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CAMPUS MONTERREY
DIVISION DE INGENIERIA Y ARQUITECTURA
PROGRAMA DE GRADUADOS EN INGENIERIA

TECNOLÓGICO
DE MONTERREY®

ACHIEVING COMPETITIVE ADVANTAGE THROUGH MASS CUSTOMIZATION

T E S I S
PRESENTADA COMO REQUISITO PARCIAL
PARA OBTENER EL GRADO ACADEMICO DE:

MAESTRO EN CIENCIAS CON ESPECIALIDAD EN
SISTEMAS DE CALIDAD Y PRODUCTIVIDAD

POR:
JORGE ALBERTO PEÑA SUAREZ

MONTERREY, N. L. MAYO DE 2004

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Los miembros del comité de tesis recomendamos que el presente proyecto de tesis presentado por el Ing. Jorge Alberto Peña Suárez sea aceptado como requisito parcial para obtener el grado académico de:

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Dedicatoria

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seguir este camino sin desviaciones
y culminar este sueño.

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Introduction.

The globalization of the markets, the reduction of the world, the abolishment of commercial boundaries and other economic and social factors have created an environment of fierce competition among industries. Customers are no longer willing to buy a product just because it is the cheapest, now they are demanding better products, better quality, requiring special features that satisfy the customer's individual needs, and besides of all this, they want it faster and cheaper.

Mass Customization (MC) is a business strategy to satisfy these new trends on markets. This new business strategy offers to fulfill customer's individual requirements at prices that match those of mass production items and shorter lead times to customers. All this makes that customers have a greater perceived value for the product and the company, therefore creating loyalty for the brand or the company.

But Mass Customization is not only benefiting for the customer, but also for the company. MC enhances profitability reducing production cost, reducing lead time, and also helping to reduce inventory. This is achieved by implementing Lean Manufacturing techniques of waste reduction, shorter setup times, lower batch sizes, etc. This eventually makes the shift to agile manufacturing systems that react faster to changes in demand and product characteristics.

Mass Customization requires the integration of all departments within the company and also with customers and suppliers. It also requires that products will be design for modularity. This means that the product design should have the ability to adapt to different configurations just by changing a few components, without having to build a new product. Design for modularity helps to achieve the flexibility needed to offers

mass customization, because it reduce the lead time, and therefore, the response time to customers.

This strategy is creating a new way of doing business, and another way to achieve competitive advantage. Mexican companies are not apart of the global competition. They also have to search for new ways of competition. This study presents the current state of Mass Customization in Mexican companies.

There were not studies that present results on the state of Mass Customization in Mexico, reason why this study is an exploratory survey. It was asked to respondents to answer issues related to the benefits, negative consequences, difficulties found in the supply chain, and barriers to increase the degree of customization by implementing customization strategies.

The results shows that Mexican companies are in the beginning stage of achieving Mass Customization, mainly because it offers customized products not as a strategy, but as a way of capture a customer that wishes a product different from the standard. This approach lead to increase the manufacturing and materials cost, in order to satisfy that need. The culture and organization change are among the barriers found to increase the degree of customization. Mass customization requires flexibility in the production system, and this includes workers, managers, processes and attitude. But not everything is bad; Mexican companies have perceived an increase on customer satisfaction, although the companies still do not have an increase on the customer knowledge.

This study might be the beginning of future researches that seeks to identify the causes and/or consequences of the implications presented in this study.

Table of contents.

