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Implementation of Mass Customization in a Furniture Manufacturing Plant: The Case of Shermag Inc.

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Abstract. Shermag Inc. is a major Canadian wood household furniture manufacturer, its main markets being the USA and Canada. Founded in 1977, the company applied successfully mass production concepts to gain market shares. Due to a changing business environment and increasing competition Shermag decided to improve its value offer by implementing a mass customization concept for its Canadian plants. The present paper describes the economic changes in the North American furniture industry. A mass customization model adapted to the furniture industry is introduced. The main challenges to implement mass customization in a mass production furniture company are highlighted based on the Shermag case study. Mass customization implementation was still ongoing at the time of editing the present paper, but Shermag's management agreed that it had a positive impact on production flexibility, inventory levels, daily scheduling and most importantly sales volume.

Keywords. Competitive advantage, strategical change, change management, organizational restructuring.

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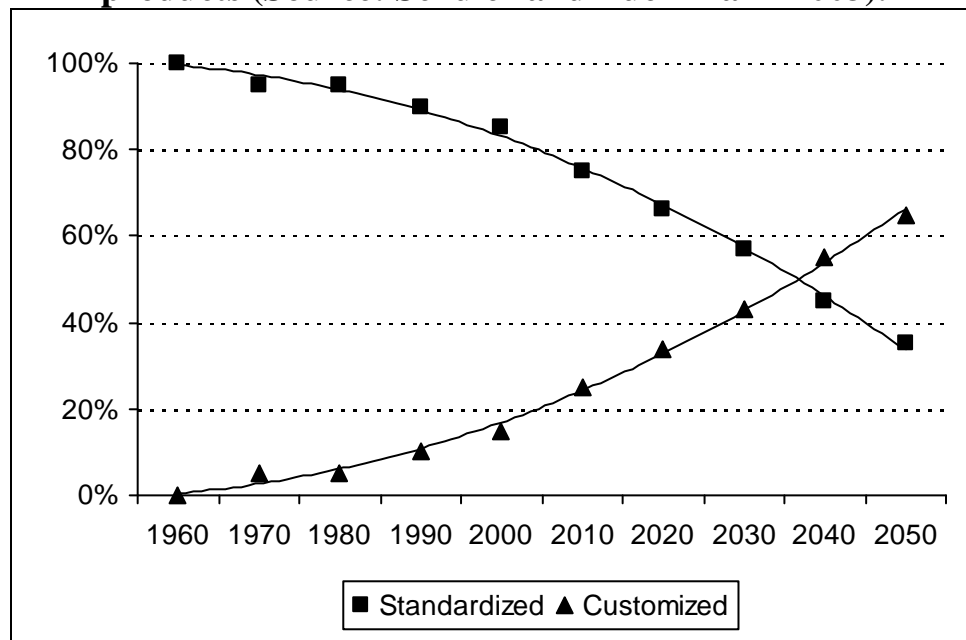
Mass Customization market and industry environment

Competition from low labor cost countries, which have dramatically increased their exports to the U.S. over the past few years, has led to serious downsizing in the U.S. furniture industry (Buehlmann *et al.* 2004, Hilsenrath and Wonacott 2002). This happened in a favorable market environment for furniture over the past few years. The North American furniture market is predicted to continue its growth at a moderate pace following the demographics and income forecasts of Americans (Schuler and Buehlmann 2003, Bullard and West 2002). In particular, the American population is characterized by the presence of about 76 million baby boomers, many of whom are in good financial shape. This group represents the most important market segment of the furniture industry into the foreseeable future since they generally have better than average income and a preference for personalized products. To satisfy their particular needs and demands, price is not the main sales argument. Available options to customize the product, pre- and post sales service, and delivery time influence their decision to buy a product. Schuler and Buehlmann (2003) forecast an increasing market share of customized products over the next several decades (Figure 1).

Mass customization (MC), for a variety of reasons, is considered a promising approach for domestic manufacturers to maintain and grow their operation (Buehlmann 2004). Standardized, mass-produced furniture is made more cheaply, at similar or better quality, in low-cost offshore countries. Mass customized furniture gives producers who are close to customers a sustainable competitive advantage. Therefore, the domestic furniture industry should be aggressive at exploring and implementing opportunities to manufacture mass customized furniture.

The objective of this paper is to review the mass customization concept, to propose an application and to explore the challenges to adopt such strategy in the north-american furniture sector through a case study. The present paper also proposes that the level of MC offered by furniture industry sub-sectors is correlated with loss of market share of domestic manufacturers.

Figure 1. Market share of standardized, mass produced versus customized products (Source: Schuler and Buehlmann 2003).



Mass customization concept for the furniture industry

In 1987 Stanley M. Davis introduced the term « mass customization » in his book *Future Perfect*. He described mass customization (MC) as a trend towards the production and distribution of individually customized goods and services for mass markets. The idealized definition of the concept may be stated as a business strategy for profitably providing customers with anything they want, anytime, anywhere, in anyway (Hart 1995). As an ideal, this definition can only be approached but never truly reached by a company. A more practical description of MC relates to the ability of a business entity to provide customized products or services in high volumes with short lead times through flexible processes at costs similar to standardized mass products (Silveira *et al.* 2001; Hart 1995). Pine (1993) considers MC as the historical successor of mass production while Kotha (1995) or Westbrook & Williamson (1993) see it as a system that may co-exist with mass production. Products can be customized in many different ways but MC is always achieved through manufacturing to order.

