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# Process Transformation Mandates for Manufacturing Customized Furniture

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## ABSTRACT

This study combines two case studies with an in-depth survey of selected furniture manufacturers to empirically assess how the interaction between process transformations on the one hand and supply-chain characteristics, the design platform, the customer interface, and related issues on the other hand affect performance in a customizing business. Based on pre- and post-customization performance comparisons, a case is presented for comprehensive manufacturing system improvements rather than superimposing advanced concepts piecemeal on suboptimal systems. A framework is also provided for furniture manufacturing businesses to evaluate their readiness to implement a mass customization strategy.

*Keywords:* customized furniture, manufacturing process

## Introduction

Furniture manufacturing, like many other forms of manufacturing, is not immune to the effects of growing market demand for customized products. Typically, the furniture industry has sought to provide customized products by increasing variety. Increased product variety *per se*, however, introduces greater complexity arising from a greater number of stock keeping units (SKUs) and higher inventory costs, without commensurate improvements in service levels. Mass customization offers an alternative in terms of efficiently meeting the needs of individual customers within a defined solution space (Piller 2003). By using flexible processes and structures, organizations can manufacture individually customized products without losing the cost advantages of standardized production (Hart 1995).

Mass customization is a comparatively new principle for contemporary furniture manufacturers, and there are operational dimensions that require more in-depth contextual research. Firstly, from a manufacturing standpoint, there is the need to understand what and how technology can be strategically deployed, what manufacturing processes can be efficiently engaged, and the cultural change mechanisms associated with mass customization. Secondly, from a business standpoint, does

mass customization improve business performance within a reasonable business planning frame? Conceptually, the inherent responsiveness in mass customization models enables manufacturing firms to pursue an effective business strategy in spite of frequent marketplace changes. This reasoning runs counter to the assertion that mass customization benefits relate more to customer and market impact than to costs and profit (Åhlström and Westbrook 1999). Practically though, a business must be able to translate its market impact into profits unless its competitive strategy is an exercise in futility. In other words, if an analysis of costs and profits does not suggest that the latter exceeds the former considerably within a reasonable business planning frame, the customization strategy will be unattractive.

Using data from two case studies and an in-depth survey of 19 furniture manufacturers in the United States, Canada, and Germany, this study investigates what process transformations are required to successfully implement mass customization. The objective was to examine, for a specific manufacturing context, how process transformations help businesses to transition to a successful mass customization model. This study explored how process transformations on the one hand and supply-chain characteristics, the design platform, the customer interface, and related issues on the other hand interact to affect performance in a customizing business. Based on pre- and post-customization performance comparisons, a case is made for comprehensive manufacturing system improvements rather than superimposing advanced concepts piecemeal on suboptimal systems. This assessment of process transformation effects on mass customization effectiveness extends the literature and provides a context for furniture manufacturing businesses to evaluate their readiness to implement a mass customization strategy.

## Literature Review

### Mass Customization – Key Concepts

Mass customization, the foundations of which are credited to Toffler (1970), Davis (1987), and Pine (1993), essentially approaches the individualized preferences of customers as an opportunity for business rather than an obstruction to the manufacturing system. Without disregarding previous mass customization definitions (Pine 1993, Alford et al. 2000, Mann and Domb 2001, Anderson 2003, Tseng and Piller 2003), this study viewed mass customization as the fulfillment of customized orders for defined segments of mass markets, at costs and lead times that communicate value rather than an associated penalty for personalization or order size. This definition captures the fundamental concept of offering products that better fit the needs of customers on a large scale, while accommodating the perspective of segmentation theory (Jiang 2000) – the view that heterogeneous markets comprise a number of smaller homogeneous markets. This view tones down the assumption of perfect heterogeneity of customers, and enables the provider of customized products to pursue its objectives (profit maximization, brand image enhancement, etc.) by crafting a tactical response to the demands of the smallest viable market segments. In this way, situations are avoided where customized furniture is sourced only for orders that are not time-sensitive and by customers who can afford the characteristically high premiums. Implicit in our definition, and of primary concern in this paper, are the strategic deployment of technology, improved manufacturing processes, and cultural change mechanisms which make mass customization cost effective for a business.

The underlying principles that appear to be shared by successful mass customization systems across different industries are modularity, agility, supply-chain integration, and competitive cost (Pine and Pietrocini 1993, Kubiak 1993, Kotha 1996, Feitzinger and Lee 1997, Duray 2002, Fogliatto et al. 2003, Whitelock and Bardakci 2005).

*Modularity* refers to the use of common units such as product and process families in the design and manufacture of product variants (Huang and Kusiak 1998); it enables organizations to offer customized products at lower internal costs (Da Silveira et al. 2001, Pine et al. 1993).

*Agility* refers to an organization's ability to proactively cause and respond to changes in market dynamics (Dove et al. 1996). Management practices and organizational structure influence important dimensions of agility such as cultural change and functional training (Pine et al. 1993, Hart 1995, Zikpin 2001). An agile business is also a learning organization in the sense that it harnesses the information that accrues through the collaboration of different team members and disseminates it in a way that allows the organization to continually adapt and respond to changes in the marketplace (Owen and Kruse 1997, Senge 1990).

*Supply chain integration* describes the responsiveness and performance of suppliers associated with a business. The extent to which a manufacturer develops supplier relationships will affect the level of customization that is possible in the manufacturing system (MacCarthy et al. 2003). These relationships must address how prospective partners can share costs, risks, and information for their mutual benefit (Lewis 2006).

An operational combination of these briefly discussed principles is indicative of intrinsic characteristics such as flexibility and responsiveness which, with the right market dynamics and transformational leadership in a business (Hamilton 2004), can manifest in a robust mass customization strategy.

## Implementation Challenges

The most significant roadblocks to implementing mass customization in manufacturing are inertia, confidence in the status quo, and an unwillingness to change (Burns 2000). Such organizational attributes limit the incorporation of advanced manufacturing technologies such as computer numeric control (CNC) programmable tools (Lau 1995, Pine et al. 1993) or the reorganization of workstations into cells.[1] Efficiency in manufacturing customized products can be enhanced by developing products in synergistic families with standardized parts and materials (Andersson 2004), by controlling configurations (Abbot 1998), or by assembling combinations of modules (Anderson 2003). Thus, substantial re-engineering of manufacturing processes, order flow patterns, and user-interfaces may be required to improve customization capability (Alford et al. 2000). For example, in the case of customized furniture, it is important to determine an optimal range of specifications for "non-critical product details" to give greater opportunity for customizing the product features that matter most to customers. What limitations might be specified for color, size, and size increments, for instance? This customization approach is applied in the car industry where a limited range of exterior colors is offered for a particular car model, but more choices exist for accessory combinations (Alford et al. 2000). How then might a furniture manufacturer improve the user-interface such that customers can explore plausible configurations of the product features they consider critical to their satisfaction?