TABLE OF CONTENTS. 1

TABLES 3

GRAPHICS 4

FIGURES 4

CHAPTER 1 5

1. INTRODUCTION. 5

2. COMPETITIVE ADVANTAGE. 6

2.1 OBTAINING COMPETITIVE ADVANTAGE BY LEADERSHIP IN COSTS 7

2.2 OBTAINING COMPETITIVE ADVANTAGE BY DIFFERENTIATION. 8

2.2.1 Value. 9

2.2.2 Customer perceived value. 10

3. MASS CUSTOMIZATION. 12

4. MASS CUSTOMIZATION REQUIREMENTS. 16

4.1 CUSTOMER INVOLVEMENT AND EXPLORATION OF THEIR INDIVIDUAL NEEDS. 18

4.2 USE OF MODULAR PRODUCTION SYSTEMS. 19

4.2.1 Maximizing reusability. 22

4.2.2 Product platform. 22

4.2.3 Integrated product life-cycle. 23

4.3. MASS PRODUCTION EFFICIENCY 24

5. MASS CUSTOMIZATION BUSINESS MODELS 24

6. STRATEGIES COMPARISON. 36

7. CONCLUSIONS. 40

BIBLIOGRAPHY 42

CHAPTER 2 46

1. INTRODUCTION 46

2. RESEARCH METHOD 48

3. SURVEY RESULTS 51

3.1 General conditions. 51

3.2 Method to provide customization 52

3.3 Benefits of implementing customization 55

3.4 Negative consequences brought by the implementation of customization 58

3.5 Difficulties implementing customization extended to the supply chain 60

3.6 Barriers to increase the degree of customization. 62

4. GENERAL RESULTS COMPARED AGAINST UK RESULTS. 64

5. INTEGRATION WITH CUSTOMERS AND SUPPLIERS 70

6. CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH. 71

BIBLIOGRAPHY 76

APPENDIX A 79

APPENDIX B 81

APPENDIX C 89

APPENDIX D 97

APPENDIX E 105

Tables

TABLE 1. DEFINITION OF MASS CUSTOMIZATION BY AUTHOR. 15

TABLE 2. MASS CUSTOMIZATION REQUIREMENTS ACCORDING TO DIFFERENT AUTHORS. 18

TABLE 3. CLASSIFICATION OF MASS CUSTOMIZATION STRATEGIES. 36

TABLE 4. MASS CUSTOMIZATION STRATEGIES BY AUTHOR. 37

TABLE 5. INDUSTRIES DISTRIBUTION 49

TABLE 6. COMPANY'S SIZE DISTRIBUTION 51

TABLE 7. METHOD USED TO PROVIDE CUSTOMIZATION. 53

TABLE 8. COMMERCIAL, MANUFACTURING, AND SERVICES DISTRIBUTION BY METHOD AND NUMBER OF METHODS 53

TABLE 9 RESULTED RANK. 54

TABLE 10. BENEFITS RANKED BY METHOD TO PROVIDE CUSTOMIZATION 56

TABLE 11 RANKED RESULTS OF NEGATIVE CONSEQUENCES BY IMPLEMENTING CUSTOMIZATION STRATEGIES. 59

TABLE 12 RANKED DIFFICULTIES FOUND IN THE SUPPLY CHAIN BY METHOD TO PROVIDE CUSTOMIZATION 61

TABLE 13. RANKED BARRIERS TO INCREASE THE DEGREE OF CUSTOMIZATION BY METHOD 63

TABLE 14. COMPARED BENEFITS 66

TABLE 15. COMPARED NEGATIVE CONSEQUENCES 67

TABLE 16. DIFFICULTIES IN THE SUPPLY CHAIN COMPARISON 68

TABLE 17. BARRIERS TO INCREASE THE DEGREE OF CUSTOMIZATION 69

Graphics

GRAPHIC 1 VARIETY AND CUSTOMIZATION ANALYSIS. 65

Figures

FIG. 1 ANOVA TEST FOR METHODS 56

FIG. 2 ANOVA TEST FOR THE BENEFITS 57

FIG. 3 ANOVA TEST RESULTS FOR NEGATIVE CONSEQUENCES 60

FIG. 4 ANOVA TEST RESULTS FOR DIFFICULTIES FOUND IN THE SUPPLY CHAIN TO IMPLEMENT CUSTOMIZATION. 62

FIG. 5 ANOVA TEST RESULTS FOR BARRIERS TO INCREASE THE DEGREE OF CUSTOMIZATION. 63

FIG. 6 KRUSKALL-WALLIS ANALYSIS OF REDUCED ORDER RESPONSE TIME 67

FIG. 7 KRUSKAL-WALLIS TEST FOR CULTURE AND ORGANIZATION CHANGE. 69

Chapter 1

Achieving Competitive Advantage with Mass Customization.

Mass customization is a way of satisfying customer's individual needs using economies of scale and scope. Mass Customization uses the advantage of mass production systems to offer this unique product at prices almost equal to mass produced products, but without the trade-off of these.
Because MC offers a unique product for the customer, this is perceived as of great value and increases the customer's satisfaction and therefore increases sales. This allows companies to achieve competitive advantage among competition.
This study presents the different strategies that the literature has identified and compared one to each other to mention their benefits and drawbacks. A generic level of customization is presented for eight different strategies. As part of the study, different definitions were identified for Mass Customization and the requirements that the authors review present for achieving Mass Customization. The study ends with recommendations for further research.

1. Introduction.

Mass Customization is a new way of doing business, by providing the customer a product or service that is perceived as of great value. The company satisfies personal customer's needs by offering a product or service that meets what customers want at a reasonable price [Radder and Louw, 1999].

Mass Customization uses the advantage of mass production for reaching economies of scale and the principles of customization to provide a unique product for the customer. The principle of Mass Customization is based on modular product design and customer involvement in the process [Duray, 2000]. In the computer industry, companies are looking new ways of achieving competitive advantage by offering products that satisfy customers' wants, at a reasonable price. Dell and Gateways are two companies that offer personal

configurations for the product. By doing so, these two companies are using Mass Customization systems [Jiang, 2000]. Another example of Mass Customization is present in Paris Miki, an eyewear retailer that offers its clients to personalize their rimless glasses by using a software that takes a digital image of the customer and then chooses from a variety of lenses according to the client's specifications [Gilmore and Pine, 1997].

