Abstract Number: 002-0279

Paper Title:

Supply Chain Production Planning in a Mass Customization Environment\textsuperscript{a}

\textsuperscript{a}This work has been developed in the framework of an European Project funded by the European Community, titled ‘Virtual Enterprise for Supply Chain Management (V-CHAIN)’. Ref. GROWTH GIRD-CT- 2000-0821.

Name of the Conference: Second World Conference on POM and 15\textsuperscript{th} Annual POM Conference, Cancun, Mexico, April 30 – May 3, 2004.

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Supply Chain Production Planning in a Mass Customization Environment

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Abstract

Mass Customization consists of the design, production, marketing and delivery of customized products and services on a mass basis (Pine, 1992). Some of the strategies of mass customization are: supply chain management, modular product design, virtual enterprise, the web, best-of-breed ICT and agile manufacturing. In this context, the European Community Growth project called ‘Virtual Enterprise for Supply Chain Management (V-Chain)’ is trying to introduce the concept of extended enterprise and promote the collaboration between the automobile manufacturer and suppliers. Thus, data from this project are used in this paper to analyse and prescribe the main characteristics of an automobile industry supply chain required to mass customize from a production planning point of view.

Keywords: Automobile industry, supply chain, production planning and mass customization.

1 Introduction

Artisan manufacturing, mass manufacturing and lean manufacturing are three terms used to describe three manufacturing strategies that have evolved inherently to the own evolution of the automobile industry. Womack et al. (1992) describe how the artisan and mass makers work and present the lean manufacturing as the ‘Synthesis of Contraries’ that agglutinates the advantages of one and other, annulling their inconveniences (Figure 1).
Actually, the customization of the products, by means of the offer of great quantity of options, is one of the tendencies that contemplates this sector due to the evolution of the markets. This context provides the setting for the manufacturing strategy denominated mass customization.

In this paper, the characteristics of an automobile industry supply chain are studied from a production planning point of view. Then, some of the most important strategies required by the mass customization are reviewed. This manufacturing strategy is covered from the point of view of the studied automobile industry supply chain.

### 2 Characteristics of an Automobile Industry Supply Chain

The automobile industry has been an important component of the industrial and economic progress and its development has characterized the global competitiveness of leading industrialized economies (Dangayach and Deshmukh, 2001).

![Figure 1: Synthesis of Contraries in the automobile manufacturing. Source: Lario (1996).](image)
The studied assembly plant of automobiles, that belongs to one of the big groups of automobile manufacturers, Ford Motor Company, has certain particularities that deserve to be outstanding. Some are fruit of a global politics of the company, while other, as the connected Industrial Park of suppliers, have been developed in the Spanish plant and they are being implanted in other plants of the automobile group.

2.1 Components of the Supply Chain

The studied factory of automobiles manages relationships with hundred of individual supply companies. This entire series of business entities involved in meeting the customer's demand forms a supply chain.

The supply chain of the automobile factory, is comprised of: (i) the Press, Chassis Painting and Assembly Plants, included several control warehouses among the different Plants; (ii) two Engine Plants; (iii) other Press and Chassis Plants at Europe; (iv) the suppliers in the Industrial Park; (v) other sequenced, JIT and daily delivery suppliers; and (vi) the Consolidation Logistical Centre.

Related to the final products and parts subject to external demand, they are produced and assembled: (i) vehicles of different models and with several types of chassis, engine size and finishes; and (ii) components, subsets and sets that are devoted to the spare markets or to the supply of other European assembly plants. The factory does not operate as an intermediary between spare companies and concessionaires, it only intervenes in those elements of own production.

In 1995, Ford Motor Company initiated a restructuring plan called Ford 2000 to reduce costs by reengineering and globalizing of the corporation’s organisations and processes. The company developed the Order-To-Delivery (OTD) and Ford Production System (FPS) projects to give
answers to the market’s competitiveness and globalization. One of the goals is reducing OTD time from more than 60 days to less than 15.

FPS is a simplified, flexible and disciplined production system, common to all production plants, that can be defined as a set of processes that uses a capable personnel, with initiative, that is learning and working together under safety conditions to produce automobiles with a quality, price and lead time better than expected for customers. The FPS processes are related to human resources, industrial materials, synchronous materials flow, process control, total productive maintenance and engineering.