Taxonomies for MC and manufacturing without finished goods inventories have been proposed by numerous authors (Amaro *et al.* 1999; Gilmore & Pine 1997; Hart 1995; Lampel & Mintzberg 1996). Montreuil & Poulin (2005) propose a personalization framework containing eight levels. The following framework has been adapted here for the furniture manufacturing industry:

1. Popularizing: the mass producers' solution to customization, offers a limited number of furniture collections or furniture items that can be stocked by the retailer. Focus is on evolving the popular product mix in line with evolving customer needs. These items are sold off-the-shelf and are often positioned at the low end of the furniture price structure.
2. Varietizing: the objective is to offer a broader range of furniture models covering a wide range of customer needs. Retailers pick those they want to offer off-the-shelf and rely on quick delivery from the distribution network for fast replenishment. Most often variety is achieved with relatively simple changes to the standard product line, such as adding additional color options or furniture items to a furniture collection. Another simple example of varietizing may be shipping standardized furniture in boxes showing the logo of the retail store, which also increases perceived variety.
3. Accessorizing: refers to the production of standard core modules that may be personalized by adding accessories from a specified set of options. Particular types of finishing are also considered as an accessory. Final assembly of accessorized products is performed either by the customer, the retailer or the manufacturer.
4. Configuring: offers end-users the opportunity to design furniture from a set of standard components or modules. Configuring may be performed directly by the end user through the use of software tools and samples or it may be realized with the assistance of trained sales representatives.
5. Tailoring: Product designed/engineered to customer needs. The customer is closely involved in the product specification and realization process. It removes the strict adherence to a pre-defined set of variety. However, limits are defined as boundaries of what can be manufactured efficiently and not as a given set of pre-defined objects as is the case of configuring. Tailoring may be offered to end users or to retailers. Furniture manufacturers often offer tailored, exclusive collections to major retail accounts.
6. Servicing: refers to assisting the customer in developing a complete home (room) furnishing concept. Within this concept, furniture may be personalized by any of the seven other options of the model. In addition to the desired furniture, the end user receives the service of a professional designer to add other furniture pieces, accessories, moldings, colors, or wall paper to match his

particular taste or interests. The furniture manufacturer is part of a network of home furnishing producers offering a complete range of products.

7. Adjusting: product is adjusted to customer needs after usage. The product has to be adaptable to offer options allowing for adjustments. An example for adjusting would be a baby crib with side rails that may be used as head and foot panels for a twin size bed when the baby has grown. Adjusting may be integrated to create an evolutionary furniture item (eg. adjustable office chairs).

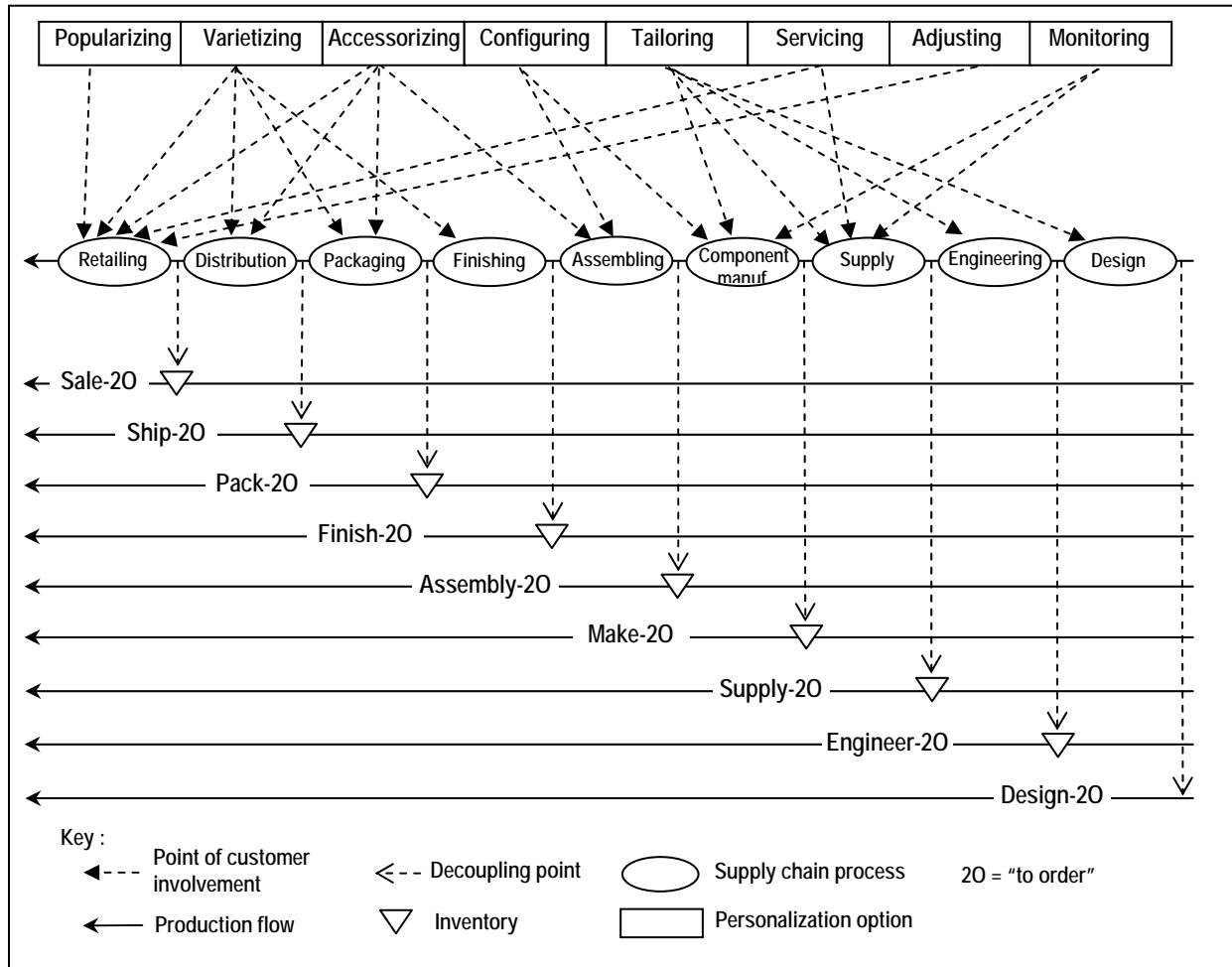
8. Monitoring: refers to the ongoing gathering of data regarding the evolution of the needs of a customer. The objective is to know when to suggest new products or services to a customer. For the furniture industry, this could mean finding the moment in a customer's life when new furniture that better fit her evolving lifestyle, might be sought after. Other examples would be gathering customer information on the acquisition of a new home, setting-up a home office, additional persons joining the household or persons leaving the household, e.g. events that offer the potential for new business for furniture manufacturers and/or retailers.