(1) Work cells are organized locations within the manufacturing facility that combine interdependent machines and employee teams for manufacturing specific product families in a continuous flow (Kupanhy 1995, Huber and Brown 1991). Cells benefit the organization by facilitating materials handling and improving variance control, thus enhancing responsiveness.

Better use of information technology (IT) could help customers to not only configure their preferences at the point of sale, but to also have their individualized orders translated into adjusted quotes and bills of material for direct transfer into the manufacturing system. This potential for developing a seamless interface between the point of sale and the manufacturing system, and between unique units within the manufacturing system, is facilitated by "parametric configurators" – software applications based on operational logic (Strobel 2004). Parametric configurators incorporate logical commands (if/then/else statements, loops, subprograms, etc.) to increase the flexibility of a CNC program such that an entire range of parts for a particular product may be scaled or modified. The direct benefits of such IT tools include extending the functionality of the CNC machines deployed within the manufacturing system and reducing the cost of adjusting product parameters for any specific order.

## Transformation Requirements

Manufacturing systems offering customized products need to develop the capacity to both accommodate variety and respond to change without sacrificing efficiency – i.e., the manufacturing system must be flexible and responsive (Gindy et al. 1999). Flexibility and responsiveness in manufacturing are supported by the principles of just-in-time (JIT) delivery, reduction of set-up and change-over times, reduction of cycle times throughout the value chain, and order-based, rather than forecast-based, production (Pine 1993) – all of which are key aspects of lean manufacturing (see Womack et al. 1990 for detailed discussion on "lean"). Lean manufacturing takes the perspective that the most reasonable path to cost reduction and value-delivery for customers in changing markets is through systemic improvements in process flow and waste minimization. The obvious connection between flexibility and "lean" suggests that "lean" is an essential precursor to mass customization. By focusing on flexibility-related adjustments to the manufacturing process, a firm improves its ability to respond quickly to customer demands and achieve good performance over a wide range of products (Upton 1994, 1995). Given that several essential factors interact in an effective mass customization model, a business may be unsuccessful at implementing mass customization without engaging the process transformations that can enhance synergistic interdependencies between unique units of a defined manufacturing system.

## Hypothesis

Based on the earlier discussion about organizational responsiveness and performance, and its significance to the attractiveness of a mass customization strategy, a company transitioning to mass customization (from mass production or from custom manufacturing) is expected to:

- record higher levels of productivity and profitability compared with its pre-implementation situation, and

- demonstrate these improved business outcomes in spite of increased material and production costs associated with logistics trade-offs.

In the current study, it could be debated whether any reported changes in business performance have resulted from mass customization or just from normal improvements in the manufacturing function over time. Firstly, it must be shown that transformations have indeed occurred in the manufacturing process in terms of the design platform, the customer interface, and the production process. Secondly, the presence of some combinations of modularity, agility, supply chain integration, and competitive cost in the operations of an implementing company must be validated. It was proposed that if these observed combinations are supported by evidence that a company pursued process transformations in direct response to specific market demands for customization, it will constitute sufficient ground to attribute the driver of productivity and profitability outcomes to mass customization. This position will also be reinforced if the company leadership is observed to be actively refocusing the workforce through emerging learning experiences, in line with the foundational principles of a mass customization strategy (Ramirez 1999).

# Methods

## Background

A two-pronged approach was used in this study by carrying out both an exploratory case study and in-depth experience survey of selected furniture manufacturers. Experience surveys are “productive” tools of exploratory research (Churchill 1979) and provide a means to elucidate concepts; they involve judgmental samples of knowledgeable, articulate, and thoughtful individuals who are representatives of the phenomena under investigation. In the experience survey, the focus was to obtain insights into the relationship between several interconnected factors rather than to achieve a simple consensus on best practices. From a slightly different perspective, case studies clarify the phenomena under study by illuminating the world of the subject(s) for the observer (Marshall and Rossman 1999). Because mass customization is an emerging area of study, useful exploratory insights can be expected to be generated by using the case study approach (Thietart and Wauchope 2001).

Case study research is an appropriate approach when, in an attempt to understand a phenomenon, develop taxonomy, or examine an emerging theme, the relevant literature or theories are relatively sparse (Meredith 1998, Handfield et al. 1997). Descriptive and exploratory case studies have been used extensively to investigate the operational mechanisms of mass customization in other industries (Heim 2004, MacCarthy et al. 2003, Duray 2002, Da Silveira et al. 2001, Alford et al. 2000, Ross et al. 1996, Kotha 1996). The limited number of furniture companies currently implementing mass customization also presents practical challenges for large sample analysis. Contrary to the view that idiographic studies are only suitable for investigating local causality (Miles and Huberman 1984), the case study approach may transcend the boundaries of the cases being researched and offer a basis for analytical, rather than statistical, generalization (Yin 1994). Thus, the strengths of case studies and experience surveys were combined in this exploratory study of the role of process transformations in mass customization.

## Sampling

A purposeful sampling of furniture manufacturing businesses that are known mass customizers in the furniture industry was used for the experience survey. The companies were selected from a sample of furniture manufacturers recommended by respected industry consultants. Individual in-depth interviews (IDI) were conducted in 2006 with furniture industry specialists from 22 selected companies in Canada (59%), the United States (18%), and Germany (23%); the latter being included to provide a European perspective on mass customization.

Two case studies were also conducted in 2006 to ascertain what transformations have taken place in the ongoing pursuit of mass customization by two furniture manufacturers in the United States. Using the pool of companies provided by industry consultants, a realistic consideration in selecting the specific companies was their willingness to commit time for a detailed discussion and to share vital information on their operations. Being exploratory in nature, the case study approach also lends itself to purposeful sampling as a means to provide information-rich cases for in-depth study.

This study covered one case goods manufacturer (Company A) in detail and included complementary information from a manufacturer of home entertainment centers (Company B). Company A is reputed to manufacture high-quality case goods to both standard and customized specifications; it engaged in various process transformations after recognizing lean manufacturing as "an imperative step" that develops a company's capacity to offer significant customization. By contrast, Company B evolved from being a custom home furniture builder to a manufacturer of customized home entertainment furniture. This company illustrates the progression of some organizations to mass customization from a custom product knowledge base rather than from mass production (Duray 2002).

The sampling was replicative only to the extent that Case B serves to confirm or query observations in Case A; it is not the intention of this study to construe it as a multiple case study since it does not meet the requirement of 4 to 10 cases (Yin 1994, Eisenhardt 1989). The extent to which observations between the two companies can be compared and contrasted is also limited by the fact that, citing confidentiality concerns, Company B declined to disclose financial details for their operation. It is useful to note that both businesses represent important size classes of U.S. furniture manufacturers – in a 2004 study of companies that experienced the greatest growth in revenue, 36 percent (the largest category) had revenues of $1 to 5 million while 22 percent (the next largest) were in the $10 to 50 million category (Kim 2005). Companies A and B were from these two size classes.

