CUSTOMIZATION: A KEY COMPETITIVE FACTOR IN THE NEW ECONOMY

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ABSTRACT
This paper discusses the advantage of using kanban, postponement, modularization, just-in-time, production sequencing, milk-run and cross-docking by companies that intend to increase their flexibility, agility and reliability in order to support web-based businesses. It presents the results of a survey that was carried out with more than 600 manufacturing companies in the state of Sao Paulo, Brazil, and evaluates the changes that are taking place in operations, in order to make companies better suited to provide customized products that are made to meet the individual requirements of each customer.

Key-words: Internet, customization, personalization.

INTRODUCTION
The possibility of the customers personalizing products, choosing the desired configuration among the options made available through the Web site of the company, changes the logic of any manufacturing process, as the product doesn't need to be available for prompt delivery and can be made to order. As a consequence of that, some production methods and techniques (which aren't new) become more relevant than before, because they are well fit to e-businesses. Among such methods and techniques, this paper will deal with some of those that allow for the production of customized items, with flexibility of volume and mix, faster cycle times and more reliability. Those are performance criteria that are valued by customers, according to Slack *et al.* (1999), and which are emphasized in e-business.

The advantage of using *kanban*, *postponement*, *modularization*, *just-in-time*, production sequencing, *milk-run* and the consolidation of materials/products for transportation will be discussed here, as they all relate to the possibility of offering more flexibility, speed and reliability to operations.

Then, we present the results of a survey that was carried out with manufacturers in Sao Paulo, the most industrialized Brazilian state, whose purpose was to understand the way such companies are incorporating the use of the Internet to their competitive strategy and their daily business practices. The paper focuses on the evaluation of the responses with respect to the methods and techniques that could help organizations to pull the production of customized items.

METHODOLOGICAL APPROACH
An electronic survey was sent to all manufacturers contained in FIESP's database, which had a valid e-mail address. 655 usable responses were obtained, corresponding to a return rate of ca. 8%. The structured questions followed a Likert scale. Participants could choose from a list of alternatives presented in a *drop-down* menu, which made the process of filling in the questionnaire very fast and easy.

The questionnaire was pre-tested, with respect to the content, having been presented to a group of executives working in the field, who conveniently happened to be taking one of the author's graduate courses. They gave important contributions that made questions more accessible and understandable to the "actual" participants, in a later stage. With respect to the format, the authors randomly separated one per cent

of the whole database and sent the questionnaire to those companies a month in advance. No changes in format were necessary, after the pre-test answers arrived and, by the time the larger group of companies was invited to participate in the survey, the researchers already had a reasonable idea of the return rate that could be achieved, based on the return rate of the pre-test sample.

There were questions about technologies, methods and techniques that the organizations use or intend to use in the future. Tabulated data were handled using Excel and Minitab, for the generation of graphs and statistics.

As the study was conducted based on a convenience sample of companies that agreed to respond to the questionnaire, it should be highlighted that any inference about the behavior of the population of industrial companies in the country is dangerous. That represents a limitation of the study. Even so, demographic data on the companies comprising the convenience sample were roughly compared to data on the population of manufacturing companies contained in FIESP's database, as a whole. The authors have no reasons to believe that the sample they obtained is not representative of the population.

MASS CUSTOMIZATION AND PRACTICES THAT MAKE IT FEASIBLE

There is a trend, which started developing much before the Internet appeared in the business scenario, of production process automation, particularly in the case of manufacturing companies. The use of information systems has, recently, allowed a more flexible kind of automation, also making it possible for some sort of personalization of the products to be manufactured, based on information made available to the operation from databases. The Internet has a magnifying effect with respect to the level of possible personalization, because the customer can directly interfere in the process, feeding those databases and, consequently, the production system with specific data related to individual needs. This changes the dynamics of manufacturing, which can really benefit from techniques and practices, such as mass customization, kanban and postponement, as will be discussed ahead, in order to offer flexibility and agility.

Mass customization is an attempt to achieve the benefits of scale economy and customization at once. It can be obtained as a result of the design of modular products, capable of being rapidly configured according to the customers' taste, without that representing a burden to the production process.

Some companies attempted to use production systems that were capable of manufacturing customized products, adjusted to specific needs of individual customers, without giving up the advantages of scale production, as early as the beginning of the 1990's. Levi's even conceived a business model, in which customers visited a department store, took their measures, chose the cloth, paid for the product and went home, to wait for the pair of jeans to be delivered to their home address. The retail employee was able to transmit the required information for the production of the "almost" tailor-made product from a computer terminal in the store, directly to Levi's production line, allowing for "pulled" production of the item, according to the actual demand (McKenna, 1995; Peppers, 1998). Unfortunately, Levi's ended up abandoning the project, because it was not able to manage the conflict of interests with retailers, who felt threatened by the new trading model, which could exclude department stores from the deal, in the future.