The concept of product platforms as described by Vuuren and Halman (2001) is strongly related to accessorizing and configuring. These authors point out that the underlying logic of a product platform consists of three aspects: 1. modularity, 2. standard interfaces for assembling and 3. design standards that the modules conform to. Product platforms may be considered as enablers for accessorizing and configuring.

The eight customization levels may be divided into three groups: 1. pre-sales product customization, 2. after sales product customization and 3. ambience customization. Popularizing, varietizing, accessorizing, configuring and tailoring are related to product customization and activities are performed prior to furniture sales. Adjusting and monitoring are related to after sales options while servicing may put any of the seven other customization levels in an ambience adding value to the product.

Figure 2 presents the relation between the eight personalization levels, customer involvement, and manufacturing processes. This model from Poulin *et al.* (2004) is adapted to the furniture industry. The production flow direction goes from right to left reflecting that the end customer is the starting point pulling the production process towards him. The decoupling point marks the beginning of the process leading to a personalized product. From the decoupling point on, production is strictly done to-order. Prior to this point, production may be in either a push or pull mode. Achieving fast responsiveness and low production costs becomes increasingly difficult when moving the decoupling point up stream (e.g. closer to product design). For cost minimization purposes, inventories of products at the decoupling point have to be kept at a minimum. For minimal cost, variety before the decoupling point should be minimized by adopting part standardization and modular design (Åhlström and Westbrook 1999; Pine 1993). Low cost in a MC environment is achieved through economies of scope - the application of a single process to produce a variety of products and the use of standardized core modules to build personalized products (Kotha 1995; Feitzinger and Lee 1997).

Figure 2. Point of customer involvement and decoupling point for furniture manufacturing (adapted from Poulin *et al.* 2004).



Moving to MC is a strategic decision which impacts the organizational structure of a business. However, it has the potential to uncover revenue drivers that might otherwise be forgone or be seized by competitors (Hart 1995). Kotha (1996a) also sees MC as a competitive advantage for a first mover, although this advantage may be fleeting. Nonetheless, a company that finds itself and its competitors offering similar levels of MC might discard MC as a competitive edge (Amaro *et al.* 1999). In such cases, MC is simply a core characteristic of the business which allows it to stay at level with competitors. As discussed in more detail later, the use of MC strategies in the furniture manufacturing industry may vary from one sector to another. MC might be considered as a competitive edge in one sub-sector (e.g. the wooden casegoods household furniture industry) and be part of the core characteristics of business practices in another (e.g. the kitchen cabinet industry).

Benefits of MC are more often related to customer and market impact than to costs and profits (Åhlström and Westbrook 1999). The example of the National Bicycle Industrial Company (NBIC) of Japan may be cited to confirm that statement. However, the introduction of MC bicycles had an important impact on customers' perception of the NBIC brand name and undoubtedly increased NBIC's core business – mass produced bicycles (Kotha 1995, 1996a, 1996b).

Furniture industry economics

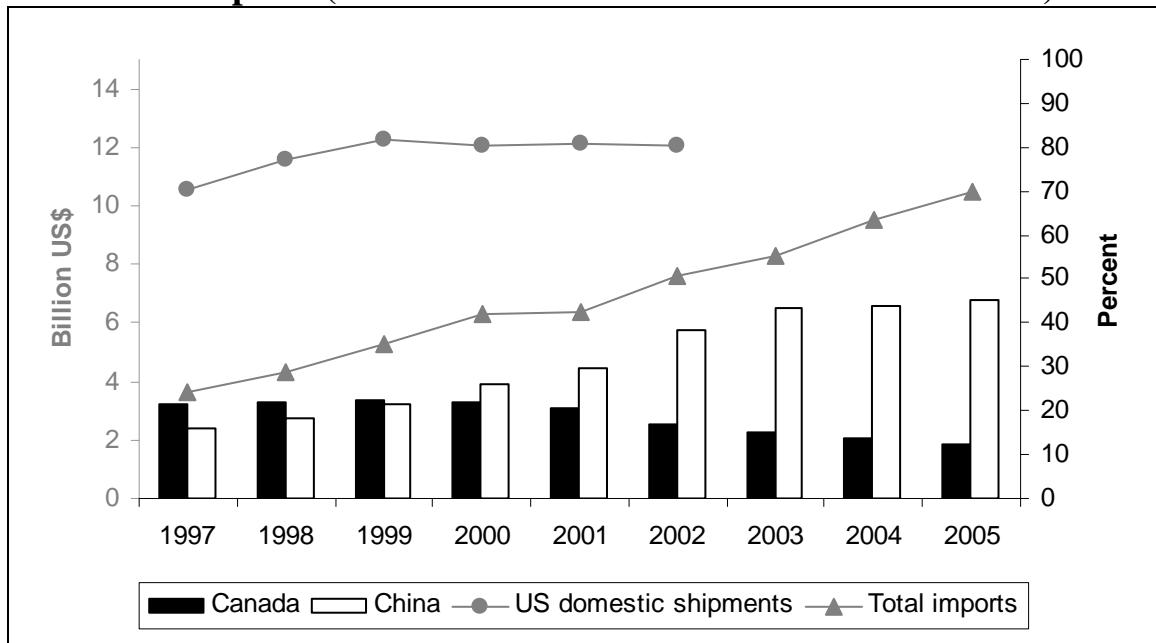
MC has been mentioned as one of the strategies that could allow North American furniture manufacturers to stay competitive in a context of global competition (Postrel 2005, Buehlmann *et al.* 2004, Schuler and Buehlmann 2003, Bullard and West 2002, Collins 2002). An argument can be made that furniture, given its prevalence in everyday life and its use as a status symbol, is extremely suited for the concept of MC (Buehlmann *et al.* 2004, Fletcher and Wolfe 2004, Schuler and Buehlmann 2003). If customers pay premiums for customized computers, cars or clothes, furniture products should represent similar opportunities. One theory is that there may be a correlation between the level of imported furniture sold in the U.S. market and the level of MC adaptation. While no conclusive evidence can be offered due to the complexity of such industry-wide analysis, data is presented below to support this proposition.