Based on an understanding of mass customization concepts from the literature and first-hand access to company processes (Gummesson 2000), a discussion is presented on how the design platform and order process, supplier and inventory issues and the manufacturing process affect the customization operation. The focus is on which process transformations are operationally critical for successfully implementing mass customization and how productivity and profitability are impacted over the period of transformation. Observations are also related to current literature to evaluate the extent to which our contextual framing is internally valid. Further, the latent constitution of the observations from different aspects of the companies' operations are examined to delineate the underlying reasons for specific company actions and discuss the structures and rules that form a context for corporate reasoning (Sayer 1984, Bhaskar 1978). Thus, although conclusions that are statistically representative of all customized furniture manufacturing cannot be made, the intricacies,

underlying dynamics, and qualifications of the particular manufacturing contexts under study can be accounted for as a way of exploring theoretical relationships between the variables affecting success in mass customization (Dyer and Wilkins 1991, Van Maanen 1979). Therefore, the contribution of this idiographic exploratory study is in providing insights on how manufacturing transformations can be a mechanism for generating the organizational characteristics that facilitate survival in volatile markets, using a mass customization context (Tsoukas 1989).

## Data Collection and Triangulation

The information included in the case studies was pooled from focused interviews, field notes of personal observations, company archives, and other documentary evidence including trade magazines (Yan and Gray 1994, Crabtree and Miller 1992, May 1990). Initial discussions were held with management of both companies about the objectives of this study and a comprehensive set of relevant questions was sent to them which they returned with responses in a few weeks (see Appendix 1 for questions with some verbatim responses). Follow-up discussions were held with senior company officials to clarify responses and probe some issues further. This preparatory interaction preceded a 3-day (1-day in the case of Company B) in-plant study, during which time two facility tours were guided separately by the two senior officials in Company A and one in Company B.

Specific steps were taken to limit investigator bias, although it could not be eliminated entirely because of our direct involvement with the companies and the need to approach them with a positive attitude about their business model. The collection and analysis of data overlapped to allow for adjustments in the data collection. For example, longitudinal financial data of Company A was analyzed at the end of the first day and then used as a basis for a discussion the next day on the connection between operations and performance in a mass customization context to help direct the focus within the facility. One-on-one unstructured interviews were also conducted with personnel in charge of order -entry, engineering, machining, and assembly with the goal being to learn what their jobs involved, what new demands are placed on their respective jobs by the implementation of mass customization, and how they perceived the effect of mass customization on the overall performance of the company. Through these interviews, an attempt was made to determine the extent to which the company is a learning organization – whether there is evidence of constant change in processes and instructions, to the point of challenging basic assumptions of the operation. Notes were not taken during the in-plant interviews because note taking was considered counter-productive to free expression, but the essential issues were documented electronically immediately after each interview. Recorded notes were discussed with the CEO to obtain a balanced view of the emerging issues. To ensure the accuracy of the information gathered, a detailed fact-finding report was submitted for auditing by senior company officials (Lincoln and Guba 1985).

The second stage of data collection involved administering a detailed survey with 26 open-ended questions to the selected companies in 2006. With the permission of the respondents, all interviews were recorded with a digital voice recorder; additional notes on interview circumstances and any other particularities were recorded in a survey logbook. Later the responses were transcribed and coded using typical content analysis (Taylor and Bogdan 1984). Perceptions of these manufacturers were analyzed concerning:

- the internal processes perceived as critical enablers for mass customization,

- the major challenges encountered or anticipated in implementing the paradigm, and
- the extent to which they perceived mass customization as a useful competitive strategy.

Two of the 22 respondents represented software developers and one represented a furniture manufacturer association to provide additional perspectives on the impact of mass customization on the supply chain. Since this second stage also provides a means to validate inferences from the case study, 19 responses were used representing customizers of household furniture, kitchen cabinets, office furniture, upholstered furniture, and furniture components (53%, 16%, 11%, 11%, and 11%, respectively).

The fact that 64 percent of the survey respondent companies also reported annual revenues below $50 million provides additional basis to compare the survey results with the case studies. Comparing findings from the survey with insights emerging from the case studies is a means to corroborate both stages of this study and increase the degree to which the conclusions in this study can be applied in other situations. Thus, ignoring the bias-related constraints in validation associated with judgmental sampling, parallels from the two stages of our study are presented as substantiated exploratory insights. These insights need not be derived from the "best practices" in the industry to be valid as an illustration of the processes that are operationally critical for successfully implementing mass customization (Piller 2003).

## Results

To begin with, observations from the two case studies are summarized and a tabular comparison of pertinent issues between the two companies is presented. Then supporting insights using findings from the experience survey are provided.

### Company A

Company A recognizes that mass customization involves a process of transformations, for which investments must be made carefully and gains consolidated. Its overarching business objective is to assure growth in a changing market by streamlining production to reduce complexity and provide the responsiveness needed in a customization mode of operation. The focus of operations has shifted from a predictable range of line items with minor variations, such as color preference, to orders featuring a higher variation of specifications. With all of its current production made-to-order and 25 percent of this total customized, it is clear that what triggers the flow of materials in this company is essentially customer demand, not forecasts.

#### *Design Platform*

Standard products exist in fixed combinations of parts, while customized products are mainly engineered based on an extensive database of standard product configurations to which the demanded features are appended. The company is developing a modular design platform to introduce parametric design and extend the configuration possibilities, while achieving scope economies.

### Order Process

Order lead times are currently between 2 and 3 weeks, with deliveries scheduled three times a week, in consultation with customers. Terms of purchase are informed by a customer's credit status, and the amount of down payment is determined. The down payment both improves cash flows and reduces the risk of stocking up unclaimed items.

At the manufacturing location, orders are manually entered into an information system together with the appropriate work tickets. The software spontaneously generates a bill of materials for the purchasing department so that inputs for production are sourced based on orders received rather than on historical material use data. This order entry process is usually completed within 24 hours to avoid delays in purchasing the required inputs. The major constraint associated with the order entry process is the cost of rechecking customized order details to detect possible product specification errors at the point of sale. Software applications based on operational logic are being explored to help overcome this bottleneck between sales and production. Additionally, order entry personnel are also trained in engineering detailing to ensure a smoother process flow as a stop-gap measure – a strategy facilitated by the current cross-functional consultation and open work culture.