Working with a direct sales model, Internet operations such as North-American Land's End and Brazilian shirt shop Closet.com.br now insist on the tailor-made (customized) clothes mass production.

The clothing industry is just one of the sectors in which the Internet promises to be a key element for the sale of customized products, produced in scale. There are many web sites today that allow customers to configure product and trigger the production process from the comfort of their homes. Some examples are car assemblers (GM's Celta operation in Brazil was designed to assemble cars to be sold primarily through the Web), computer assemblers (Dell's expertise with direct sales was easily converted to the new media), bicycle factories (sevencycles.com asks all sorts of questions about the buyer's cycling style and ergonomics, in order to specify the right product), shoe manufacturers (nike.com and other competitors allow customers to customize products, which are then made to order and delivered to the customer's address), doll manufacturers (MyTwinn.com customizes dolls to resemble the owner's looks) and even candy shops (M&Ms allows Internet customers to choose colors and even monograms to be printed on chocolate chips).

From the manufacturer's point of view, mass customization is attractive due to several reasons: as products are made to order, there is no need for stocking finished goods; as the customer defines the features and the configuration of the product, there is better alignment between what is needed and what is offered; the product or service has more value to the customer, who may be willing to pay more for it, as a result of the better alignment of offer and needs; and customers who place personalized orders help the manufacturer to better understand the market, improving its planning also for the mass market.

From the customer's point of view, the major advantage is to receive a product or service that is better adjusted to one's needs. Of course, this advantage comes along with an increased effort to configure the product. Therefore, the company has to make sure that the required effort is kept as low as possible. Customers won't be interested, if the effort is higher than the perceived improvement in the results.

In spite of all the advantages, there are difficulties that need to be overtaken, so that customization can definitively be incorporated to production processes: made to order production, which usually is associated to customization strategies, reduces the possibility of efficient use of the manufacturing system, as warned by Steger-Jensen and Svensson (2004). That increases costs and production complexity.

For customization to take place, at manufacturing time, without great efficiency loss, the product needs to have been conceived with that purpose in mind. It is also important to develop production processes that allow for a good balance of inventory, equipment and labor, in order to achieve a reasonable environment for build-to-order production. The system needs to have been designed to be lean, capable of producing only what the customer wants and when s/he wants it (TREBILCOCK, 2004).

Kanban

Traditional manufacturing production involves pushed processes. That means that each link in the value chain , after having carried out its activities, dispatches the result of its work to the next link downstream, regardless of any request in that sense. This type of production system generates *work-in-process* inventory whenever there is any production capacity unbalance or whenever there is any unforeseen interruption of work anywhere along the chain. Another inconvenient issue is that those involved in the production don't get to know if, and at which rate, the result of their work is being used by production stages ahead.

After the 1970's, especially as a result of Japanese influence, manufacturers started adopting the philosophy of pulled production, in many areas. Among the advantages of such approach are the reduction of inventory levels and better understanding of production process problems that need to be overcome and of the market.

The tool that was developed by the Japanese to signal the need of additional parts to be processes and to ensure that they are manufactured in due time, in order to replenish the next production/assembly stage is kanban (SCHROEDER, 2000). This technique consists on the use of cards or other visual records presented to the supplier to warn it that the production/delivery of items under its responsibility needs to be resumed.

Although, at first sight, this production system seems to make the operation more vulnerable to problems in the production process, that doesn't happen in practice. As the process needs to be fault free, because the results of any failure would have direct impact on the organization's ability to fulfill customers' requests, those involved pay much more attention to the reliability of the production process. In addition to that, kanban ensures that only products for which there is demand are manufactured, a key issue in business environments where the consumer is in control, as in a typical Internet purchase situation.

Postponement

Sometimes, companies find it interesting to organize their operation in a way that part of the production process is pushed and the remaining is pulled by the customers. Slack *et al.* (1999) refer to the pushed part of the production process as being the speculative stage. After the customer tells exactly what s/he wants, defining the product or service to be produced, the operation performs its activities in a firm order manner.