Wooden casegoods household furniture (NAICS 337 122)

A typical wood casegoods household furniture plant in North America may produce 10 different furniture collections. Each of these collections may count for about 15 furniture items. Design and construction are seldom standardized or modularized. Given that one collection represents 500 to 1000 components, the total number of components may reach 20,000. Production planning is centralized and based on market forecasts. The plant layout is often a mixture between the job shop concept and flow shop layout and production operates in push mode (Chase *et al.* 1998). Buffer stock is present on the input and output side of each process resulting in a high level of work in process (WIP) pieces. Finished furniture is inventoried and distributed from the factory to distribution centers or retail stores. Despite the high level of inventory that such a plant carries, customer order response time is generally between six and twelve weeks. The wooden casegoods household furniture industry is mainly operating in a ship-to-order mode. Little personalization is possible under such conditions.

Figure 3 presents total wood household furniture imports from 1997-2005 and imports from the two leading exporting countries to the U.S., namely the People's Republic of China and Canada, respectively. Total imports are presented in billions US\$ (left axis) and imports from the leading countries are presented as a percentage of total imports (right axis). U.S. domestic shipments (defined as domestic production-exports) from 1997 to 2002 are presented in billions \$ and relate to the left axis. The latter indicates the presence of U.S. manufacturers on their domestic market and may be considered as a measure of domestic market control. Official production data were available to 2002. Import and export data were available to the year 2005. According to Figure 3, domestically made and sold wood household furniture increased slightly from 1997 to 1999 and kept stable until 2002 at roughly \$12 billion. The American Home Furnishings Alliance (AHFA) estimated no significant change in US wood household furniture domestic shipments from 2002 to 2005. China replaced Canada as the number one wood household furniture exporting country to the U.S. in 2000. These numbers show that U.S. domestic producers were not able to profit from a growing domestic retail market which grew from \$14.2 billion in 1997 to \$19.6 billion in 2002. Imports gained market share, reaching 63% of the domestic shipments of wooden, residential household casegoods in 2002. Total imports continued steadily to increase from 2002 to 2005. In that year, China represented nearly half of all imported wood household furniture.

Figure 3. US wood household furniture domestic shipments and total imports in billions \$ and imports from the leading countries as a percentage of total imports (Source: US Census Bureau and USITC 2006).



Typically, for a product offering little options for personalization, price, quality, and order fulfillment time are the main sales arguments (Kotha 1995; Hart 1995; Bullard and West 2002). As discussed previously, U.S. wooden casegoods furniture manufacturers are not known to offer significantly faster order fulfillment time than do off-shore manufacturers (Buehlmann and Bumgardner 2005). Moreover, quality often is not different for products from different origins. Under those conditions, price becomes the most important sales argument. However, as the statistics show domestic manufacturers fair poorly in markets where competition is based on price (Buehlmann and Schuler 2002).

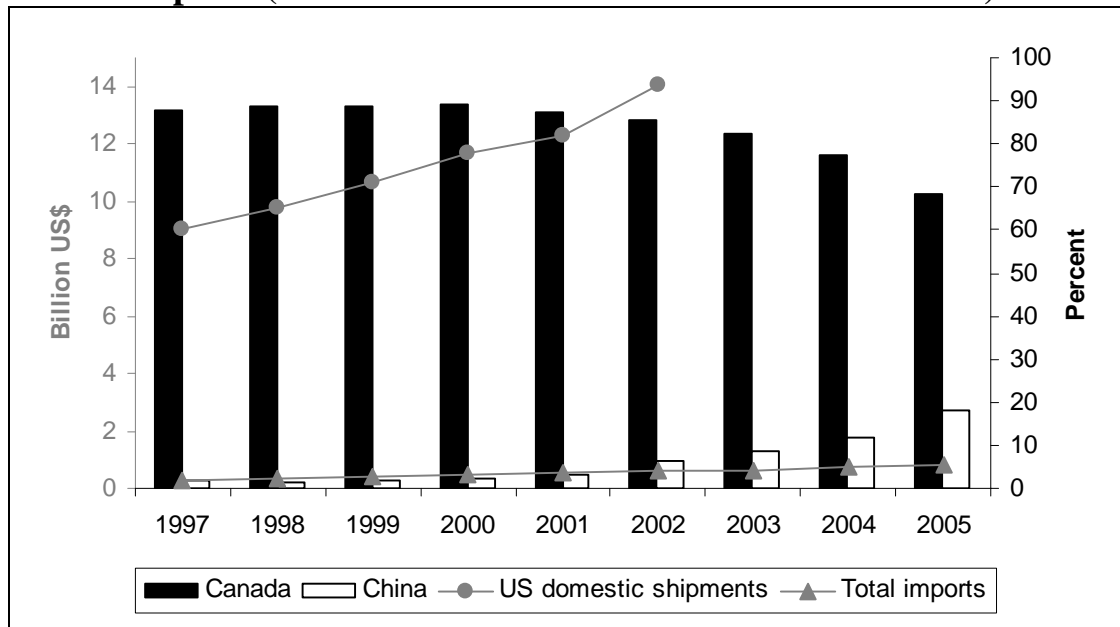
Wood kitchen cabinets (NAICS 337 110)

Broadly defined, wood kitchen cabinets (KC) consist of cases with shelves or drawers and fronts. Cases and shelves are generally made from composite wood products in rough, melamine coated or veneered forms. Fronts and drawers may be made from solid wood or composite wood products. To ship a complete kitchen, all units of a given order are often processed as one batch. However, fronts, drawers, shelves and cases may be processed in different departments or even different facilities. The kitchen cabinet industry has some of the most advanced systems to facilitate such dispersed production. The parts will merge on the assembly line. Appliances, however, may be shipped directly to the installation site.