The result in Ford España SA has been the DAD (Direct Automatic Delivery) with an Aerial Transport System (Tunnel-Conveyor) and the creation of the supplier Industrial Park. This has required a new buyer-supplier relationship framework: A convergence of organizational cultures, supplier collaboration for parts design, supplier identification, etc.

2.2 Production Planning and Control in the Supply Chain

In the case of Ford Motor Company, the production planning process is centralized at a multinational central office. It is suitable to highlight the CMMS3 project, described by Nieto (1999) that tries to get an only information system for every factories and even with suppliers linkages. Perez et al. (2002a) analyze the production planning and scheduling process of Ford España SA (Figure 2).

The Strategic or Long-Term Planning involves to top-level managers and concerns to the acquisition of new resources, the introduction of new products, etc. The Annual Plan is elaborated from the annual budget, this Annual Plan fixes the expected profit levels and establishes the car model quantities to produce. Then, the Marketing and Sales departments make
an Aggregate Demand Forecast with a six months forecast horizon. Ford Europe allocates the European demand to the different plants at Europe.

![Diagram of production planning process]

*Figure 2. Ford España SA. Production planning and scheduling process. Source: (Mula et al. 2003a).*

The automobile assembler and manufacturer is characterized by a large final product variety that is the result of a smaller number of intermediary modules. At the same time, the intermediary modules consist of a large quantity of parts and raw materials. The companies with such Bill of Materials (BOM) are denominated “T” type (Gibson *et al.* 1995). In the auto industry, it is used the concept of Pseudo-Bill of Materials or S-Files (Perez *et al.* 2002b), based on the allocation of items to modules or options in order to get an optimum use of BOM in the production planning process.

Forecasted demand, available inventory, manufacturing constraints and firm orders are used to develop the Release. The Release allocates the production quantities among each assembly plant with a forecast horizon of six months and a forecast period of a month. This document contains
detailed and aggregate data and establishes a medium-term demand forecast of the required modules or options to be supplied.

The production scheduling process is named Segmentation. The Segmentation process allocates due date to the car assembly for a time horizon of 6 weeks. In this process, firm orders are taking into account. Finally, the sequencing process is done.

The production planning process is organized so that the customization steps (firm orders) are postponed until as late as possible (segmentation process), allowing for mass production economies at earlier stages.

In an automobile industry supply chain the medium-term production plans are implemented with difficulty. The plans present an unavoidable variability. The automobile makers try to improve the consistency of the demand information along the supply chain using integrated Information Systems for the production and EDI. In this context, the demand is communicated through the supply chain like production programs that are sent to its immediate suppliers electronically.

3 Mass Customization in the Supply Chain of the Automobile Industry

The mass customization model presents a challenge to the production planning process in the automobile industry.

Mass customization implies that the customers can select, order and receive a specially configured product (with hundred of options of the product) to satisfy their specific requirements.

The goal of mass customization is to produce a high quality product with the shortest order to delivery time and lower cost. Mass customization is accomplished by proactively developing product families around a modular product architecture, implementing a flow manufacturing to achieve one-batch-size capability, establishing a spontaneous supply chain around standard
materials, creating agile systems to order process based on product configuration and building parametric CAD templates with automatic CAD/CAM linkages to CNC equipment (Anderson, 1997).

Dell Computers assembles different final products using a relatively small group of common components (Dell, 1994). Dell Direct model is based on a reconfiguration of the supply chain, a tight integration of the capabilities of the B2B (Business to Business) and B2C (Business to Consumer) systems, sale of products and services to non managerial consumers via Internet, and new approaches to dealing with customers (Magretta, 1998).

Dell’s successful mass customisation model has been object of study by the auto industry (Austin, 1999). Besides the existence of a powerful dealer distribution channel Ford’s supply base is different in its nature and complexity from Dell’s supply base. Another major difference between Dell and Ford is purchasing organisation. Purchasing is organisationally independent of product development and it is a powerful force within Ford. Other key difference, is the more integrated nature of Dell’s Sales, R&D and Manufacturing Operations.

In the future, many companies will go from a make-to-stock to a mass customization business model. For instance, General Motors plans to transform from a make-to-stock company to a mass customization company to reduce the costs of parts and unsold cars, they plan to reduce the total delivery time from 8 weeks to 11 days (Simison, 2000).

Some of the important strategies required for the mass customization are:

- Supply chain management,
- Modular design,
- Virtual enterprise,
- Internet,
• Best-of-breed IT,
• Agile manufacturing.

Next, these strategies are reviewed in detail from the point of view of the production planning in the studied automobile industry supply chain.