The reason to use a mixed approach, i.e., pushed-pulled, is to try to achieve the best of "both worlds". On one hand to ensure that the customers receive what they want in a diligent and efficient way, even if unpredictable situations happen (an advantage of pushed production). On the other hand, to benefit from only making production decisions after the customer has manifested his/her interests (a benefit of pulled production), allowing for the personalization of the product. The strategic decision to be taken when a pushed-pulled production system is adopted is to define what to postpone, i.e., to determine the frontier between the pushed and the pulled part of the operation. That represents the point after which the product can be differentiated, depending on specific demands (COTTRILL, 2003).

In order to make it easier to determine the point after which to differentiate the product, and thus the stage after which work can only be performed after firm orders are placed, modular design may be used (see next item).

A good postponement strategy may prevent the cycle time for delivery of customized products from becoming much longer than the time required to deliver mass production items (CSILLAG e SAMPAIO, 2002).

Postponement is a particularly useful technique to reduce cycle times to "spoiled" customers, who find it very easy to configure and order products through the Web and think that the seller should be able to manufacture, transport and deliver the product with the same diligence and agility.

Postponement also contributes to the reduction of the operation's uncertainty level, considering that part of the decisions are transferred to a moment after the customer expresses his/her wishes and needs, reducing the speculation about the demand's behavior. The concept may be extended to several activities, depending on the type of uncertainty one wishes to reduce or eliminate. It is possible to postpone the development of the product, the purchase of materials, the production or assembly, packaging, labeling or distribution (ZINN, 1990; YANG, BURNS e BACKHOUSE, 2004).

Modular designs, as discussed next, make postponement easier, because the production of modules may be carried out in a "pushed" manner, while assembly may be "pulled".

Modularization

For Baldwin and Clark (1997), modularity means creating a complex product or process having smaller subsystems as the starting point, which can be designed in an independent way, in spite of working together as one only thing. The development of modular projects allows for a large mix of products to be obtained from just a few components (SCHROEDER, 2000).

Modularization helps to introduce mass customization and other strategies that allow for more flexibility in the operation. The concept is not new. In the 1960's, Starr (1965) already argued that products should be made of pre-assembled modules in order to optimize final assembly and also to contribute to diversified output, without significant impact to costs. The simplification of the assembly process, resulting from fewer modules (as compared to single parts) allows for faster assembly. Modularization makes postponement feasible, i.e. final production/assembly can be delayed until there is demand for a specific item. That results in inventory savings. Modules can be conceived to allow for different versions of the product, which can be assembled according to customers' diversified needs.

The more recent concept of mass customization is a powerful business proposition, when modularity's potential is leveraged by the use of the Internet as a channel for direct communication with consumers.

MASS CUSTOMIZATION AND PRACTICES THAT MAKE IT FEASIBLE

The practices that are presented next, although not having their performance directly affected by the Internet, except for the improvement of communication with business partners, are important within the new scenario of Web based operations, in which customers request personalized products that need to be designed, manufactured, assembled and made available to consumption in short periods of time.

Just-in-time

In many cases, better information sharing may effectively replace the flow of goods, to be produced/assembled closer to the consumer. The impacts of the use of the Internet and other IT will also be noticeable in decisions on inventory level (SKUs) and the location of production and inventories.

Changes may also take place in the products themselves, the production processes or the way business partners coordinate their activities in order to produce and deliver products to the consumers. Sophisticated logistics schemes will be used, which will only be possible thanks to better coordination and integration of the parties involved in the provision of materials and parts, production and distribution of finished goods. Techniques such as *parts sequencing*, in the production line, *milk-run*, in the inbound logistics and *cross-docking*, in the distribution of products, become important, in order to ensure competitiveness in the new scenario. All those practices contribute to the achievement of a *just-in-time* operation, which becomes more relevant now that customers started designing and customizing the products they wish to buy through the Web.

In order to work according to the *just-in-time* philosophy, a company needs to keep inventory levels as low as possible, but that is just a way to achieve *just-in-time*'s major objective, which is to ensure continuous improvement (MORTON, 1999). The reduction of inventory levels is necessary because high levels of inventory disguise quality problems and inefficiencies, machinery break-down issues or set-up problems (CORRÊA e GIANESI, 1993). JIT's emphasis on reducing inventory levels intends to make such problems evident, allowing for their identification and correction.

Production sequencing

Sequencing procedures intend to make sure that the right parts or modules are made available to the production/ assembly line at the right time and in the right order. *Just-in-time* involves the supply of a specific item at the time it becomes necessary. *Just-in-sequence* takes that concept beyond: it involves not just precision with respect to the timing, but also the sequence in which items are handed in to the production process, to meet specific needs with respect to the item being processed (Automotive answers the "made-to-order" call, 2004).