### Manufacturing Process

Advanced manufacturing technologies and the use of work cells are an important part of the manufacturing process. Customized orders are input into a CAD system that generates parallels to existing drawings of standard orders. CNC codes are produced for the drawings, and production instructions and tracking codes assigned to both standard and custom items for release to production. Case-construction from laminated board is done in-house using mainly a programmable beam saw, an edgebander, and a point-to-point CNC router in clearly defined cells. The company is exploring the elimination of horizontal drilling in its next generation of product families to reduce set-up complexity, and achieve uniform flow in the manufacturing system. Such a focus on improving process flows is a prerequisite to incorporating adequate levels of automation.[2]

(2) An appropriate level of automation can benefit the organization by improving production efficiency and reducing error associated with repetitive tasks to achieve consistent product quality (Wei et al. 1998).

### Supply Chain Management

As is the case for other made-to-order manufacturers, Company A requires speed of delivery and reliability of standardized raw materials from its suppliers, mostly located within a 70-mile radius of the plant. Company A seeks to implement a postponement strategy to synchronize its raw material inflows with its production process and delivery schedules through partnership-oriented negotiations with suppliers.

Inventory concerns relate mainly to reducing costs. Inventory levels have been a function of both jobs-on-hand and reorder quantities set by suppliers for particular panels (i.e., reorder level, r, and quantity ordered, Q, are a function of board type). Variations in the lead time of its suppliers, however, led Company A to increase its safety stock levels, and its (Q, r) policy was not followed. Thus, the

company recorded an inventory of panels exceeding the minimum by 8 percent of total panel purchases in 2005, resulting in overcrowded storage spaces, more frequent loading and unloading, and increased complexity in tracking raw materials. Logistics costs were negatively affected and were at 12 percent of sales – a relatively low performance according to the American Furniture Manufacturers Association (2004).

### *Financials*

Notwithstanding higher capital costs in technology and high variable costs associated with logistics, Company A showed significant improvements in overall performance over the period of study. Company A's performance in the two most recent financial years was compared with its average performance before implementing any transformations to enhance customization capability. This comparison was made on the strength of the fact that the company reports working "towards mass customization for the last two years". Thus, comparing current figures with 1998–2003 averages presents a before and after scenario and provides a sense of the impact of recent changes on current performance. As shown in **Table 1**, the company appears to have improved over its pre-customization performance both in terms of profitability and labor productivity.

**Table 1.** Comparison of pre- and post-customization performance.

| Performance measure | Post-customization change | Current performance as a ratio of three top manufacturers |
|---|---|---|
| Revenue | +75% | -- |
| Cost of goods sold | +25% | 0.88 |
| Gross margin | –22% | 1.24 |
| Net profit margin | +140% | 0.38 |
| Sales per employee | +84% | -- |

Company A's performance was also compared with the average of three top furniture manufacturers (Herman Miller, HNI, and Knoll[3]). It is interesting that gross margin, though it decreased as a result of higher levels of cost of goods sold, compares favorably with the three-company average, and indicates a good relative control of direct production costs. The company does require improvement in its cost structure (e.g., overhead and financing costs) for net profit margins to have a reasonable comparison. These issues are important to the extent that they constrain investment and limit the ability of the company to improve its customization capability. The improved performance recorded following Company A's implementation of process transformations, however, is a useful indication of the positive effect of mass customization on its profit potential.

(3) According to Plantz (2006) the office segment and these large companies in particular, led growth among FDM 300 companies in 2005. Though Steelcase and Haworth were also mentioned, they were excluded from this average because financial results from Haworth were not available and sales of Steelcase alone were almost double the average of the other three.

## Company B

Company B has maintained a historical focus on low inventory, project-based fulfillment of orders through its transition to mass customization. Choices of employees are guided to support the core values of delivering consistent high quality and service through customized products and responding in a timely and effective way to changes in the marketplace.

### *Manufacturing Process and Delivery*

Company B is a solid wood operation and has the added function of grading, sorting, and color matching lumber, but like Company A, it uses work cells extensively in handling the production of variable batch size combinations. The manufacture of standard parts and moldings is controlled by a kanban[4] system. Early machining operations are grouped in large batches but assembly operations are conducted in distinct but coordinated cells where poka-yoke techniques[5] are used to reduce error. Batch sizes reduce to one in assembly cells to help focus on a set of products at a time and to deliver all required components as a batch to the finishing operation. Finishing cells also have the option to slow down a line in order to complete product detailing that might require longer cycle times. This slack is built into the entire manufacturing process to allow adjustments to be made spontaneously in response to process variation.

(4) Kanban is a signaling system for re-supplying parts and materials for production such that there is no storage in the production area. By acting as an authorization to produce more inventory kanban responds to observed demand and facilitates an uninterrupted supply of parts (Anderson 2003, Roos 1992).

(5) Poka yoke techniques involve designing constraints into tools and procedures in order to mistake-proof an activity by forcing the use of correct methods (Shingo 1986).

Completed orders are accumulated in geographic pockets for efficient delivery runs, mainly using the company's own trucks. In this way, Company B can better control the quality of its delivered items up to the point of sale – an advantage that Company A does not possess.

## Comparison of Company A and B

**Table 2** presents a comparison of company-specific observations for Companies A and B. **Table 2** emphasizes the importance of partnerships not only between manufacturers and suppliers but also between manufacturers and retail outlets.

**Table 2.** Comparison of basic operations between the two companies.

| | Company A | Company B |
|---|---|---|
| Driver of mass customization strategy | Response to demand by major customers | Need to improve efficiency of custom furniture manufacturing |

| | | |
|---|---|---|
| Completion of order | At retail outlets | At retail outlets |
| Selection of configuration options | Browsed at retail locations | Browsed both at retail locations and online |
| Customer support | Retail professionals (with access to engineers) guide customer choices | Sales associates/designers help customers select options |
| Employees | Empowered; multi-task trained | Empowered; multi-task trained |
| Production mode | Entirely made-to-order | Entirely made-to-order |
| Customized design | Specified customer features appended to standard product configurations; new configurations attract 5% engineering premium | Range of configurations predetermined to yield 250 basic SKUs with over 200 optional decorative or functional features |
| Updates for design | Mainly based on customer needs and requests | Includes research input on home trends, family dynamics, and emerging technology |
| Order process | Multi-stage to ensure accuracy in transferred information. Orders transferred by fax/email. | Multi-stage to ensure accuracy in transferred information. Orders transferred by fax/email. |
| Order lead time | 2 to 3 weeks | 4 to 5 weeks |
| Manufacturing process | Advanced manufacturing technologies in work cells. Basic construction from laminated panels; solid wood parts outsourced. Batch runs eliminated; orders processed on first-in first-out basis; cycle variation monitored to maintain smooth production flow. | Advanced manufacturing technologies in work cells. All solid wood and hardwood-plywood construction done in-house. Regardless of dimension or species, orders are first grouped to facilitate quick changeovers and reduce setups. |
| Supplier lead time | 9 to 13 days | 14 to 21 days |
| Distribution | Contracted carriers; scheduled thrice weekly in consultation with customers | 95% using company trucks; finished goods inventoried no longer than 3 days |

The operational context for providing an adequate range of configuration options involves retailer-relationships for both Companies A and B. It appears that the traditional distribution chains will remain important in the foreseeable future such that retailer involvement cannot be underrated. Retailers play a critical role in the success of mass customization because they are both the main customers and the channel by which end-user preferences are captured. The opportunity for exploring product options online is also a useful complement to an in-store product configuration. Company B's website was functional but Company A's was under construction at the time of the study.