3.1 Supply Chain Management

A typical supply chain in the automobile industry is formed by thousands of companies related with the raw material supply, the part production, the sub-assembly, the final assembly and the distribution. As example, the Hyunday supply chain (the first automobile maker at Korea) has, approximately, 400 first tier suppliers, 2,500 second tier suppliers and an unknown number of third or superior tier suppliers (Kahn et al. 2000).

One of the problems in the automobile industry is the simultaneous combination of a large-volume-production requirement with a large variety of small-lot make-to-order requirements involving a big number of suppliers (Miyashyita and Rusell, 1994).

All the automobile makers have to develop production programs. Although it is difficult to manage the conflicting objectives of increasing the product variety, reducing the delivery times and to reduce costs.

In order to build cars on-order, mass customizers must be able to build parts on-order from materials that are always available. This will require a spontaneous supply chain. The first step in supply chain management must be supply chain simplification. There are many effective ways to simplify the supply chain with standardization, automatic re-supply techniques like kanban, and product line rationalization which can eliminate the unusual parts by eliminating or outsourcing the unusual products (Anderson, 1997).
In an ideal mass customization environment, the demand forecasting accuracy for the final products could improve and even eliminate the demand forecasting for the final assembly by accessing to data on consumer preferences expressed during order configuration. However, the uncertainty in demand continues existing for the suppliers along the supply chain that have to react in a spontaneous way to face the customer orders received by the automobile maker.

In logistical terms, a supplier can be considered like a station more inside the production chain. It is logical, therefore, to extend to the suppliers the same JIT philosophy that is applied internally. Gonzalez (2000) carries out a study on which are the problems that the first tier suppliers are confronting in the Spanish automobile industry, after the automobile assemblers have adopted JIT systems. The results indicate that, if the 80’ and the beginning of the 90’ were characterized by the adoption of JIT philosophies by the automobile assemblers, now it has been entered in the era of the first tier suppliers. Thus, the first tier suppliers have difficulties to adopt the JIT systems into their companies and with their own suppliers. In the Spanish automobile industry and under a JIT supply context, the first tier suppliers have assumed more responsibilities and tasks of the supply chain, such as, inventory management, quality management, product design, information systems or even, planning and design of logistic networks. The author highlights the difficulty about delegating more responsibilities to second tier suppliers because of, mainly, to the second tier supplier size or his dedication to various activity sectors.

On the other hand, the complexity resulting from customized orders could become unmanageable along the supply chain. Respect to the production smoothing, a production system based on a production scheduling that combines ‘pull’ and ‘push’ demand requires new production planning and control systems.
The most relevant production planning and control systems found in practice today have in common that treat the world as being deterministic, i.e. they do not contemplate the many environment and system uncertainties that can arise. The did not emerge under a mass customization environment. In Mula et al. (2003a, 2003b), we argue the need for new models for production planning that can formalize the possible uncertainties present in the manufacturing environments.

Many companies, with simpler production processes (e.g. shoe and clothe manufacturers), accept the built-in inefficiencies of mass production and to deal with rising manpower costs and falling prices, move manufacturing off-shore where manpower costs are cheaper. In the automobile industry, characterized by a great complexity of the design, production process and supply chains and where there is a high technological factor, it could not be an adequate manufacturing strategy.

Automobile manufacturers must improve their current supply chains to cope with the requirements of mass customization and reduce order-to-delivery times to meet market demands. An online mass customization system requires to deliver a custom-ordered car within a reasonable time, probably less than week. Actually, the average number of days required to deliver a custom-ordered vehicle is 38 days for Ford España SA.

3.2 Modular Design

The modular design requires the use of product definition tools to develop products highly customized to a low cost (Sanchez and Collins, 2001).

One of the key concepts of mass customization is the modulation. The modules are constructive blocks that can customize a product assembling several combinations of modules. Examples of
modules that would include many components in automobiles are: engines, transmissions, audio system, etc.

Dell (1994) has shown that modulation can work. In the automobile industry, Helper and MacDuffie (2000) argue that modularity could make the final automobile assembly process much shorter and simpler. However, the authors, have some doubts about the real costs savings and benefits of modulation, such as:

- Problems with the control of key aspects of the car design.
- Problems with retaining duplicated engineering staffs if modules are designed and produced by suppliers.
- Standardized separate modules of auto parts (4,000 to 5,000 parts for each vehicle) implicate a high complexity.
- The product architecture for the automobiles is integral and closed.
- Most of the components is not standardized
- The component specifications are considered as owners of a specific model and they are only shared among a supplier.