Milk-run

Traditionally, suppliers deliver materials, parts and components that they produce, dimensioning volumes to be transported according to the convenience of the transportation equipment and not based on the customer's immediate needs. That may disturb the customer's inbound logistics, causing large concentration of vehicles in the inbound logistics yard; peaks of vehicle concentration at delivery times; lack of reliability in the delivery of components; and need of physical space to store items that can't be immediately sent to the production line.

Milk-run is a system for the collection of materials or distribution of finished goods (WOOD, 2004). In the case of its application to inbound logistics, a single equipment is used to collect materials from several sites and to deliver them to the destination, respecting pre-established schedules (collection/delivery windows).

Although milk-run is usually used with the purpose of reducing the delivery batch size, allowing for a better match of supply to demand, load consolidation can also be used to reduce logistics costs. It may not be wise to use *full truck load* (FTL), just to reduce transportation costs, but it is also not reasonable to transport *less than truck load* (LTL), just to reduce storage, handling and financial costs.

In an attempt to optimize external logistics costs (transportation), as well as the internal logistics costs (storage and handling), companies may choose to consolidate loads, i.e., to use a single equipment to perform the transportation of two "half-loads" coming from nearby suppliers.

Milk-run reduces the quantity of an item that needs to be transported at each trip, while it increases the frequency of deliveries. That contributes for the operation to work with lower levels of inventory, which is especially good for organizations that make at least part of their production to order. As it stimulates pulled operations, it suits well companies that sell products through the Web, which do not need to have the product readily available when the customers demand them, but still have to be quick in addressing customers' needs, so that they don't need to wait long for their orders.

Cross-docking

Sometimes, particularly when the suppliers are far away from the customer but close to one another, it may be interesting to use a consolidation center close to the suppliers. Reid and Sanders (2004) call *transport cross-docking* the consolidation of LTL loads and small size items with the purpose of achieving transport scale economies. The increase in frequency of trips between the consolidation center and the customer makes it possible to reduce inventory levels and work closer to a *just-in-time* situation, without great impact to overall transportation costs.

Another reason for the use of a warehouse to receive and consolidate loads of materials and parts prior to the delivery to the operation is to ensure *just-in-time* delivery to the production line, which is known as *manufacturing cross-docking* (REID e SANDERS, 2004). In this case, it is more common for the warehouse to be located closer to the manufacturing facilities, in order to reduce transport time uncertainties. Such warehouses are also used to perform sub-assemblies, consolidate kits of parts and organize parts to be delivered *just-in-sequence* to the plant.

FLEXIBILITY AT THE RIGHT MEASURE

The production process and the product need to be designed in a way to provide the required flexibility during fabrication, so that customers gets what they want, i.e., product features that were configured by them from the comfort of their house, using the Web.

Care should be taken, when developing flexible products/services and processes, in order to allow customization for (or by) the customer in a sensible way, defining the right level of flexibility to be provided.

Flexibility in excess may puzzle the customers, making it difficult for them to decide and also increasing the costs and complexity of the production process. Although people want to emphasize their individuality and to be in control of the purchases they make, in practice, one realizes that people aren't so different from one another, after all. Even when companies offer a great mix of products from which to choose, people use their "individuality" and their "free will" to choose very similar items to those chosen by other consumers. Companies need to be warned against the danger of over-flexibilization of production processes and products.

Simple products may be easily mass customized without much problem: mouse pads, pens and key-rings that are distributed as gifts by companies are a good example of that. However, most such items don't allow for functionality customization. Only "cosmetic" changes to the looks are possible. To customize the functionality is more difficult. Quality perception of a product, after it is used, usually relates to its functionality and not to its appearance, although appearance may have been important to determine the purchase. If a great level of customization is allowed, including functionality customization, functionality may even be reduced due to the

customer's intervention, as the average customer is not well prepared to take decisions on product engineering. A good example of that is the dilemma faced by the manufacturer of a precious stone cutting equipment, whose customers whished more flexiblility, so that they could define any cut they wanted. The manufacturer, however, alleged that, although there were no engineering restrictions that prevented the company from providing the flexibility the customers wanted, such flexibility would be harmful to the customers, as they would waste a lot of material, attempting to perform technically unfeasible stone cuts (POLLACK, 2002). In that company's opinion, the cutting system should only allow customers to configure the product/service to the extent it still provided good results, in order to avoid unhappy customers due to their own choices.

