994), tacit knowledge involves both cognitive and technical elements. The cognitive element centers on 'mental models' in which humans beings form working models of the world by creating and manipulating analogies in their minds. The technical element of tacit knowledge contains concrete know-how, crafts, and skills that apply to specific contexts (see Nonaka, 1994: 16).

[8] The entire manufacturing and assembly time required to complete a single order is approximately 150 minutes. In 1989, the factory employing 18 workers (15 workers in 1987) had the capability to make about 60 custom-order bicycles daily. By 1993, the factory had increased its production capacity by employing additional workers.

manufacturing. Interestingly, NBIC managers have instituted policies that require these highly skilled (mass custom factory) workers to train workers at the mass-production factory. Such training forces craftsmen to externalize their tacit knowledge by articulating their experience to other employees. In other words, tacit knowledge accumulated at the mass custom factory is made more explicit through training of other employees at the mass-production factory. Additionally, the rotation of workers between factories also has the effect of further broadening the knowledge and skill base of already skilled mass custom factory workers.

Changes in the firm's wider knowledge system

In changing environments, an innovation produced by one part of the organization can create a stream of related information and knowledge and thereby trigger changes in the organization's wider knowledge systems (Nonaka, 1994). In order to benefit the firm as a whole, the NBIC has instituted a centralized group of product and process engineers who facilitate the sharing of information and knowledge between the two factories (and across the different market segments). The highly skilled craftsmen (at the mass custom factory), through interactions with this centralized group, synthesize the tacit knowledge and help make it explicit.[9] It is this centralized group of product designers and process engineers, in conjunction with constant rotation of highly skilled workers between the factories, that enables the development of new manufacturing capabilities in both advanced custom-made bicycles and mass-produced bicycles.

Moreover, through such interactions much of the explicit knowledge is then embedded into new process technologies (i.e., equipment and machinery). For example, the NBIC was the first bicycle manufacturer in Japan to introduce robots for painting in mass production. With some minor modifications, this innovation was then adopted in the mass custom factory. Because the requirements of the mass custom factory are driven by individual customer specifications, each bicycle frame and fork manufactured is checked to ensure that they correspond to the customer's original specifications. The firm's engineers and skilled line workers, in conjunction with managers from the NBIC's parent corporation, have devised a three-dimensional automatic measuring machine to automate this verification task (Kotha and Fried, 1993). This machine is also employed for quality-control inspections in the mass-production factory. Furthermore, much of the software required to operate the advanced information and computer-aided manufacturing systems used in the mass custom factory was developed in-house and latter modified and adapted to automate parts of the mass-production factory. Moreover, the knowledge-creating activities of the mass custom factory, when linked to the mass-production factory, enable the mass-production factory to transform itself into what Adler (1993) terms a 'learning bureaucracy.' In other words, the lessons and the manufacturing skills the firm acquires in the custom factory are transferred to the mass-production factory.

Also, the NBIC's rotation of its skilled workers from the mass custom factory to mass production meets the 'key' design requirement for establishing a knowledge-creating system (cf. Nonaka, 1994); that is, by doing so NBIC opens up the boundaries that inhibit the flow of information between the factories and the production systems (see also Garvin, 1993). Consequently, the mass-production factory has undergone slow, but significant changes. For example, lot sizes employed in mass production have steadily decreased from 50 units a few years ago to a mere 20 units in 1993. In other words, parts of the mass-production system are slowly, but surely, beginning to resemble the adaptive and flexible custom factory.

The discussion so far can be summarized in a framework which is presented in Figure 2. As Figure 2 illustrates, both the mass-production and mass-customization approaches are implemented simultaneously, albeit in different segments of the JBI. It also delineates the different organizational mechanisms instituted by the NBIC to link the two different production approaches to

[9] The NBIC's centralized organizational structure resembles what Nonaka has termed 'middle-up-down management' by forming 'the bridge between the visionary ideals of the top [management] and the often chaotic reality on the front-line of business.' It is this group that mediates between 'what is' and 'what ought to be' in new product and process development, and thereby acts as a leader in the knowledge creation process by serving at the intersection of the vertical (within the factories) and horizontal flows of information (between the factories) in the company.