This product architecture is the result of the automobile industry history, where the modular design has not been a priority.

The automobile seats are an illustrative example of an automobile part easy to modulate, since the seat is connected with the rest of the car in a single place. In the studied supply chain, the seat supplier is a sequenced and synchronized supplier that manufactures and supplies his products according to the car assembly sequence.

Now, the seat makers are working internally in making more modular their designs, so that they can be broken down in smaller modules to help to the car customization.
3.3 Virtual Enterprise

The objective of a virtual enterprise is to develop networks of partners with buyers and suppliers to make more effective the answer and the cost of the supply chain, and to add value to the supply chain. Combining the basic aptitudes of many companies inside the network, each virtual enterprise is more powerful and flexible than what it could be as an addition of the isolated members. Each one of the companies that belongs to the virtual enterprise is chosen by the excellence of their productive process. The integrated companies in a virtual enterprise develop processes instead of producing final products. When all those processes work united it is obtained in a successful way the final product.

A series of strategies that define the characteristics of a virtual enterprise exists (Lario and Tormo, 2001): (i) Vertical Integration of a logistical network, to incorporate suppliers and buyers to the whole value chain; (ii) Co-manufacturing, not in fact guided to the operations but to the product design, production of essential components, application of technologies and holistic business generation; (iii) Reduction of the supplier basis to some, strongly integrated in the business, to reduce in a drastic way the costs; (iv) Creation of a common information system for the operations, order delivery and planning, design and realization of changes; and (i) Outsourcing of the support and management processes to specialized companies.

In these companies the suppliers have passed of playing a conventional role to go beyond their performance like associate suppliers and to become nodes of character fully cooperative. In the first place, there is cooperation to design new products and technologies. The suppliers are integrated in the buyer's operations and a feeling of common destination exists. The supplier looks after the buyer and this looks after the supplier's capacity to take care of his company. This progressive way, the components of the buyer's product are based on the supplier's technology.
It is also given a constant interchange of information on the products and the processes. The marketing personnel of the buyer company returns information directly to the supplying company, what allows the partners to work quickly and adopt global decisions about any change that is necessary to introduce in the product.

All these characteristics are the basic parameters that define a virtual enterprise. So that the fundamental requirements to assure the feasibility of the use of the virtual enterprise model can be summarized in: cooperation, combined access to the information and the technology, put in common of the business strategy, co-responsibility, interdependence and mutual trust among the system nodes.

Obviously, all these requirements are not easily accessible for any company type, and this is what will determine the applicability of the model. In spite of the advantages in terms of costs that the model of virtual enterprise bears for the linked companies, it also takes place for these a loss of independence that few companies are willing to assume.

In all these situations it is difficult to determine where a company begins and it finishes the other one, since the members of a virtual enterprise are closely interrelated. In a virtual enterprise no company can offer for itself and in an independent way a final product for the consumer and to say 'I made it' since the final product is possible because of the intimate collaboration of several companies constituted as a extended virtual enterprise.

The example of the automobile manufacturers is clearly reflected in the work rules of the studied factory. Thus, the Consolidation Logistical Centre and other suppliers in the Industrial Park to the factory supply to the automobile assembly plant all the necessary components for the JIT production.
The conformation of this Industrial Park as an extended virtual enterprise is a fact, since the implied companies carry out unique processes in those that are highly specialized, giving place among all them to a chain of processes whose aim is to obtain the final product, a car. None of these companies is capable at the present time, in a separate and autonomous way of carrying out the complete production of a vehicle.

For it, this companies are intimately interrelated, with a system of very strong interdependence that takes them to share the information systems and to act like a single company. The failure of one of them implies the stop of the production in the rest of companies involved in the global production system.

In this context, Supplier Relationship Management (SRM) is a recent concept, which object is the utilization of the latest technologies to build networks of collaborative relationships, that bring joint benefits to large companies and their suppliers (Gulledge, 2002). SRM takes supply chain management to the next level, allowing supply chain partners to act as a single business entity, in a virtually linked supply chain. This defines a new model of buyer-supplier relationship, with requirements at all levels, as a strategic as an operational level. Currently, it is in the production scheduling and planning where this interconnection occurs more. The applicability of the virtual enterprise is increased in companies that can exercise a great control on its suppliers and they can convince these of the necessity of constituting a virtual net, like it is the case of the automobile industry. In this environment arises the European project called 'Virtual Enterprise for Supply Chain Management' (Mula et al. 2003a).