Figure 4 presents total wood kitchen cabinet imports from 1997 to 2005 and exports to the U.S. from Canada and China, the leading KC exporters to the U.S. Total imports are presented in billions \$ and imports from the leading countries are presented as a percentage of total imports. The value of domestic shipments of wood kitchen cabinets increased continuously from \$9 billion in 1997 to \$14 billion in 2002. Overall import share is low at 4% of domestic shipments in 2002. However, imports increased continuously to 2005. Canada, the leading exporter to the U.S. represented about 90% of the total imports in 2000. Its import share decreased to 69% in 2005 while China, the second most important exporter of kitchen cabinets to the U.S. saw its import

share increase to 18% in the same year. American kitchen cabinet manufacturers do not appear to be under particular pressure from international competitors. Therefore, the U.S. based companies were able to take full advantage of an expanding U.S. market and have grown domestic sales by 56% from 1997 to 2002. An argument can be made that the make-to-order manufacturing strategy of the kitchen cabinet industry presents a significant barrier to offshore imports.

Figure 4. US kitchen cabinet domestic shipments and total imports in billions \$ and imports from the leading countries as a percentage of total imports (Source: US Census Bureau and USITC 2006).



Discussion of furniture data

It has to be pointed out that the presented furniture import data includes finished products only. Furniture component and raw material imports are not captured by these numbers. Given the data shown and the observations made on the two different sub-sectors of the furniture industry, the proposition can be made that MC practices do have a positive influence on the prosperity of an industry sub-sector, or at least they help domestic manufacturers better cope with imports. To further substantiate the assumption, it is worthwhile to contrast two extremes, the wood household casegood sector versus the kitchen cabinet sector. The former is losing market share on a large scale (by now, more casegood furniture are manufactured outside the U.S. than inside, while the latter seems to contain imports successfully at single digit levels (Buehlmann *et al.* 2004)).

Indications exist that the level of MC adaptation in these two industries are one reason for the difference of levels of the market share held by the domestic producers. Indeed, household casegood furniture is sold from inventory with little or no customization while kitchen cabinet manufacturers make a completely different value proposition to their customers. Home Depot Expo Design Center division, as an example, offers nearly 30,000 different combinations of color, style and wood species to buyers of kitchen cabinetry. The center customizes wood stains to any color sample customers bring in. Additionally, to give the resulting kitchen cabinets a lived-in look, buyers may choose from a menu of special effects, including cracks, dings and

deep gouging. Through the entire design process, customers are guided by professional designers or specially trained staff. Different cabinet modules may be configured according to individual customers' needs. The designer or sales representative configures the kitchen using software developed by the kitchen cabinet industry. The software has built-in visualization, permitting instant three-dimensional visualization of the design for assessment by the customer. Configuration, colors, materials and functionality are easily modified until the customer is satisfied with the result.

After placement of the order, a second software module generates the bill of materials, orders all third-party components and creates all CAD/CAM information needed for the kitchen cabinet manufacturer. Then, the kitchen is made-to-order and sent to the customer's home for installation on a predetermined date (Fletcher and Wolfe 2004). This development of the kitchen cabinet industry was initially driven by the need to optimize space. In the 1950's companies started to offer cabinets fitted into a given space instead of individual free standing fixed dimension cabinets. To produce those fitted cabinets efficiently, standardization and modularity were essential. To create a functional cooking environment, many special purpose accessories were introduced. Kitchen cabinets were now sold as complete systems and have become the most expensive part of all furniture usually found in a home. The design complexity and the importance of the investment created a need for assistance by professional designers – end users wanted to be sure they were buying the best possible system for their kitchen space. Wood household furniture consists of individual furniture pieces. These items are generally not fitted into a given space and manufacturers had less pressure to develop component standardization and product modularity. This lack of standardization is today a major barrier for companies to offer customized products. Wood household furniture is sold as individual items with little possibilities to modify the product and no designers are needed to assist end users. All which make this furniture vulnerable to copy and production in low labor cost countries.

Should the proposition that the level of MC adaptation has a positive influence on the prosperity of an industry sub-sector be true, then the industry should actively move towards MC.

Brief company description

Founded in 1977, Shermag Inc. designs, manufactures and distributes wood casegoods household furniture through different retail stores and major retail accounts in Canada and the USA. These activities are realized throughout a proprietary network of sawmills, component production plants, assembly plants, warehouses and distribution centres. Product design, marketing, sales and the support activities of finances, human resources and information technology are centralized in one headquarter. All its plants are located in Eastern Canada. Regarding annual sales, the company is ranked in the top 100 list of North American household furniture manufacturers (www.fdonline.com) and employs more than 1750 employees.

Table 1. Overview of company data.

	Company data
Name	<i>Shermag Inc.</i>
Address	Sherbrooke QC Canada
WWW	www.shermag.com
Year of foundation	1977
Number of employees	1300
Industry	Wood casegood household furniture
Products	Dinning rooms, bedrooms, gliders, sofas
Markets	USA and Canada

The previous section described the changes in the wood casegoods household furniture sector in the USA over the last nine years. The growing percentage of imports from China, the increasing US/CAN exchange rate and the consolidation of distribution channels have had a particularly heavy impact on the Canadian industry. To avoid an increasing loss of profit margins and strengthen the competitiveness of local plants, the company decided to pursue a strategy of MC, with new accessorizable and configurable products.

Aiming at a close to ideal MC proposition, these new products should be offered at almost the same price and with shorter order fulfillment time than regular products. The traditionally varietized, high volume mass produced items should then be gradually replaced in local plants by this new value proposition. This case study portrays the initial changes that have been made in one of the company's plants to adapt it to this new business model. The plant operations cover component production, assembly, finishing and packaging of bedroom furniture.