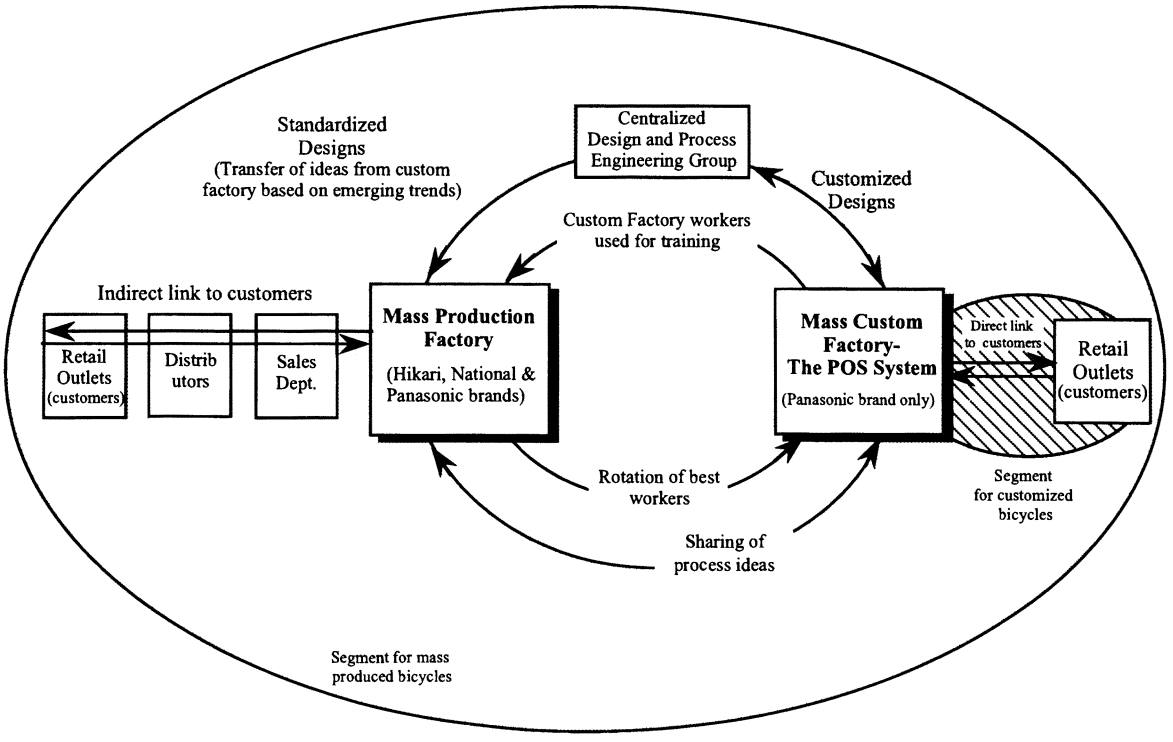

Figure 2. The interaction between mass-customization and mass-production systems

competitive positioning in this industry. The NBIC's approach to strategy in the JBI suggests that the mass custom factory serves as a 'learning' factory.

At the NBIC, customer information and manufacturing process knowledge are acquired, generated, exploited, and accumulated through a 'circular movement' of highly skilled workers, in conjunction with the centralized group of engineers (see Figure 2). These skilled workers, along with the firm's product and process engineers, form the basic source of new knowledge creation.

How does the interaction between mass customization and mass production provide strategic flexibility? By utilizing a centralized organizational structure of product and process engineers, the NBIC exploits the information asymmetries that exist from competing in different segments of the bicycle industry. For example, using the information gathered directly from consumers in the custom segment, product designers identify certain customer trends, such as popular color combinations and patterns, and unique customized features that are likely to appeal to customers of the broader mass-production segment of the industry.[10] Armed with direct customer feedback regarding choices from among the numerous alternatives, the product designers and process engineering group, in conjunction with skilled workers, create new product designs for the mass-production factory. Based on the forecasts provided by the marketing department, the mass-production factory then manufactures the new design and introduces the mass-produced Panasonic brand bicycles ahead of the NBIC's leading rivals. Thus, the mass custom factory acts as a conduit for new product ideas based on 'innovative' users who choose from the numerous product combinations offered by the NBIC. it is because of this interaction that some 'redundancy' actually benefits the firm by enabling it to achieve its goal of growing the

[10] In the mass custom factory, it is the customer who, by choosing from thousands of potential combinations, becomes directly involved in the new product-development process. In this sense, the *consumer* becomes the *prosumer*, because he or she initiates the process of design and production rather than chooses among premanufactured alternatives (Womack, 1993).

larger high-end mass-production segment based on ideas generated from the mass custom segment.