Company B maintained an order lead time of 4 to 5 weeks based on its experience that a 6 to 8 week lead time is acceptable to the customized products market. This experience is contrary to that of Company A. Kodzi and Gazo (2006a) also found that most customers find 2 to 4 weeks a reasonable wait for customized furniture, with only a slim minority willing to wait more than 6 weeks. Company B's position, however, may have arisen from its previous expertise in custom home furniture building, and may be suitable for its current customer base.

Team leaders in the different functional departments indicated, during the one-on-one interviews, that their responsibilities had generally expanded to accommodate the variability inherent in the customization process. But, they felt the learning that occurred in the course of the transformations that preceded the introduction of mass customization had helped them to transition easier into the new responsibilities. Employees felt that mass customization, though challenging, was a useful step for their organizations. This observation provides an important lesson: employees must be trained in new sets of skills that support responsive processes. As shown in **Table 2**, employees are multi-task trained and empowered to make reasonable decisions in both companies. Organizational learning is supported through a shared philosophy of customization, and new knowledge is appropriately disseminated

across the entire organization. Employee input is solicited, acknowledged, and implemented, and the successes are shared through a bonus plan.

The design process of deriving customized products from existing standard configurations uses the concept of product families (the fundamentals of modular design) to the advantage of the engineering department. In the case of Company A, products are presented to the customer as prototypes that can be customized by modifying standard components. But, this detailing is done after, not before, the order is placed so that adapting order specifications to existing designs in the database poses a challenge without the information processing and transfer capabilities of a parametric configurator.

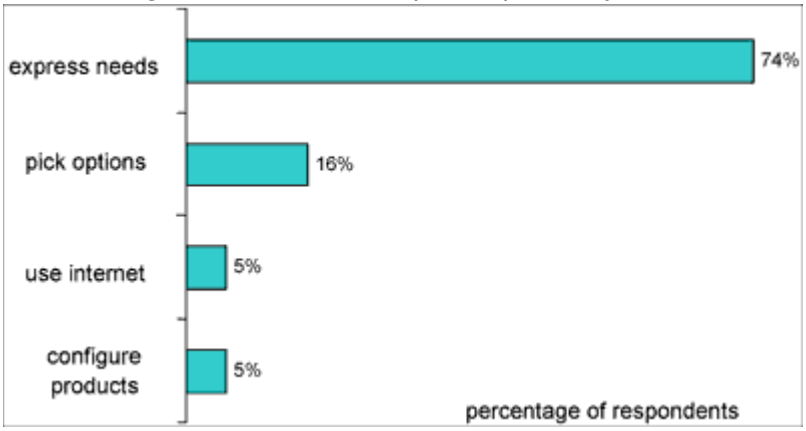
## The Furniture Manufacturer Survey

Findings from the experience survey are presented and observations are related to the case studies where appropriate.

### *Customer Input*

**Figure 1** summarizes the survey responses to the question "what inputs should the end-user provide to customize furniture?" Manufacturers were of the opinion that customers should express their needs clearly. It is the notion that once customers can articulate their needs correctly, they are better able to select the options that are offered by the manufacturer. Therefore, customers must be willing to invest time clarifying their needs to demonstrate their readiness for the customization process.