In brief, flexibility in excess may puzzle the customers or generate stress, due to the quantity and difficulty of the choices tinvolved; it may also reduce the functionality of the product/service and generate additional production costs, which surpass the benefits provided by the possibility of meeting specific needs. Therefore, organizations should be guided to choose the right level of customization to offer to their customers, taking into consideration the risks involved in providing flexibility in excess.

RESULTS OF THE SURVEY

Next, we present the results of the survey that was carried out with more than 600 Brazilian manufacturers, asking them about several practices that impact the way they manufacture their products, with special focus on the possibility to offer customized products, in order to meet specific demands of each customer.

Just-in-time

Large companies that participated in the survey use *just-in-time* to a greater extend than smaller ones, although the difference is not so significant. Thirty per cent of the large companies use *just-in-time* at least moderately. Among mid-size companies, 26.1% do it, while small companies use *just-in-time* even less frequently (only 11.8% of them use *just-in-time* at least moderately, as shown in **Figure 1**).

Customization/configuration of products

Among large companies, 18.2% consider that the impact of the Internet and other IT on the configuration/ customization of products was at least moderate, along the last 3 years (see **Figure 2**). This percentage is slightly smaller for mid-size companies (17.1%) and, curiously, a little higher for small ones (20.8%). Originally, the authors thought that, maybe, smaller companies were benefiting from the opportunity to offer better suited products to individual needs, assuming that they are more dependent on their customers, individually, and, therefore, need to pay more attention to their specific needs. This reasoning doesn't survive the analysis of the current use of customization by the participants, though. The companies that claimed they made the most intense use of customization were the mid-size ones (**Figure 3**), precisely those that stated that the impact of customization was the least, along the last 3 years. Mid-size companies that use customization at least to a moderate extent represent 32.6% of the sample. For large companies, that percentage was 26.3% and for small ones, 23.3%. It was not possible to identify the reasons for this apparent inconsistency in the data shown in **Figure 2** and **Figure 3**, which is an interesting topic for future research.

Product modularization

When analyzing the information provided by the respondents about modularization, one thing that called the authors' attention was the fact that large companies consider it much more important than smaller ones (19% of large companies claimed that they used modularization at least to a moderate extent, while mid-size companies and small companies presented much lower percentages: 9.9% and 7.3%, respectively). The percentage of mid-size and small companies that said that they don't intend to use modularization within the next 3 years or that consider it doesn't apply to their businesses was very high: 69.4% and 67.3%, while 38.1% of the large companies have the same opinion), as can be seen on **Figure 4**.

Manufacturing Postponement

As can be seen on **Figure 5**, the level of use of manufacturing postponement is very low for mid-size and small companies. For large companies, 18.8% use this practice at least to a moderate extent. The percentage of companies that believe the technique doesn't fit their business is large.

As it was expected, the graphs that were obtained for the use of modularization (see **Figure 4**) and postponement (see **Figure 5**) are very similar, and that didn't happen for nothing: modularization makes it easier to adopt postponement, as it defines more clearly the point after which the production process will be "pulled", i.e., the point where modules are going to be connected to one another to form different possible configurations of finished goods.

Milk-run

The use of milk-run by the companies that took part in the survey was insignificant. Though a few respondents mentioned using it a lot, considering it essential to their businesses, they were percentually irrelevant.

In fact, that was somewhat predictable. Although the technique is useful for operations that intend to keep low levels of inventory, adopting just-in-time supply, it presents specificities that make it only suitable to very specific circumstances. Besides, its introduction in the country only happened in the last few years. Thus, it wasn't a surprise to find out that the majority of the surveyed companies doesn't use it, neither intends to use it within the next 3 years. Only 5.5% of the large companies, 6.0% of the mid-size ones and 4.2% of the small ones use the technique at least moderately. The percentage of companies which intend to start using it along the next 3 years is also modest: 5.6% of the large, 7.8% of the mid-size and 8.1% of the small ones. Most companies consider the technique is not useful for their businesses or just don't inted to start using it in the near future (77.8% of the large companies, 81.9% of themid-size ones and 82.9% of the small ones).

Cross-docking

Analyzing the answers to the question about cross-docking, one realizes that small and mid-size companies give very little importance to it, differently to large companies. Only 1.8% of the small companies use cross-docking at least moderately and only 9.6% intend to start using it within the next 3 years. 87.1% of the small companies don't intend to use it in the near future. For mid-size companies, figures aren't much different: 4.0% use it at least moderately and 6.0% intend to start using it within the next 3 years. 84.0% do not intend to use it. Large companies, in their turn, though still not using cross-docking intensively (only 12.5% of them make at least moderate use of the practice), are more receptive to it: 25.0% say they intend to start using it soon. 37.5% consider that it is not suitable to their businesses or don't intend to use it in the next 3 years.