This approach is consistent with von Hippel's (1986) description of novel product concepts from 'lead users' and Gerwin's (1993: 404) observation that when the market needs change rapidly, future radical needs can be derived from lead users.[11] Moreover, gathering such 'innovative' user information provides the guidelines for determining whether to contract or expand product variety, thereby making the NBIC less susceptible to the current fads in their industry (Gerwin, 1993). This is critical since existing organizational routines (e.g., rapid prototyping) deployed by firms to compete on 'time-based' competition can create blind spots (Henderson and Clark, 1990) and commit the organization to a course of action that is not in tune with its environment. The gathering and employment of information from a segment of 'innovative' users helps the firm dynamically manage the proliferation of new product designs (see Stalk and Webber's, 1993, discussion of product proliferation in the Japanese context).

Moreover, by processing and accumulating important customer information directly at the point of production (i.e., mass custom factory), the NBIC has recognized that it can avoid costs associated with what von Hippel (1994) calls 'sticky' data. According to von Hippel, data are sticky when there are costs associated with replicating and diffusing 'location-specific' information.[12] However, directly collecting customer information at the point of production obviates the need for transferring location-specific information from one place to another. As a result, both the *rapidity* and *the accuracy of meeting customers' unique responses increase.*

Also, by focusing on lead users with unique requirements at the custom factory, the firm is attempting to establish what Hirschhorn (1984: 92) terms 'fringe awareness.' It is the continuous feedback received by a system through lead users at the fringe of awareness, along with conscious planning (e.g., at the mass-production factory) at the 'center of awareness,' that enables the NBIC to respond both *flexibly* and *rapidly* to changing customer needs. Finally, by constantly analyzing marketing information and by rotating very highly skilled workers between the two production facilities, the firm continuously updates its competencies and the organizational routines that it employs (Pasmore, 1988). Moreover, as noted earlier, the 'circular movement' of employees further broadens their knowledge and skill base, thereby permitting multiskilling. In environments where product variety and quick responses require fluid response mechanisms, multiskilling overcomes the rigidities that set in from the division of labor (Adler, 1988; Walton and Susman, 1987). Thus, the NBIC is able to respond with greater flexibility and rapidity as compared to its competitors.[13]

Broad performance implications

To date the literature on mass customization has offered very little evidence that pursuing this strategy leads to superior performance. In other words, *what are the broad performance implications of implementing the POS system at the NBIC?*

The NBIC's customized bicycles manufactured under the POS system only accounted for 2 percent of total production. Prior to POS, the NBIC's market share was languishing behind its two major competitors in the high-end segment, but within a few years of introducing POS the firm's total high-end (Panasonic) market share position improved dramatically. For the first time in its history, the NBIC became the industry's second largest manufacturer of high-end bicycles. *More importantly, the contribution of the high-end Panasonic brand has more than doubled to 27 percent of total revenues* (see Kotha and Fried, 1993). Thus, mass customization has influenced the NBIC's overall competitive strategy in the

[11] See Garvin (1993: 86–87) for examples of how companies use customers as a 'fertile source' of new ideas. Additionally, see Garud and Kumaraswamy (1995) for learning from users as it pertains to economies of substitution.

[12] 'Sticky' data emerge because of encoding, coupling, and diffusion costs. Encoding costs arise due to difficulties associated with embedding and recontextualizing transferred knowledge at the receiving site. Coupling costs arise due to difficulties associated with integrating transferred knowledge with complementary knowledge at the receiving site. Diffusion costs arise due to difficulties associated with transferring data from one site to another.