**Figure 1.** End-user input required by manufacturers of customized products.



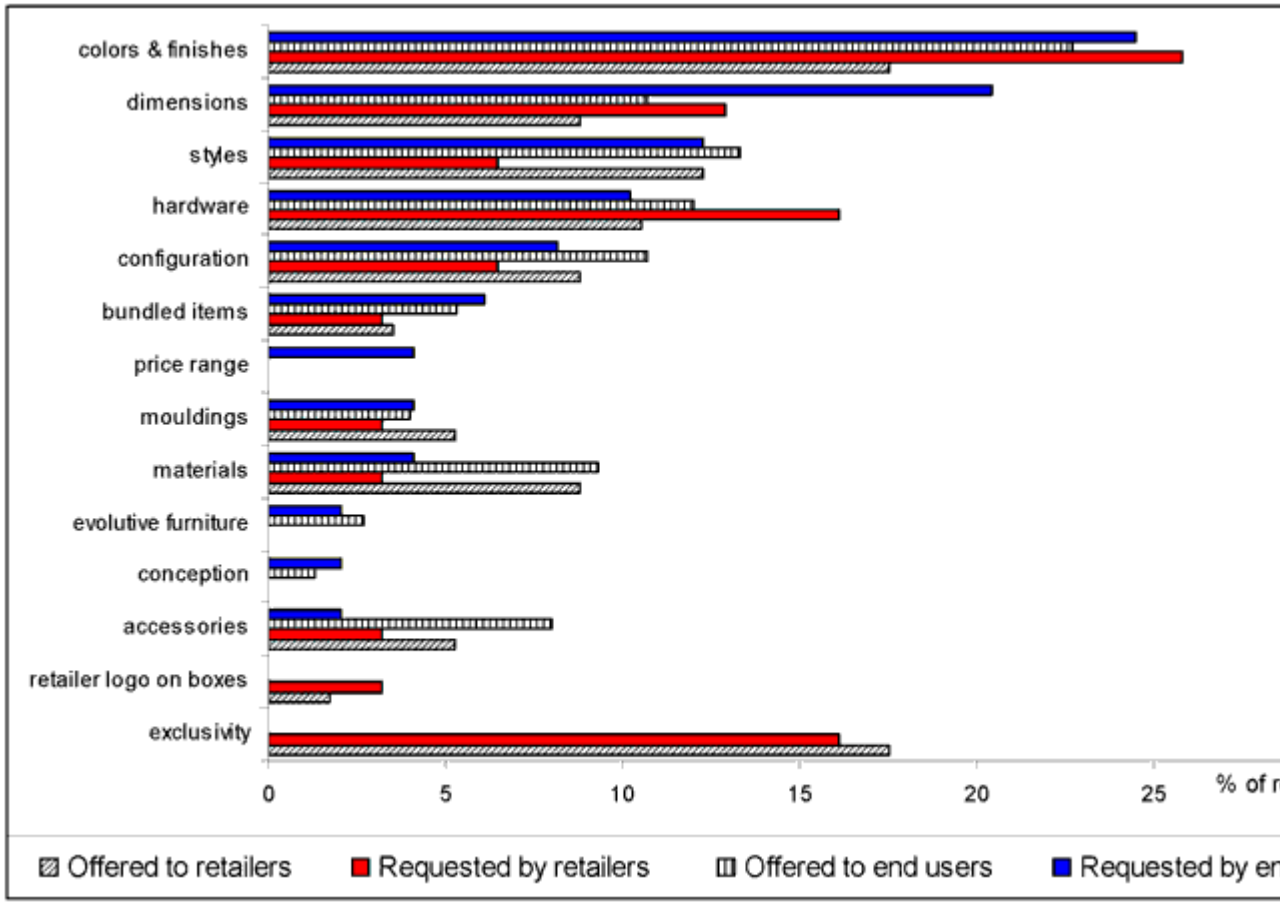

### *Manufacturer Discretion*

The question "to what extent should your furniture be customizable?" generated three main responses from the survey. Sixty percent of respondents said customization should be limited by the design capability of end-users, 25 percent said it should be limited by manufacturing capabilities, and 15 percent said it should be unlimited. Intuitively, respondents who thought it was reasonable to limit customization to the end-user design capabilities were more concerned about promoting customer innovation. They could also have been concerned that customization options should not be more complex than the average customer can navigate comfortably. The concern about the extent of manufacturing capability, however, may be perceived to reflect an attempt to limit the configuration

scope such that defined market segments can be served efficiently. Similarly, the range of options made available for customization was also a major concern for both Company A and B, although Company B had more experience in specifying this range. Given that a company has made an offer for a wider range of customization options, it may need to change some design attributes of its current offering to improve the manufacturing process.

It also appears from the survey that much of furniture customization is currently in terms of color and finish choices, dimensional changes, design styles, and hardware accessories (**Fig. 2**). For colors, finishes, and dimensional changes, retailers and end-users requested more options than were offered by manufacturers; the situation was reversed for design styles and hardware accessories. The differences between the demand and supply specifications of the customization options suggest that the manufacturers did not allow for unlimited choice of features by customers. Based on considerations such as design appropriateness and process constraints, the manufacturing company restricted configuration outcomes for a customized product. It is interesting, though, that for certain features (e.g., styles, materials, and accessories) manufacturers offered a broader range than requested by both end-users and retailers.

**Figure 2.** Range of furniture customization requests versus options offered by manufacturers.



### *Retailer Input*

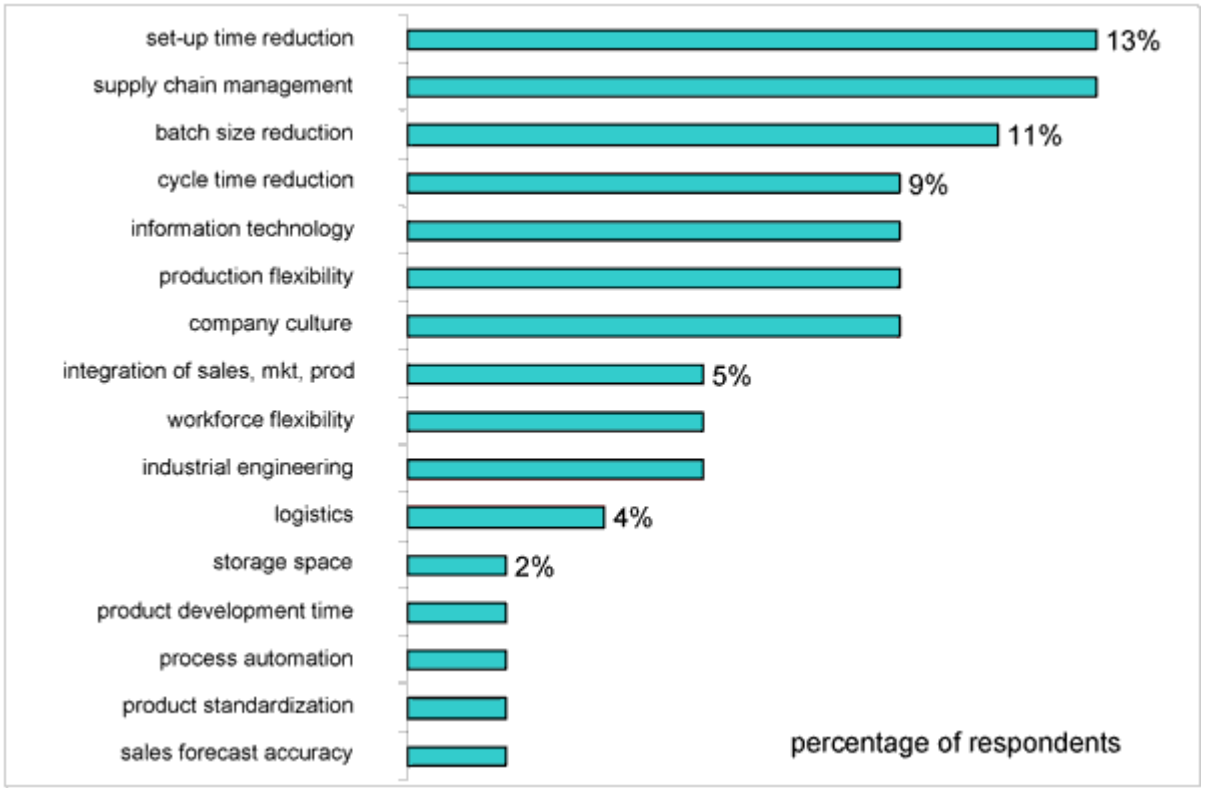
The profile of customization requests from retailers in **Figure 2** differs from that of end-users and included exclusivity ahead of dimensional changes and design styles. The inclusion of "exclusivity" in the list suggests that retailers are not inert channels of end-user demands; retailers act as aggregate customers and influence the customization profile by their own tastes and preferences. The survey also showed that customer requests for customization were channeled more through retailers (62%) than made directly with the manufacturer (38%; comprising 34% through sales representatives and only 4% through the internet).

### *Prerequisites and Main Challenges*

The prerequisites critical to implementing mass customization by survey respondents were listed as "investment in information technology" (30%), "lean manufacturing" (27%), "investment in production technology" (22%), and "different labor skills" (22%). These elements have also emerged from the foregoing case study discussion. Main implementation challenges (**Fig. 3**) were set-up reduction and supply chain management (both 13%) and batch-size reduction (11%).

Implementing mass customization is expected to affect the supply chain in terms of reducing batch sizes (34%), reducing lead times (24%), increasing flexibility (17%), enhancing supplier integration (12%), and improving communication (12%).