The relationships between buyer and supplier have received many attention by the research literature (Helper, 1991, 1992; Smitka, 1992). But such a position sits uncomfortably with the logic of the transaction cost school, and particularly writers like Oliver Williamson (1975, 1985
and 1996). Williamson argues that the types of relationship that buyers and sellers form with each other should be determined by the characteristics of the transaction in question. In all exchanges buyers (and sellers) must guard against the risk of moral hazard and holdup. These risks are most acute for those transactions that require one or both of the parties to undertake costly non-fungible investments and for those transactions that exhibit high levels of uncertainty. Under such conditions firms inability to adequately protect themselves from the risks involved will lead them to vertically integrate production rather than to try and form collaborative relationships with external agents. Because mass customisation is all about firms making costly non-fungible investments in high volatile markets, the transaction cost approach would tend to suggest that it requires far fewer collaborative relationships of the type to be found during the earlier phases of production and (especially lean supply).

3.4 Internet

As in other industries, the Internet revolution has had a number of different impacts on the automobile industry.

Marti et al. (2000) indicate four primary areas where automobile manufacturers are applying Internet technologies: (i) the procurement and supply chain operations; (ii) integrating Internet services into vehicles, such as web and email access; (iii) sales, marketing and distribution systems; and (iv) to attract on line customers.

The Internet facilitates e-procurement (applications for the purchase management via Internet that provide the automation of the supply process of products and services from the order until the payment) across the auto industry. The low cost and high speed of this communication method is necessary for the mass customisation strategy to be economically feasible and to tell the automakers what you want them to build (Helper and MacDuffie, 2000).
The advent of electronic commerce over the Internet has facilitated new relationships for connecting with new supply chain partners, thereby significantly increasing the quantity and quality of inter-organizational information flows. Warkentin et al. (2002) identify and analyze the new informational flows that are leading to new kinds of relationships in the e-commerce marketplace. The authors demonstrate how the advent of web-based e-commerce technologies is altering the information flows between the traditional players in the supply chain. The direct channel between manufacturers and consumers is enabling mass customization, and is influencing the production planning process. As a consequence, producers get better signals regarding the consumers’ preferences and demand levels, which in turn leads to better inventory management and production planning.

In the B2B commerce exchange, a recent process of disintermediation (using the web platform) has created entirely new ‘direct channel’ opportunities. Firms, such as, Dell.com and Amazon.com are selling their products directly to the consumer, by bypassing the traditional intermediaries. Dell.com allows to the consumers to design their own computers on their website (www.dell.com), which is tightly connected to the JIT production system, which customizes the assembly of each order.

Since March, 1995, when Autobytel.com appeared as the first independent Online Buying Services (OBS) many more sites had emerged (Marti et al. 2000). Jack Faucett Associates classifies the automotive internet sites into seven categories. These include: (i) referral sites (Autobytel.com, Microsoft CarPoint, GM BuyPower, Driverseat.com, etc.); (ii) brokers (CarsDirect.com); (iii) direct sales (FordDirect); (iv) classified advertising (Yahoo!’s automobile section, cars.com); (v) reverse auction (Priceline); (vi) media/information sites (Edmunds.com); and (vii) dealer sites (AutoNation).

3.5 Best-of-breed IT

The correct combination of Information and Communications Technologies (ICT) plays a fundamental role to achieve the benefits of the mass customization. Bourke (1999) describes some of the ICT essential elements for the mass customization classified in two groups: product definition and production planning and control.

The Ford reengineering plan, denominated Ford 2000 and already mentioned previously, required the use of the best technologies to conquer the geographical restrictions on the information flows. Teams of different countries need to be able to work together as if they would be in the same building. Also, in practically all the reengineering projects, the ICT are a critical factor. The union between the success of the reengineering and the groups of ICT of the company became explicit during the Ford 2000 restructuring process (Austin, 1999).

Ford developed a public place in Internet by the middle of 1995, two years later the number of visits to the Ford's web reached more than 1.000.000 per day. In a similar way, Ford developed an intranet in 1996 and in January of 1997 Ford developed a B2B system, through which in a sure way the intranet could extend beyond the limits of the company in an extranet, connecting Ford with its suppliers. Ford together with Chrysler and General Motors formed a team to work in the Automotive Network Exchange (ANX) whose objective is to create consistently standard and technological processes in the supply network, so that the suppliers, pressed to diminish
costs, do not have to manage different meanings of interaction with each automobile manufacturer (Austin, 1999).