[13] See also Garud and Kumaraswamy (1995) and Sanchez (1995) for a detail discussion on other related approaches that a firm can adopt to compete successfully in dynamic product market settings.

bicycle industry. As noted earlier, given the growing market penetration of 'assemblers' at the low-end segment of the industry, the NBIC's emphasis on building the high-end segment of the business can be crucial to future competitiveness.

Mass customization has also benefited the firm in other ways. Soon after the announcement of the POS, journalists following this industry began expounding on its revolutionary nature. These discussions in the Japanese press were soon noticed by foreign journalists and within 2 years, NBIC's approach to customization was featured in *Fortune* magazine, the *New York Times*, and the *Washington Post*. Because of such publicity, the 'Panasonic' name is increasingly viewed as the only 'truly' mass-customized bicycle in Japan. According to industry experts, the firm is currently viewed as the leader and innovator in the industry, which enables it to charge a higher price for its *mass-produced* Panasonic line. Thus, along with the development of new capabilities and technological know-how, one of the outcomes of perfecting the manufacture and delivery of mass-customized bicycles is a creation of an 'image' (i.e., reputation) as a leader in mass customization.[14] Itami (1987: 1) has argued that reputation and technological know-how constitute 'invisible assets' and 'only a firm that carefully cultivates such assets will be in a position to maintain a record of successful strategy.'[15]

Despite imitation, why were the NBIC's rivals, Bridgestone and Miyata, unable to match the NBIC's approach to mass customization? And what, if any, are the industry conditions required for the pursuit of mass customization?

According to a senior manager at Bridgestone the main reasons that they are unable to duplicate all aspects of the NBIC's strategy are as follows (Yamazaki, 1993):

> Since NBIC was the first firm to introduce this idea, they have established a strong image in the customer's mind. When you mention customization, the consumer only thinks of Panasonic. Also, National's parent company, Matsushita, is famous for its marketing savvy, and it is difficult for us to match them.

This observation suggests that the NBIC's success in this industry may be attributed to 'first mover advantages' (cf. Lieberman and Montgomery, 1988). This is perhaps an important consideration because the market for mass-customized bicycles has experienced less than expected rapid growth. Also, the ability to synchronize manufacturing capability (internal) and marketing approach (external positioning and image creation) is required for successfully exploiting the strategy of mass customization.

As noted, the NBIC's main rivals have been less successful in imitating its approach to mass customization. Knowledgeable sources in the industry note that the NBIC has been the only company to have successfully mastered the art of mass customization and that competitors are unable to match physically the same degree of choices that the NBIC offers. *Unlike the NBIC, leading competitors simply increased their inventories of frame types and model sizes to accommodate customization demands by their customers.* Additionally, the NBIC is located in Osaka, close to major bicycle parts suppliers (e.g., Shimano). Frequent and reliable parts delivery from suppliers helps the NBIC build 'truly' custom bicycles without carrying excessive inventories. According to Mr. Hata, 'There is little need for us to hold large inventories of finished frames and other parts unlike others [competitors] outside the Kansai region' (Hata, 1993).

This suggests that industry-related conditions such as firm location, the close proximity of parts/component suppliers, and the employment of manufacturing practices, collectively referred to as 'lean production' (Womack, Jones, and Roos, 1990), enable the successful pursuit of mass customization. Additionally, an examination of the industry conditions at the time when the NBIC introduced POS suggests that growing product proliferation among firms may be necessary for firms embarking on mass customization (cf. Pine, 1993).

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[14] Meredith (1988) provides an interesting example of a U.S. firm, Peerless Laser Processors (PLP), that has used advanced manufacturing technology to increase product variety and customization. One of the 'serendipitous' outcomes of using advanced technology was an enhancement of PLP's 'image.' Notes Meredith (1988: 8), 'Just having the sophisticated technology increased their image, not only among their customers but also among their employees. As work spread about their ability [to make custom products], this provided additional publicity for their products.'

[15] According to Kogut and Zander (1992: 393) imitation by competitors is impeded by the possession of at least one bottleneck capability, as long as this capability is rewarded by the market. Such a bottleneck can arise through benefits of: (a) reputation among consumers; or (b) patent protection; or (c) the exercise of monopoly restrictions.