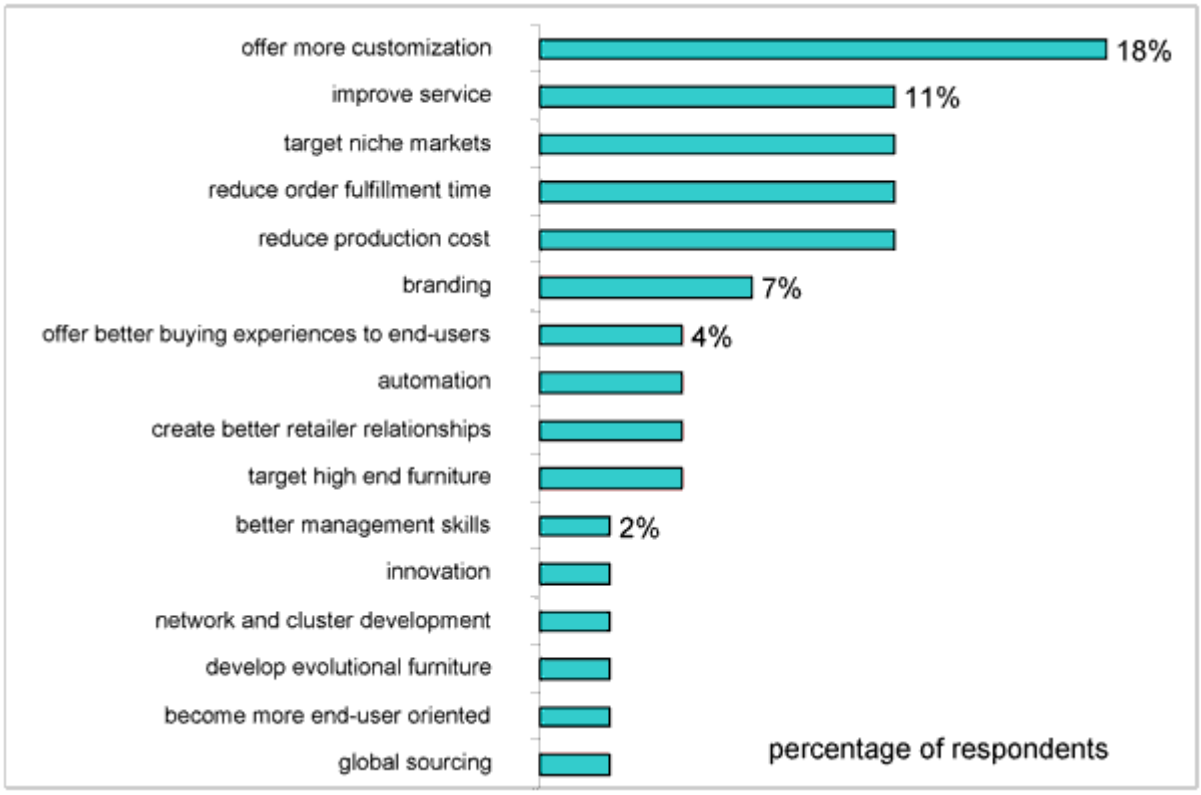
**Figure 3.** Main mass customization implementation challenges.



### *Mass Customization and Competitiveness*

Survey respondents were generally very positive about the potential of mass customization to deliver a competitive advantage. **Figure 4** illustrates the responses to the question "how can the furniture industry in your country stay competitive?" There was agreement among all respondents across countries that mass customization is critical as a strategy in the furniture industry for remaining competitive. For country-specific respondents, however, Germany ranked branding just as high as mass customization; other important considerations were targeting high-end furniture, targeting niche markets, and developing networks and clusters. Canadian respondents also ranked reducing production costs as high as mass customization; other competitive issues were mainly reducing order fulfillment time and improving service. For U.S. respondents, the second most important consideration was reducing order fulfillment time, followed by automation, better management skills, and reducing production costs.

**Figure 4.** Strategies for retaining competitiveness.




## Discussion

The experience survey corroborates the case studies in many respects and provides useful exploratory insights. Mass customization currently appears to be an important business principle for furniture manufacturing. In both the survey and the case studies, manufacturers were unequivocal about the positive effects of mass customization on competitiveness. It is significant that given the open-ended questions in the survey and the different countries, there was such strong consensus about the role of mass customization in a competitive market environment. This consensus is consistent with the finding by Iyer et al. (2006) in a study of the Indiana Wood Products Industry, of a prospect among furniture manufacturers that increasing the proportion of their customized production will contribute

to future business success. But, implementing mass customization is not without challenges. The results suggest that manufacturers must engage process transformations to promote a synergistic interaction of technology and human resource within their manufacturing systems, such that customized products might be offered efficiently.

It appears that customization capability is impacted by the interactions between design and manufacturing (modularity, customer interface options, and manufacturability), organizational responsiveness, and supply chain interconnections. In the case of Company A, there is evidence of customization-driven process transformations in response to a changing market and an increase in performance metrics following the implementation of mass customization. Thus, the improved business performance is attributed to the effective implementation of mass customization, and in a mass customization context, process transformations are indeed an important mechanism for improving business performance. It is conceivable that the externally driven costs associated with mass customization will be further reduced with greater adoption among a network of furniture manufacturers.

The main challenges related to implementing mass customization that emerged from the survey were shared by the two case studies as well; prominent among which were set-up and batch size reduction. Reducing set-up time could be addressed by incorporating setup considerations into the design process (as with the review of horizontal drilling in Company A) and by increasing the use of CNC technology. Company B addressed its batch size issues by grouping orders in the initial production stages to increase process efficiency and then reducing batch sizes in the assembly cells.

It is interesting that the internet did not feature strongly as a channel through which end-user input for customized furniture is currently captured. This survey finding further substantiates the view that, for furniture purchases, customers appear to relate less effectively to virtual products than to physical products. Customers might use the internet as a tool to explore what options are available on the market, but then will more often visit a physical furniture outlet to complete the configuration process and place the order; a position held by both Company A and B. The customer-direct mode of customization is not the dominant strategy of survey respondents at this time presumably for logistical reasons. Thus, consistent with the case studies, retailers will continue to play a critical role in the success of mass customization implementation in the next few years.

The survey results have reemphasized the coordination of a responsive supply chain as a major hurdle that needs to be overcome to make mass customization operational. Without adequate flexibility in the supply chain, the quick customer-specific response required by mass customization will introduce unjustifiable internal manufacturing costs. In Company A, efforts to reduce the order lead time to less than 2 to 3 weeks were not perceived to be comprehensive enough without complementary improvements in supplier responsiveness. As we have previously noted in the literature, supplier relationships affect the extent of customization feasible in the manufacturing system.