Figure 1 – Current use of just-in-time and perspective of future use

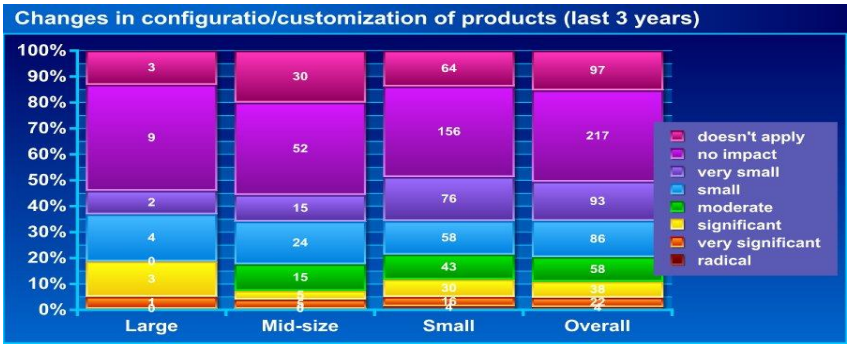

Figure 2 – Internet's impact on product configuration/customization along the last 3 years

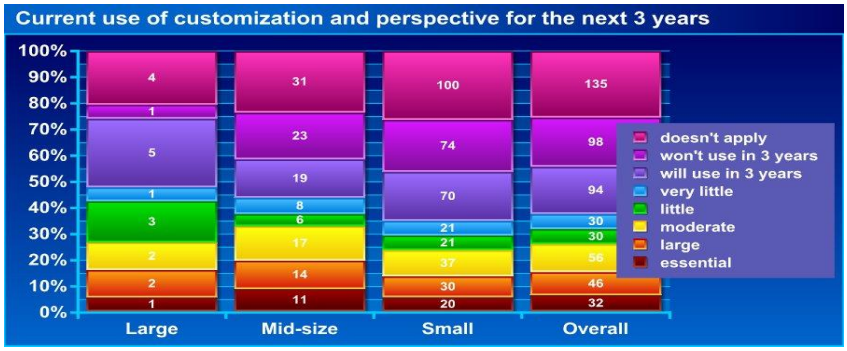

Figure 3 – Current use of customization and perspective of future use

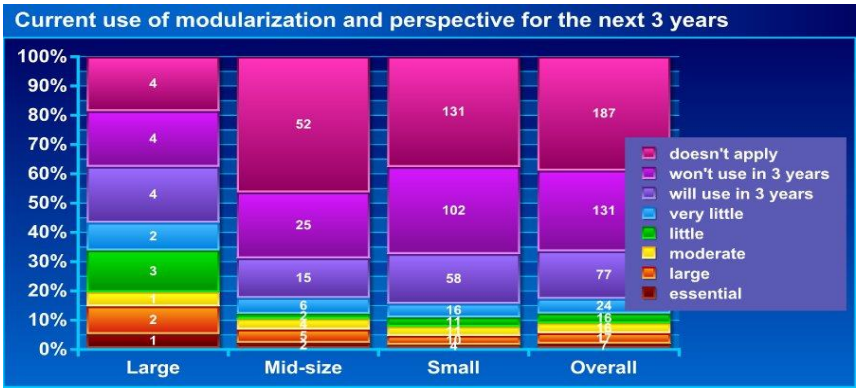

Figure 4 – Current use and perspective of future use of modularization by manufacturers in Brazil

Figure 5 – Current use and perspective of future use of postponement by manufacturers in Brazil

PREDICTION OF CUSTOMIZATION LIKELIHOOD

As it was said before, customers are each time more demanding with respect to the fulfillment of specific needs and organizations. The literature review that was carried out, as well as the authors' experience with the issue, indicate that to deliver customized products, or products that the customers can configure through the Web, companies need to modify their processes to become, simultaneously, more flexible and more agile. Several practices that can contribute towards those objectives have been discussed, as well as their impacts on the organizations' performance objectives.

Having collected data on many different variables, the authors attempted to determine the extent to which it was possible to predict a company's likelihood to perform manufacturing customization based on production and logistics techniques it uses. In order to do that, several multiple linear regressions were calculated.