Finally, by developing and implementing its approach to mass customization, the NBIC has forced its major rivals (i.e., Miyata and Bridgestone) also to pursue a mass-customization strategy, because not having the capability to mass customize puts them at a competitive disadvantage, relative to the NBIC. Implicitly, this has altered the competitive landscape by forcing all the top three players in industry to pursue mass customization, along with their mass-production systems, in order to be competitive in the high-end market segment. As noted by Bell (1993), 'rival firms felt virtually obligated to institute their own such operations.'

IMPLICATIONS AND CONCLUSIONS

This paper has explored the NBIC's unique strategy in the JBI which is characterized by change and intense competition. Despite limitations inherent in drawing conclusions from a single study, it is possible to draw useful inferences regarding the NBIC's approach to mass customization and, more importantly, its link to the NBIC's overall strategic positioning within its industry.

It should be apparent from the discussion so far that implementing mass customization need not be framed as an 'either–or' proposition, as is often the case in emerging literature (e.g., Kotler, 1989; Pine, 1993). Unfortunately, the discussion whether mass-customization and mass-production approaches are incompatible resembles the prolonged and misguided debate in the 'generic strategies' literature regarding the mutual exclusivity of cost leadership and differentiation strategies (Porter, 1980; Hambrick, 1983; Mintzberg, 1988). While U.S. researchers argue whether or not a sustained commitment to one strategy is necessary to achieve success, many Japanese firms (and some American firms) have shown in practice that a simultaneous pursuit of both strategies is possible (Hambrick, 1983; Hayes and Pisano, 1994). Moreover, like the NBIC, many firms contemplating mass customization are likely to find that their largest source of revenues (and accompanying profits) is currently derived from exploiting the paradigm of 'mass production.' Nothing in practice precludes such firms from pursuing mass production in one segment of the industry and mass customization in another. The NBIC approach indicates that pursuing mass customization and mass production simultaneously, albeit within different segments of the same industry using the same product line, is a viable and extremely attractive option for gaining a competitive advantage.

However, pursuing both mass production and mass customization simultaneously requires that a firm compete in two market segments that require different competitive priorities. From a manufacturing perspective, this invariably results in inconsistent and conflicting task requirements regarding production volumes, the process design used, and the process technologies employed at the factory (Hill, 1994; Skinner, 1974). Therefore, when firms pursue both mass-production and mass-customization approaches simultaneously, it is prudent to adopt the notion of 'factory focus.' Focused manufacturing links an organization's manufacturing facilities to the appropriate competitive forces of its businesses, thus enabling a firm to gain greater control of its competitive position (Hill, 1994). More importantly, the concept of factory focus has implications for new knowledge creation both at the individual and organization levels.

It is the establishment of organizational mechanisms that fosters interactions between the focused factories that lead to new knowledge creation and greater strategic flexibility. The mechanisms instituted by the NBIC (e.g., worker rotation, the sharing of process ideas through such rotations, centralization of engineering personnel) can be employed by other firms. It is the centralization of the design and process engineering function that enhances a firm's ability to exploit novel product ideas gathered from the innovative users in the custom segment. This centralization, as discussed before, permits the early introduction of new products and permits the NBIC to avoid the unnecessary product proliferation characteristic of other Japanese firms (cf. Stalk and Webber, 1993). Furthermore, worker rotation between the factories helps overcome the disadvantages associated with worker skill limitations and promotes the diffusion of the best practices among the factories. Rotating workers results in the establishment of a 'knowledge-creating system' that enables the conversion of *tacit* knowledge to *explicit* knowledge. Such knowledge conversion can have important impli-

cations for continuous improvement and organizational-level learning critical for competing in a changing competitive landscape.

The NBIC is another example of how Japanese firms leverage their manufacturing capabilities that result from a blending of advanced manufacturing technologies and human expertise.[16] Whereas U.S. managers are generally more inclined to look toward advanced manufacturing and information technologies as a panacea for competitiveness (cf. Schonberger, 1982; Keller, 1989), the Japanese managers generally emphasize blending human expertise and advanced technology to attain flexibility. This approach is consistent with Jaikumar's (1986) findings that manufacturing technologies alone are insufficient to attain flexibility (Garud and Kotha, 1994). More importantly, the NBIC's approach recognizes that it is humans, in conjunction with advanced machinery, who create the new knowledge required for refining existing skills and developing manufacturing capabilities essential for future competition.