Training in new skill-sets consistent with expanded employee responsibilities is also a critical mass customization consideration based on the case studies, the survey results, and current literature. It is valuable to entrench a customization-supportive culture as Company B did (to the extent that office employees customized their workspace designs). Such a culture allows employees to challenge the

*status quo* and be innovative. One benefit of a shared philosophy of customization is improved information flow across the organization.

Other noteworthy parallels between tactical actions observed in our study and current literature related to mass customization studies in other industries include:

1. Furniture is customized in some cases by modifying standard components of prototypes presented to customers (Lampel and Mintzberg 1996).

2. A premium is charged for some new product configurations (MacCarthy et al. 2003). Kodzi and Gazo (2006b) suggest that a 5 percent premium (such as is charged by Company A) is not a deterrent to customers of customized furniture. It may be of research interest to investigate what premium thresholds are acceptable to customers in specific contexts, assuming price sensitivity for furniture buyers.

3. Field notes taken during the interviews indicate that companies were generally unable to produce customized furniture at the same costs as mass produced furniture, as expected (Anderson 2004). Any negative impacts of higher prices on sales, however, were offset by improved brand equity, leading to increased sales of standard products.

4. Order flow is monitored by the use of detailed production instructions and assigned tracking codes (Spira 1996, Choi and Jarboe 1996), and process improvements target obstructions to the flow of orders through the manufacturing system to increase customization capacity (Storch and Lim 1999)

5. The customization of 25 percent of total production by Company A is substantial, relative to the 2 percent in the frequently quoted National Industrial Bicycle Company case (Kotha 1996). The 2 to 3 week order lead time for case goods also compares favorably, as a consumer durable, with the 2-week lead time for customized bicycles in Kotha's study.

## Managerial Implications

Substantial investment may be required for a company to transition to a successful mass customization model. But, the resulting strengthening of customization capability has implications for the long-term competitiveness of the organization. In addition to improved financial performance, Company A reaped the benefit of shorter lead times, better control of a make-to-order system, and improved employee loyalty. The successful transformation gave the company further impetus to explore further improvements such as limiting human intervention (from the order transfer process, through the manufacturing process, to product delivery) as a necessary step to offer customized products on a very large scale. The costs associated with the customized manufacturing processes are expected to decrease incrementally as improvements are made.

Retailers play a critical role in mass customization at this time, and it is important to develop a proactive service capability at the point of sale. Retail associates must be sufficiently skilled and educated about the manufacturing system to appropriately capture end-user specifications and guide the configuration and ordering of customized furniture. The goal is to be proactive about reducing complexity in order specifications. Thus, plans to invest in parametric configurators to interface with

retail outlets for seamless information transfer into production are a step in the right direction. In this regard, pilot programs could be launched at the most profitable retail locations.

Given that customers may browse product configurations online, information that is made public on company websites must be consistent with the desired branding. Provision must also be made for effective monitoring of the website and for coordinating customer input through that medium, even though the internet is not currently the preferred conduit of customized furniture specifications. If customers are guided through the product configuration process at the point of sale using the same interface as is available online, repeat buyers could potentially order directly online and help to evolve the offer of customization to a customer-direct mode.

It is clear from the study that factors both internal and external to the manufacturing organization constitute essential elements that interact to support successful mass customization systems and overcome the associated challenges. There was evidence of a transformation of the manufacturing system to a form that supports mass customization through lean production techniques and through investment in advanced manufacturing technology. Product architecture was modular in design to facilitate configuration by customers and flexibility in manufacturing. Information transfer procedures were upgraded based on the appropriate technology. Employees were empowered through cross-functional training and through exacting responsibility in a shared learning environment. The role of suppliers in the success of the customization effort was also not underrated by the companies. Since mass customization cannot be implemented successfully without an effective coordination of the entire supply chain, the strategy will have greater chances of success if retailers, manufacturers, and suppliers all perceive significant prospective benefits.

Further research could employ quantitative measures of modularity, agility, and supply chain interaction in an attempt to isolate the actual profit drivers in a mass customization system. It also remains to be examined what constitutes a profitable combination of standard and customized products for a company, if it can leverage its brand position as a customized manufacturer for the benefit of its standard products.

## Conclusion

An analysis of the case studies and supporting survey leads to the conclusion that process transformations positively affect mass customization effectiveness. The financial performance exhibited by one case company relative to its pre-customization situation further substantiates this view. By offering customization in response to changes in customer demand patterns and increased competition from global sources, the manufacturers studied had identified themselves as channels by which the needs of end-users that are unfilled by standard products can be met. The underlying principles that informed the strategic actions taken by these manufacturers to make mass customization operational in their organizations were discussed. Thus, the documentation of the interactions within the manufacturing systems of these furniture manufacturers and the profit potential of manufacturing transformations contributes to the literature on customized furniture manufacturing. It also provides a context for assessing to what extent a furniture manufacturing business is prepared to implement mass customization.

Within the limits of this study, it can be inferred that a mass customization strategy mandates improvement in the manufacturing system as a whole rather than superimposing advanced concepts piecemeal on suboptimal systems. Regardless of the orientation of a prospective mass customizer in terms of mass production or custom manufacturing, the configuration tool kits for mass customization will lack the needed versatility without sufficient preparation. If the business focus is to develop the flexibility to respond to variable demands by current and future customers, the transformations can achieve greater impact in terms of productivity and profitability. As a business paradigm, mass customization should not be initiated presumptuously even though its potential benefits might be attractive.

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## Appendix 1

Questions for discussion preceding the case study (with partial answers):

1. How has the manufacturing function changed over the past 5 years and what has been the impetus for the transformation?
   *... changed from a "batch" manufacturer to ... make to order manufacturer ... our lead times were long ... customer demand forced us to take a look at the way our product flows through our facility ... we have created more capacity and a smoother ... flow*

2. What internal processes are in place, and which are perceived as critical enablers for mass customization?
   *... started to implement lean manufacturing in ... imperative step in our ability to handle custom orders ... we currently use ... for our order entry ... system ... the next critical element in improving our ability to effectively handle customized products*

3. What challenges do you face in capturing the exact needs of your customers?

4. How are orders transferred, and what is the range of order quantities? What is the ratio of standard to customized product?
   *... 25% of our products ... customized*

5. How have cost structures changed over the period of study (what does the financial data indicate?)
   *... has greatly reduced our direct labor ... however, we've seen an increase in direct material and inventory costs ... our profits have increased ...*

6. How has the distribution system evolved? What are the characteristic lead times?

7. How are suppliers integrated into the manufacturing system? What inventory policies and associated costs exist? What different strategies would you like to implement in the delivery

of your INBOUND and OUTBOUND logistics?
*... establish "just-in-time" ...*

8. What internal frictions occur as you try to increase or reduce production output?
9. What internal challenges limit your speed of changing from one SKU to the other in response to an order?
10. How has the quality control system changed? What feedback systems are in place?
*... employees ... trained and empowered ... decisions*