The two independent variables that, on their own, provided the best explanation of the level of customization adopted by the surveyed companies were "*modularization*" (21.2%) and "*postponement*" (19.6%). As the two variables are highly correlated (0.608), though, when they are used together in order to explain the "*level of customization*", the degree of explanation (R-Sq) is much lower than the sum of isolated contribution of each variable, not going beyond 25.6% (<< 21.2% + 19.6%), as shown in Minitab's output.

```
Customization = 1.30 + 0.415 Modularization + 0.373 Postponement
Predictor          Coef     SE Coef          T        P
Constant         1.2966      0.1329       9.76    0.000
Modularization  0.41484     0.07714       5.38    0.000
Postponement    0.37348     0.07938       4.70    0.000
S = 1.991       R-Sq = 26.0%     R-Sq(adj) = 25.6%
```

Variables *postponement* and *just-in-time*, on their turn, represent practices that are partially conflicting to one another. *Postponement* involves delaying tasks that do not contribute to the differentiation of the product, which are the only ones performed in a pulled way. The authors found it impossible to eliminate variable "*just-in-time*" or variable "*postponement*", keeping the other variable in the equation, without loosing predicting capability (around 5%). This probably results from the fact that some companies that customize products do it by following a just-in-time production logic, i.e., they work in a make-to-order manner. Other companies do it by postponing distinguishing steps.

The linear regression model that provided the best explanation for the dependent variable "*level of customization*" was the one that involved, in addition to variables "*modularization*" and "*postponement*", also variables "*just-in-time*" and "*virtual intimacy*", as shown in Minitab's output, below.

```
Customization = 0.714 + 0.372 Modularization + 0.248 Postponement
              + 0.213 Just-in-time + 0.195 VirtualIntimacy
Predictor          Coef     SE Coef          T        P
Constant         0.7141      0.1630       4.38    0.000
Modularization  0.37176     0.07797       4.77    0.000
Postponement    0.24804     0.08264       3.00    0.003
Just-in-time    0.21307     0.05386       3.96    0.000
VirtualIntimacy 0.19474     0.06601       2.95    0.003
S = 1.887       R-Sq = 33.4%     R-Sq(adj) = 32.7%
```

The independent variables that were selected were able to explain 32.7% of the behavior of the variable "*level of customization*". R-sq was the statistics used for that (Hair *et al*., 1998). Although this is not a significantly high value, it is enough to demonstrate the interconnection of the independent variables that were chosen in the regression and the level of customization adopted by the companies. The company's size didn't seem to be a relevant variable in this case, according to the regression model.

MANAGERIAL IMPLICATIONS AND FINAL CONSIDERATIONS

The adoption of manufacturing and logistics techniques that provide greater production flexibility is a must, at least for companies that intend to offer greater variety of output, something that is highly stimulated by the use of the Internet as a new sales channel. Customers are now able to configure products and choose the intended functionality, directly from the company's web site. But companies need to be cautious about the possibilities provided by the Internet, as remind Keenan *et al.* (2002). After all, the Web may be a good way of finding customers willing to buy made-to-order products. However, restructuring a traditional plant to cope with a great number of variations of each product, keeping quality standards and meeting individual requirements isn't a simple task. It requires careful planning. The product and the production process need to be conceived, from the beginning, with that purpose in mind. Ruddy (2002) stresses that, at the same time that for the customer mass customization means the possibility of having specific needs taken into account, quickly and for a reasonable price, for the manufacturers it means developing a sophisticated infrastructure, involving suppliers, the company and its customers as co-developers of the desired products.

Comparing the data contained in **Figures 2 and 3**, referring to *customization*, with those contained in **Figures 4 and 5**, referring to *modularization* and *postponement*, one realizes that, curiously, companies are more concerned with the possibility of providing product/service customization that with the need to adopt manufacturing techniques that would allow that to happen in a more efficient way. Maybe they are already noticing changes in their customers' behavior and are attempting to respond to the new demands, without more deeply reflecting about the adaptation of their production processes for that.

Large companies are ahead of the others with respect to the adoption of the researched practices, which may provide more flexibility to production and logistics, required for efficient mass customization. Thus, they represent a possibility of benchmark for smaller companies, although they also need to develop better skills in that sense.

The authors believe that the adoption of practices that provide more flexibility to operations will intensify along the next few years, at least for companies that start offering more output variety, a feature that is stimulated by the use of the Internet as a sales' channel for products and services. But this trend will surely not be restricted to companies that choose to sell through the Web. The Internet is teaching customers that it is possible to get products that are better fit to specific requirements. Customers will expect to find compatible levels of service also when dealing with traditional brick-and-mortar companies.