Much of the process technology and computerized information systems (e.g., numerical control machines, robotics, interfactory local area networks) installed by the NBIC's mass custom factory were an outgrowth of in-house engineering and manufacturing expertise accumulated over many years. Therefore, firms contemplating this approach to competitive strategy will be forced to rely heavily on in-house expertise in order to implement their versions of mass customization. Moreover, this observation implies that proprietary processes can be every bit as formidable competitive weapons as proprietary products (Hayes and Abernathy, 1980). Unfortunately, this does not bode well for many U.S. manufacturing firms, because they are reluctant to invest in the development of new manufacturing processes (cf. Bird and Kotha, 1994; Hayes and Abernathy, 1980). The attitudinal and organizational weaknesses that pervade American manufacturing capabilities are well documented and hardly need elaboration here (cf. Dertouzos, Lester, and Solow, 1989). Therefore, for many U.S. firms, imitating the NBIC's approach to mass customization could indeed be a risky undertaking.

Although there are many strategic advantages in pursuing mass customization (and mass production simultaneously), there are costs associated with pursuing mass customization. A summary of the potential benefits and costs associated with pursuing mass customization is provided in Table 2. When the difficulty of quantifying *a priori* the benefits associated with intangible benefits (e.g., worker motivation, new knowledge creation) and tangible benefits (e.g., reputation, strategic flexibility) are recognized, a comparison of potential costs and benefits suggests that the benefits outweigh the costs. The potential benefits and costs identified here have wide applicability and are, perhaps, generalizable to firms attempting to imitate the NBIC's approach to mass customization in various industries.

The necessary conditions for the successful implementation of mass customization are summarized in Table 3. This table highlights: (1) the industry and competitive conditions; (2) the organizational cultural and human resource practices; (3) the resources and capabilities; and (4) the interfunctional and intraorganizational coordination pressures necessary for the successful exploitation of mass customization. Although each of these elements is important individually, it is the interactions and interrelationships among them that enable the successful exploitation of the mass-customization strategy.

In sum, perhaps, the effective use of mass customization hinges on promoting an attitude that is conducive to continuous improvement, organizational and individual learning, the development of new capabilities, and the diffusion of the best practices among a firm's plants. This observation is consistent with Pine *et al.*, who note that 'the promise of technology is not the lights-out factory or the fully automated back office. It is a tool to tap more effectively all the diverse capabilities of employees to serve customers' (1993: 116).

Implications for future research

Although the practical implications of pursuing mass customization are generally clear, the NBIC's approach to mass customization raises additional issues for future research. First, one of the important propositions that emerges from

[16] This blending of human skills and computer-aid manufacturing through semi-automated machines is termed the 'socio-technical' system of production. For a detailed discussion of 'socio-technical' systems, see Pasmore (1988) and others such as Hirschhorn (1984) and Walton and Susman)1987).

Table 2. Potential benefits and costs associated with implementing mass customization

Potential benefits	Potential costs
The potential for cost savings results from: • not carrying finished goods inventories and substantially reducing work-in-process inventory • eliminating product obsolescence caused by annual model changes and new product introductions • eliminating the elaborate forecasting and market research activities carried out for mass-production systems • handling and directing 'sticky' data to the points of value creation • eliminating certain activities from the firm's value chain *Pursuing mass-customization and mass production-approaches simultaneously enhances a firm's ability to:* • effectively utilize a firm's highly skilled and motivated employee group • refine existing engineering and manufacturing capabilities and develop new abilities that promote greater strategic flexibility • promote a conducive climate for continuous learning and diffusion of best practices among different facilities • introduce new products more rapidly and be responsive to market trends at the same time • charge price premiums by satisfying unique customer requirements and needs	*The potential for increased costs results from:* • expenditures in advanced manufacturing technologies and computer-based information technologies (e.g., local area factory networks) • investments in computerized information systems (e.g., data base systems) to collect and monitor 'lead user' information • engineering resources required to develop process and product technologies in-house • increased labor expenditures resulting from the employment of a highly trained and skilled workforce • the disproportionate amount of managerial time needed to implement this approach effectively to a relatively small market segment. • equipping and training retailers so that customer orders are accurately recorded and forwarded to the factory