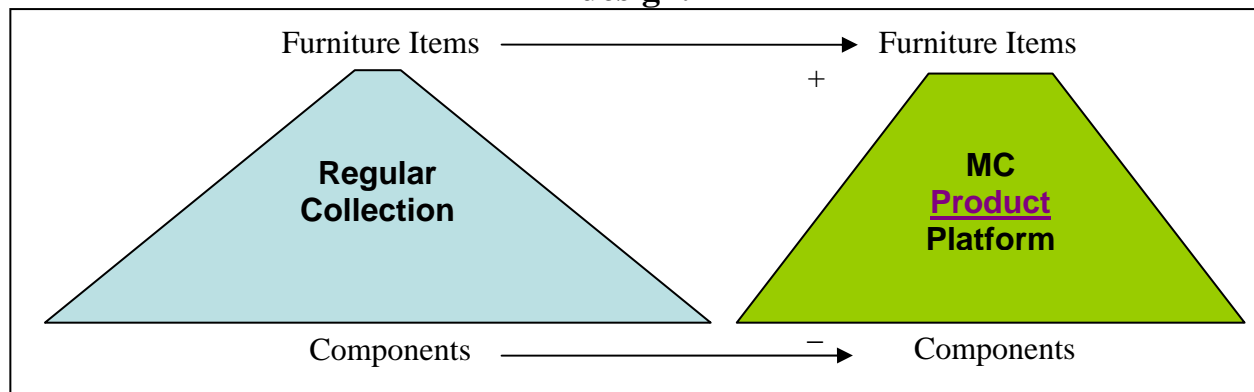
MC product

Bedroom furniture is industrially organized in collections. Each collection encompasses between 10 to 20 furniture items, such as beds, mirrors, drawers and armoires. The internal complexity of these items varies from 10 components in a mirror to more than 100 in an armoire. A regular, not customizable, collection can contain from 500 to 1000 components, with 10% of common parts within the collection and almost inexistent standardization among other collections. For these products, the customizable characteristic offered is the finishing color, generally in a range of three or four possibilities.

For the new products, two concepts were used in the product design process: product platform and component standardization. With these approaches, it was possible to design a collection that offers two times more items with 25% less components (Figure 5) and a fivefold increase in the percentage of internal common components. With this new structure, the final customer may choose between four furniture styles based on one product platform. The four styles show important aesthetical differences but have a high degree of structural commonality.

The new product also involved the participation of the suppliers of finishing material and hardware. The finishing color possibilities were doubled and it is also possible to choose between different types of hardware. This last possibility characterizes the accessorizing side of the product. The choices are made at the retail store and the sales staff has direct access to the company's ERP system via Electronic Data Interchange (EDI) to place the order. This allows the plant to see when an order enters and which retail store placed it. The final product is delivered to the company's distribution centres and then to the retail store.

Figure 5. Impact of product platform approach in the furniture collection design.



MC plant transition

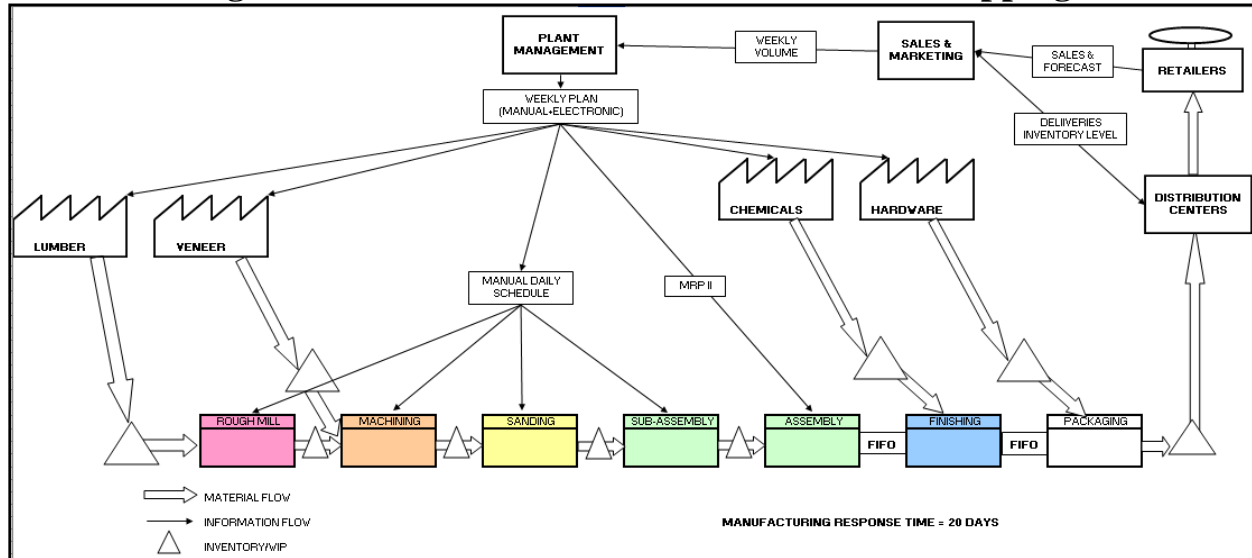
As previously mentioned this case study was conducted in one plant of the company. An action-research approach was adopted to help identify some of the changes that should be made at the plant level to sustain the new customized value proposition. This approach is characterized by a collaborative problem solving relationship between researchers and company professionals to solve real problems and to generate new knowledge, what is well suited to this type of problem. The concept of iterative action-research cycles proposed by Coghlan & Brannick (2002) was utilized. It is composed of four parts:

- i. Analyze current situation;
- ii. Define and plan the changes that have to be realized;
- iii. Implement the changes planned;
- iv. Evaluate the obtained results.

The nucleus of the action-research group was formed by the plant manager, the plant engineer and a PhD student in industrial engineering, who is one of the authors of this article. Constant interactions were made with the top management and other internal specialists when necessary. Visits to the plant were made during an eight month period in 2005. Five elements of the manufacturing plant were analyzed: layout, production technology, human resources, production planning and control (PPC) and performance indicators. The main actions taken in each of the four phases of the action-research cycle will be briefly presented in the next subsections.

Analyze current situation

The mixed-model value stream mapping technique proposed by Duggan (2002) was used in this first phase to identify and map the material and information flows in the plant. The plant ships items to distribution centers of the company and the shop-floor is divided functionally into the rough mill, machining department, sanding department, sub-assembly posts and a continuous conveyor sequentially encompassing the activities of assembling, finishing and packaging (Figure 6). The departments each contain several machines and work stations and the automation level is low.

Figure 6. Plant's current state value stream mapping

The plant has 80 unionized production employees, working in one shift. There is one supervisor per department, except for assembly and sub-assembly, which have a common supervisor. The plant management is composed of the plant manager, a production engineer and four technicians, responsible respectively for product improvement, quality control, planning and purchasing. The personnel in charge of maintenance, machine programming, industrial engineering and quality management are shared resources among several plants.