3.6 Agile Manufacturing

The Agile Manufacturing systems arose to give solution to a society with an unpredictable and dynamic demand, and with a high customization degree in their products.

The breadth of products that a firm offers at a given time and the rate at which the firm replaces existing products with new products define product variety. Both dimensions of variety have increased in many industries (Pine 1992; Sanderson and Uzumeri, 1995; Fisher et al. 1996). The managerial challenge now is how to provide the high degree of variety for competitive success while retaining the scale economies required for low cost (Lancaster, 1990).

In 1991, a group of more than 150 industry executives participated in a study. Their efforts culminated in a report titled ‘21st Century Manufacturing Enterprise Strategy’, which describes how US industrial competitiveness might evolve during the next 15 years. As a result, the concept of agile manufacturing was introduced (Nagel and Dove, 1991; Sheridan, 1993; Struebing, 1995). For many, lean manufacturing and agile manufacturing sound similar, but they are different. Lean is a collection of operational techniques focused on the productive use of resources. Agility is an overall strategy focused on thriving in an unpredictable environment, by the responsive creation and delivery of customer-valued, high quality and mass customised goods/services (Richards, 1996).

Agile Manufacturing is a new system of mass post-production for the production and distribution of goods and services that requires resources that are beyond the reach of an only company. It becomes necessary to share resources and technologies among companies. The competitive ability of a company depends on its ability to establish appropriate relationships, and this way,
the cooperation becomes key piece for complementary relationships. An agile company has the organizational flexibility to adopt in each project the management form that provides the biggest competitive advantage. Sometimes, it will be a multi-functional internal team with supplier and buyer participation. Other times, they will be carried out joint ventures or a virtual enterprise will be created (Nagel and Dove, 1991).

Sanchez and Nagi (2001) review a wide range of recent literature on agile manufacturing. The authors propose a classification scheme with nine major research areas: (i) Product and production systems design; (ii) Process planning; (iii) Production planning, scheduling and control; (iv) Design and localization of production plants; (v) Material handling and storage systems; (vi) Information systems; (vii) Supply chain; (viii) Human factors; and (ix) Business processes. In the production planning area, the authors conclude that it is necessary further research on models that can manage the many uncertainties that are present in the supply chains of industrial companies.

4 Conclusions

This work has defined the concept of mass customization and analyzed the main strategies required to mass customize from the point of view of the automobile industry.

The first analyzed strategy is related to the supply chain management, it has been highlighted the necessity to have spontaneous supply chains and the need for new models for production planning that can recognize and model the many uncertainties that arise in the initial phases on the exact characteristics of the products and their structures, the required capacity and the material requirements. The uncertainty in demand continues in the suppliers of the supply chain that have to respond from a spontaneous way to the automobile maker's orders. Also, they can
happen random events in the short term, such as, production failures, rejected parts, urgent or annulled orders, etc.

Respect to the modular design has not found too many advances in the automobile sector due to their complexity.

Then, the concept of virtual enterprise has been approached. At the present time, Internet can offer to the companies the possibility to transmit information in a quick way to low cost, favouring the integration among the different companies involved in a extended virtual enterprise model and facilitating the exchanges of information, data and work methodologies. The virtual integration implications are clearly supported by the development of the electronic commerce that allows to produce, market and distribute products in a not located way and to sell them in a global way. The e-commerce is the paradigm of the potentialities of the virtual enterprise application.

Then, the effects of Internet on the automobile industry are discussed. The arrival of e-commerce has separated the information about the product from the product itself. For instance, a consumer shopping for an automobile can now use Internet to gather information regarding the product and then go to purchase the auto or, directly, to buy a customized car on the web.

The strategies best-of-breed ICT and the agile manufacturing has also been reviewed. Also, it has been analyzed as these strategies required by the mass customization are being applied in the automobile sector. The strategies related to a spontaneous supply chain requirement, the modular design and production, the direct sale and the production planning systems that can consider the presence of uncertainties require a further research (Table 1).
Table 1. Strategies to mass customization in the automobile industry.

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<thead>
<tr>
<th>Strategies to mass customization</th>
<th>In Progress</th>
<th>For further research</th>
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<tbody>
<tr>
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<td>Close relations buyer-supplier</td>
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<tr>
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