this study is that it is the pursuit of both mass-customization and mass-production approaches simultaneously that provides a firm with greater opportunities for (a) organizational knowledge creation and (b) converting individual tacit knowledge to explicit organizational knowledge. For a firm competing in rapidly changing environments, the ability to maintain a sustainable competitive advantage lies in its management capability to create new organizational knowledge. By focusing on operational details, this study illustrates that several organizational mechanisms help foster interactions between mass-production and mass-customization approaches, thereby increasing the potential for strategic flexibility. Also, the NBIC's foray into mass customization provides evidence, albeit anecdotal, that employing this strategy, in conjunction with mass production, has benefited the firm's growth in high-end segment bicycles. This implies that it is the pursuit of both approaches simultaneously that enables the firm to earn superior returns. In other words, firms that pursue both mass-customization and mass-production approaches simultaneously will tend to outperform firms that adopt an 'either–or' strategy.

Second, I have identified several industry conditions (e.g., firm location, proximity to suppliers) that may be important for the successful pursuit of a mass-customization strategy. Specifically, it appears that first mover advantages may be critical for the success of mass customization. Despite the imitation of this firm's strategy by its rivals, the NBIC has been able to establish its reputation as the only true customizer. Reputation effects derived from first mover advantages can be important, especially if the demand for customized products does not develop into a large enough segment to support multiple competitors. Hence, *timing the entry* into mass customization may prove critical to its success. In other words, researchers can examine whether

Table 3. Conditions making success more likely in pursuing mass customization and mass production

Industry and competitive conditions

Success is more likely if
- the industry is characterized by increased product proliferation and new product introductions
- there exists a group of industry customers who can be persuaded to value customization
- there is no well-entrenched competitor already pursuing mass customization

Culture and organization design

Success is more likely when
- the organization's culture focuses on knowledge creation and the development of manufacturing capabilities
- the 'production system' rewards attention to details and stresses the importance of 'zero mistakes' in all activities of the value creation process
- each plant's manufacturing tasks and competitive priorities are matched to its product/market environment (i.e., employ focused factories)
- the top management group institutes organizational mechanisms that foster interactions among focused plants

Resources and capabilities

Success is more likely when a firm has
- access to a group of highly trained, disciplined, and motivated workers
- access to substantial in-house engineering expertise and manufacturing capabilities
- made long-term investments in advanced manufacturing technologies and information technologies
- a savvy marketing group that can excite customers about individualized product offerings

Inter- and intraorganizational coordination

Success is more likely when a firm
- achieves integration across functions while maintaining excellence within each function
- has access to a supplier network in close proximity
- develops an interconnected information network wih a selected group of trained retailers

a firm that is a first mover into mass customization reaps superior returns, relative to competitors that are late entrants.

Third, the NBIC's approach to strategy in the Japanese bicycle industry highlights the notion of 'equifinality,' i.e., that there are multiple routes to competitive advantage and the key to securing advantage is in finding unique ways to compete (cf. Kotha and Vadlamani, 1995; Porter, 1980; Mintzberg, 1988). Although Pine (1993) and others have argued that mass production is not a viable strategy in many industries, this argument is misleading. For example, there may be a plethora of soda products in the marketplace, but by far the largest sellers are Coke Classic and Pepsi, both manufactured using mass-production techniques.[17] The essence of strategy is to find uniqueness (Andrews, 1971) and the NBIC's approach suggests that there are multiple ways to achieve uniqueness. Therefore, despite the growing importance of the mass-customization approach, mass production will still continue to be viable strategy in many industries.