Four kinds of raw materials are feeding the plant at different production stages: lumber for the rough mill, veneer for the machining department, chemicals for the finishing department, and hardware and packaging material for the packaging department. The lumber and veneer suppliers are company owned. The chemical, hardware and packaging suppliers are outside suppliers and deliveries are made several times a week.

Regarding the information flow, once a retailer places an order, the Sales & Marketing (S&M) department verifies the availability at the distribution centers and schedules the delivery. The aggregated replenishment and production volumes are sent once a week to the plant management, who defines weekly and daily production schedules with the supervisors. Controlling of the processes prior to the assembly line is the daily responsibility of the supervisors. From the assembly line downstream, the PPC is realized with assistance of an ERP system, updated hourly. The regularly monitored performance indicators are the manufacturing response time, measured by the work-in-process level, the absenteeism and daily production in terms of sales volumes and workforce utilization based on standard-work levels. The critical indicator in this first action-research cycle was the current manufacturing response time that added up to 20 days and exceeded the company's objective.

Define changes

The plant's main goal was to reduce by 50% the manufacturing response time to have a shorter delivery delay. To face this operational challenge, the action-research group chose to set a decoupling point for the components of the configurable items prior to the sub-assembly operations. This initial choice for an assembly-to-order strategy for the products was in concordance with the suggestion of Astiazarán & Lakunza (2005). The processes regarding the

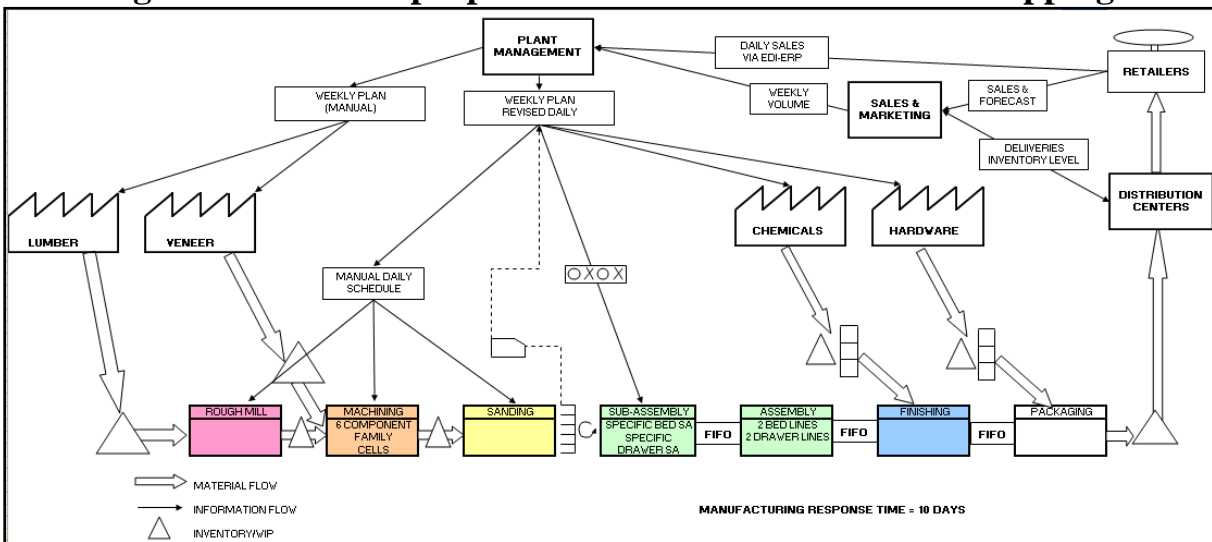
replenishment of customized inputs from finishing and hardware suppliers were not discussed in this cycle.

The plant management's first objective was to reduce and manage the inventory at the decoupling point at the minimum possible level. To reach this objective, three production management concepts were identified:

- Development and application of Kanban and pulled production routines prior to the decoupling point, as well as production management techniques to reduce lot sizes, balance and level the production scheduling;
- Application of total quality control techniques to assure the quality of the components at the decoupling point;
- Development of a culture of continuous improvement to help reduce costs and increase the efficiency of the plant.

This reflection generated an action plan regarding the plant layout, the production technology used, human resources, the PPC approach and the performance indicators. Figure 7 presents the future state value stream mapping proposed based on the discussions of the group.

Figure 7. Plant's proposed future state value stream mapping.



Layout: the need for higher flexibility drove a thorough study of the operations sequences and the product bills of material which suggested a reorganization of the plant layout for the departments of machining, sub-assembling and assembling. The machining department should be reorganized in work cells focused on component families. The sub-assembly work stations should be brought closer or integrated into the assembly line, which should be divided into four smaller segments, dedicated two by two to a specific item family (mixed model, mixed pace).

Production technology: changes or investments in machines and production technology were not identified as a priority. Some of the reasons were the identification of surplus capacity and the fact that maintenance and setup times did not substantially impact plant performance at that time. However, it was important to stress that the equipment utilized in all departments was labor

intensive. This means that variations in the number of operators directly impacted production capacity. This is one of the reasons why absenteeism was a key performance indicator.

Human resources: the reorganization of the machining and assembly departments increased the need for flexible and polyvalent operators. The union leadership should therefore participate in the decisions to validate and support the investments in shop-floor reorganization, communication and training of the employees. An agreement for employee polyvalence should also be signed. Considering the extreme importance of the workforce in the processes, training was a strategic issue. The new proposed training structure considered basic teaching of reading and mathematics, to fill educational gaps and help the comprehension of work instructions and technical formation on production improvement techniques such as kaizen, 5S, visual management and single-piece flow.

PPC: major challenges for PPC were related to real-time order entry and the management of the components warehouse for the customizable products. The orders of customized products should be added to the regular orders from the S&M department by the plant management. The employee responsible for the picking of components at the warehouse should receive the daily schedule from the supervisor and collect the components needed for each customized item. For each component, two ordering points were defined and identified visually in the warehouse. When the inventory level reaches the first ordering point, a card is sent to the planner by the employee responsible for picking the components. The component in the quantity defined by the card would then be added to the regular orders. The previous processes from rough mill to sanding in a push mode would then follow this new procedure. If a specific component in the warehouse reaches the second ordering point, a priority signal would be added to its production sheet.