Thus, the relevance of the discussion about the techniques and practices that were presented here goes beyond their impact on businesses that are solely based on the Internet. It is also important for all other forms of doing business. As our society assimilates the Internet as a way for people and companies to interact and do business, the expectations that develop for that media are transferred, even if partially, to traditional channels. Customers will demand more flexibility also from traditional businesses, due to the inevitable comparison with e-business.

Businesses that are solely based on the Web need to become faster and more reliable, in order to compete with the traditional businesses with respect to those criteria. Traditional businesses, in their turn, need to review their production processes to increase flexibility and mix, performance criteria for which virtual businesses usually have better performance. The methods and techniques discussed in this paper may help companies that make products to order to improve speed and reliability, making them more attractive to the customers' eyes. On the other hand, they may also improve the flexibility of traditional businesses, in order to keep their competitiveness when faced with the possibility of customization of products by the customer, which the Internet is making each time more popular.

REFERENCES

Automotive answers the "made-to-order" call. *Modern Materials Handling*, v. 59, n. 5, p. A3-A11, May, 2004.

BALDWIN, C. Y. e CLARK , K. B. Managing in an age modularity. *Harvard Business Review*, n. 75, p. 84–93, 1997.

CORRÊA, H. L. e GIANESI, I. G. N. *Just in time, MRP II e OPT*. São Paulo: Atlas, 1993.

COTTRILL, K. Cutting edge. *Traffic World*, p. 1, Jul 21, 2003.

CSILLAG, J. M. e SAMPAIO, M. *O conceito do postponement como estratégia de distribuição: estudo multicaso no mercado brasileiro*. São Paulo, FGV-EAESP, 2002.

HAIR, J. F., *et al. Multivariate data analysis*. Upper Saddle River: Prentice Hall, 1998.

HANNON, D. Preparing to consolidate inbound shipments. *Purchasing*, v. 132, n. 8, p. 139-141, May 1st, 2003.

KEENAN, F., *et al.* A mass market of one: As custom online ordering moves into the mainstream, Web merchants learn to fine-tune their trade. *Business Week*, n. 3810, p. 68, Dec 2, 2002.

MCKENNA, R. Real time marketing. *Harvard Business Review*, Jul/Aug, 1995.

MORTON, T. E. *Production operations management*. Cincinnati: South-western/International Thomson Publishing, 1999.

PEPPERS, D. A empresa um-a-um. *HSM Management*, p. 6-14, maio/junho, 1998.

POLLACK, S. *Re: Mass Customization*, Jan 4, 2002.

REID, R. D. e SANDERS, N. R. *Operations Management*. New York: John Wiley & Sons, 2004.

RUDDY, M. Mass customization now closer than ever. *Machine Design*, v. 74, n. 12, p. 59-61, Jun 20, 2002.

SCHROEDER, R. G. *Operations management: contemporary concepts*: McGraw-Hill, 2000.

SLACK, N., *et al. Administração da produção*. São Paulo: Atlas, 1999.

STARR, M. K. Modular production - a new concept. *Harvard Business Review*, Nov/Dez, 1965.

STEGER-JENSEN, K. e SVENSSON, C. Issues of mass customisation and supporting IT-solutions. *Computers in Industry*, v. 54, n. 1, p. 83-103, May, 2004.

TREBILCOCK, B. Lean & mean. *Modern Materials Handling*, v. 59, n. 3, p. 43-46, March, 2004.

VAN HOEK, R. I. The rediscovery of postponement a literature review and directions for research. *Journal of Operations Management*, v. 19, n. 2, p. 161, Feb, 2001.

WANKE, P. Posicionamento logístico e a definição da política de atendimento aos clientes. Rio de Janeiro: COPPEAD, 2000. Disponível em: http://www.coppead.ufrj.br/pesquisa/cel/new/fr-posicion.htm. Acesso em: 04/09/2004.

WOOD, N. Make it flow: moving from batch and queue to single piece flow. *Management Services*, v. 48, n. 5, p. 14-18, May, 2004.
YANG, B., BURNS, N. D. e BACKHOUSE, C. J. Management of uncertainty through postponement. *International Journal of Production Research*, v. 42, n. 6, p. 1049-1065, March 15, 2004.
ZINN, W. Should you assemble products before an order is received? *Business Horizons*, v. 33, n. 2, p. 70-73, Mar/Apr, 1990.