Fourth, although manufacturing technologies are necessary, technology alone is not sufficient

[17] This is also perhaps true for more complex products such as automobiles. While there are hundreds of car models that customers can choose, by far the best sellers are Ford Taurus and Honda Accord, both produced by mass-production techniques. Producing automobiles using the NBIC approach to mass customization (i.e., 'cut to fit' customization) is unlikely in the near future. Manufacturing automobiles is a capital-intensive business that requires a highly complex production system. The complexity derives from coordinating and assembling of component parts from hundreds of suppliers. Therefore, due to the capital requirements for manufacturing technologies and inherent complexity in assembling automobiles, they are more likely to be built using modularized components that permit a 'mix and match' approach to mass customization. For more details about the different approaches to mass customization see Pine (1993) and also Mintzberg (1988).

for achieving the flexibility and responsiveness required for mass customization. As illustrated earlier, achieving flexibility and responsiveness requires instituting organizational mechanisms that emphasize learning and competence building along with advanced technologies. This recognition may not bode well for many U.S. manufacturing firms, because prior research indicates that Japanese firms are better at implementing and exploiting flexible technologies than many of their U.S. counterparts (Jaikumar, 1986). Additionally, Bird and Kotha (1994) have argued that the U.S. mode of individualism, where uniqueness is highly valued, fosters a stronger emphasis on 'product' orientation within American firms (see also comments by Florida and Kenney, 1990). In contrast, the Japanese culture, perhaps because of its emphasis on collectivism, encourages a more 'process' orientation (Kotha, Dunbar, and Bird, 1995). Also, rotating workers between factories, encouraging the development of broad (as opposed to narrow) skills, stressing face-to-face communications, providing a long-term orientation, promoting intensive interfunctional communication, and employing workers to train other workers, are all hallmarks of Japanese manufacturing firms.

Although these practices are now being emulated by some leading U.S. manufacturing firms (e.g., Chrysler, Motorola, and Texas Instruments, among others), they are still not the norm in many U.S. firms. Taken together these observations imply that, at the least, one would find differences in the way U.S. and Japanese firms approached mass customization. To illustrate, the recent foray by Levi Strauss & Company into mass customization of women's blue jeans indicates that an external software firm, Custom Clothing Technology Inc., was instrumental in developing the 'system' that permits Levi Strauss to adopt mass customization of jeans (Rifkin, 1994). This arrangement is in stark contrast to the approach adopted by the NBIC where many of the processes required to pursue mass customization were developed in-house, thereby enabling the NBIC to keep them proprietary.[18]

Conclusion

The purpose of this study was to explore the role of mass customization in competitive strategy. The initial premise stated that new advanced manufacturing technologies (e.g., CAD, CAM, and FMS) have fundamentally altered the economies of manufacturing by removing the inherent trade-offs in product variety and flexibility. This development, in conjunction with other factors, has triggered a fundamental transformation in the rate at which new products are introduced, the nature of business competition and, in turn, the strategies adopted by firms in different industries. Moreover, as mentioned earlier, in rapidly changing environments the goal of manufacturing strategy is to provide a firm with strategic flexibility.

In discussing the emerging literature on mass customization, this paper raised a series of important questions that were addressed using the NBIC case. A delineation of the NBIC's approach to mass customization suggests that a careful blending of computer-aided manufacturing technology, highly skilled labor, and simple but effective organizational mechanisms in human resources practices and structure, can provide a viable approach to building 'capabilities.' When the strategy of mass customization is effectively interconnected with a firm's overall competitive positioning, it can provide a powerful and effective means of achieving and maintaining strategic flexibility (see also comments by Sanchez, 1995). Moreover, by implementing a mass-customization approach effectively, a firm can have an impact on the competitive landscape of its industry. Finally, this paper argues that the normative message from the literature—that mass customization is the only viable option for competitive strategy in the 1990s—is seriously misleading (Kotler, 1989; Pine, 1993). This message, taken to an extreme, can position the firm as trying to be all things to all people, which is a recipe for competitive mediocrity, rather than competitive advantage.

[18] According to the president of Custom Clothing Technology Inc., he would prefer not to grant Levi Strauss & Company exclusive rights to the 'system' developed by his firm (Rifkin, 1994). Therefore, unless an exclusive legal contract is signed between Levi Strauss and Custom Clothing Technology Inc., nothing precludes this firm from selling its 'system' to others. Doing so will provide many large players with the ability to imitate Levi Strauss. Thus, to a large extent this could neutralize Levi Strauss's competitive advantage.

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