Performance indicators: performance indicators should not be changed initially. Two new key indicators should be added, one to measure the on-time delivery of the personalized products and one for the quality of the products.

Implement the changes

These initial changes in the five decision areas were implemented all the while respecting the project time schedule. The union leadership supported the suggested modifications and the operators actively participated in the displacement of the machines. The new plant lay out had to be completed during the summer season when production generally slows down. This facilitated planning and reduced initial costs of implementation.

Employees were taught the basic concepts and tools of continuous improvement and lean manufacturing shop floor techniques by the plant's production engineer. An agreement was signed with the region school board to assure continuing education in literacy and mathematics. A flexibility agreement was signed with the union.

To assist the implementation of the new PPC system, the shared industrial engineer was assigned two days a week to the plant. No relevant unexpected events occurred during the implementation phase.

Evaluate the results

Once the plant management and the operators became familiar to the implemented changes, an open dialogue was carried out among the action-research group to evaluate the action-research cycle and the obtained results. At that time, the customized production level was 10% of the total volume.

The manufacturing response time, which was the critical indicator to be improved, decreased from 20 to 15 days. It was expected that as the employees would gain more experience with the

new production system and with the implementation of a continuous improvement structure, this number would continue to drop. Even if there is no quantitative measure, the plant manager agreed that plant flexibility has increased and that it became easier to make the daily production schedules.

One of the most important difficulties all along the study was the lack of process data, such as current production cycle times and setup times. This forced the group to make decisions based on experience, approximations and generalizations. The concept of continuous improvement aims to close this gap by measuring the key data necessary to evaluate the plant performance in a structured manner.

As the entire layout changes were carried out at the same time, the production engineer became overwhelmed with the supporting activities. This overload negatively affected the revision of the existing performance indicators, as well as the development of the new ones. The main learning from the negative points of this cycle was that the engineering workload related to layout changes cannot be underestimated and also that the necessary human resources should be carefully planned. Although this limitation had been identified in the definition phase, with postings for two additional jobs - setup time reduction and operations management - none of them was hired until the end of the cycle.

MC capabilities

Although this case study discussed the implications of a MC strategy at the production level, several organizational capabilities were developed simultaneously. As these efforts are recent and the MC level is not high, it is still difficult to assess their real impact. The study highlights some of the challenges of introducing a MC strategy in an industrial sector that is associated with traditional ways of operating and thinking and that had not faced major and dynamic competition for a long time.

The company has showed a commitment to make improvements and change the current situation. Nevertheless, isolated efforts were being done throughout different activities and opportunities remain for greater integration among them. The cellular phone case study conducted by Comstock *et al.* (2004) demonstrates a similar situation.

The new product design structure follows a learning process to gradually integrate several disciplines in development activities. The introduction of the first customized products in the plant was delayed and the production instructions presented errors that had to be corrected. The integration of more disciplines earlier in the design activity would reduce the errors and the development cycle time for new customizable products. Opportunities to increase product modularity could also be considered in light of the new plant layout.

The integration of the retailer through EDI and the ERP system allowed an assemble-to-order approach. Improvements in manufacturing technology and production management can make it possible to pursue a make-to-order approach, pushing the decoupling point upstream in the value chain to component production or even to the rough mill.

The external suppliers of chemicals and hardware are responsible for managing the total inventory of new customizable supplies. The inventory inside the plant is kept at a constant total level, with regular supplies based on electronic Kanban orders. The supply of veneer is based on both regular and customized orders. Lumber supply has not changed. This process could be improved by regular interchanges with external suppliers.

The high dependence on the work force and the need to have flexible and committed employees led the plant manager to develop his human resource management competencies further. To help and recognize these efforts at an organizational level, the performance measurement system should also be revised. For instance, the WIP costs are currently considered uniform all along the

value chain inside the plant. The same cost is assigned to a rough milled component and to a machined and sanded component. That does not stimulate an effort to improve and push the localization of the decoupling point upstream.

The plant started to track all the customized orders by client, color and furniture item. That information is used to control inventory level and to create customer profiles. To take full advantage of that information, the marketing department should be involved. Further integration of the areas of product design, IT, production management, performance indicators, supply chain management and customer knowledge would increase the company's MC capabilities and facilitate direct sales to the final customer.

Case assessment

This study presents the initial steps of a wood household furniture company to introduce an MC product in its mass production (MP) system. Differently from the studies conducted by Kotha (1996) and Astiazarán & Lakunza (2005), who addressed a mix of MC and MP over a ten year period, the complete change is not captured in this research. The analysis of an incomplete and ongoing change process could show the constraints and doubts that arise during such a complex change. The objective of this research was to help, understand and document some of the changes being made in a furniture plant relatively to an evolution towards MC. It also highlighted the wide and deep implications of an MC strategy in a manufacturing company.

Plant management has made some changes to improve the material and information flow on the shop-floor by increasing production and employee flexibility. The most important difficulties faced were the lack of historical and current production data and the limited amount of time that the involved people were able to assign to the management of the change process. They were not fully dedicated and pursued their production management routines in parallel.

The case highlights two elements rarely discussed in MC implementation studies: human resources and performance indicators. The participation of the union and the importance of achieving a flexible employee agreement were fundamental. Although complexity management or cost effective product variety management (De Alwis *et al.*, 2005) have already been identified as key capabilities for MC, they have not yet "reached full awareness of practitioners" (Moser, 2005). The choice of significant performance indicators is tightly coupled with this capability, especially in typical mass production environments, where the performance measurement is traditionally based on equipment and resource utilization, rather than on client satisfaction or agreement with the production schedule. An incongruent choice on the key performance indicators can limit the efforts to pursue an MC strategy. As a limit to the case study, it should be noted that only one complete cycle has been performed. Despite being based on a single company, this case describes the current situation of a large number of plants in this industrial sector in North America. It may therefore be stated that the integration of activities and the development of MC capabilities are a great challenge for the North American wood household furniture industry.

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