The purpose of this research is to present the benefits and drawbacks of the different models of Mass Customization mentioned in the literature and how these models help to obtain competitive advantage.

Mass Customization allows the companies to differentiate from the competition and therefore achieve competitive advantage.

2. Competitive advantage.

The advances in technology have created an environment of fierce competition. In the computer industry, products cannot be differentiated from each other in performance, but only by the brand and the price. To choose among all of the available options requires knowledge of the product, implicit or explicit, to differentiate them from each other. To be different from the other brands, companies must hold on their regular customers while, at the same time, attempting to take customers away from the competitors [Trout and Rivkin, 2000].

Competitive advantage is when a company performs better than the competition. This performance can be measured in many ways: profits, revenues, market share, sales, ROI, ROE, Inventory turns, etc. All of these are about money, directly or indirectly.

There are two main approaches to obtain competitive advantage: To get leadership in costs or to become different from the competence [Barney, 1996; Porter, 2002].

When companies decide to obtain leadership in costs, they focus their efforts to increase productivity. To become the cheapest option means that the market segment of which the company is part, mainly base the purchase criteria in price. Therefore, the product is a commodity and there is no difference between those of the competition [Chase, et. al, 2001].

2.1 Obtaining competitive advantage by leadership in costs.

To obtain a competitive advantage by leadership in costs requires different approaches, depending on the industry. The sources of advantage are broad and it may include improvements on the supply chain, strategic alliances, cost reductions, etc. No matter which approach is taken, if a cost leadership strategy is followed, costs become of vital importance because it is necessary to keep close to competition to apply it [Porter, 2002].

The starting point for cost analysis is to identify the activities performed in the value chain and the associated cost of each activity [Porter, 2002; Shank and Govindarajan, 1993]. It is necessary to compare the company's cumulative cost of the value chain with those of the competition, in order to establish the stand point. If the company has a lower cumulative cost, then it is possible to say that it has competitive advantage over the competitors.

It is important to mention that there are value-added cost analysis and value chain cost analysis. The former focus mainly in the activities within the company, while the latter on

the entire value chain: from the raw material source through the ultimate consumer's hands. [Shank and Govindarajan, 1993].

The value chain analysis must include factors such as size difference and economies of scale; capacity utilization, learning curve and volume of production; partnerships and suppliers relationships; strategic position analysis and supply chain performance, [Barney, 1996; Porter, 2002]. Leaders in costs search for better ways of improving the efficiency of their supply chain [Fisher, 1997]. Partnering is a good way of reducing cost outside the company. Overhead represents about 3 percent of the manufacturing cost, while spent on purchases outside the company represents 55%. A good agreement with suppliers can help to reduce cost [Rackham, et. al, 1996].

It is possible to obtain the leadership in costs if the company controls the factors of costs or if it reconfigures its value chain [Porter, 2002]. Another way to reduce cost is eliminating or minimizing those activities that do not create value in the system. This is usually called waste [Hines and Taylor, 2000].

On the other hand, when companies decide to become different, they focus on providing greater value to customers than the competition [Eggert and Ulaga, 2002].

2.2 Obtaining competitive advantage by differentiation.

A company accomplishes competitive advantage by differentiation when it offers something that the customer perceives as of higher value than similar products of the competition, at a price that is willing to pay. In the computer industry, this can be translated into a faster, with more features component. To obtain a competitive advantage by differentiation, the differences need to exist besides lower prices. Differentiation comes

from the specific activities that the company performs and in the way these activities affect the customer [Porter, 2002].

A company that better satisfies its customers' individual wishes and needs will have greater sales creating loyalty to a brand, and customers will continue buying such a brand. Companies offering a wider variety of products or customized ones, have greater chances to obtain higher profits and competitive advantage [Porter, 2002].

Competitive advantage can be achieved if the company differentiates itself from the rest by offering a product or service different from what the competition offers at a price that the customer is willing to pay and the customer perceives as of greater value. If companies offer products or services that satisfy or exceed customer's expectations, it is possible to obtain a competitive advantage.

It is important to identify what the customer wants, and how he/she wants it. But must important, is to identify what customers perceive as value, because if the company identifies what the customer truly values, it can focus its efforts in fulfilling those requirements [Eggert and Ulaga, 2002] and therefore, obtaining competitive advantage.

2.2.1 Value.

The New Lexicon Webster's Dictionary of the English Language defines value as the measure of how strongly something is desired for its physical or moral beauty, usefulness, rarity, etc. especially expressed in terms of the effort, money, etc. one is willing to spend in acquiring, retaining possession of, or preserving it.

Value is what the people are willing to pay for a good or service. Superior value is obtained by offering lower prices than competitors for similar products or special benefits which compensate higher prices [Porter, 2002].

Another definition mentions that value is a combination of benefits and sacrifices occurring when a customer uses a product or service to meet certain needs. Those activities that contribute to meeting one's needs are benefits, and those consequences that detract from meeting one's needs are sacrifices [Bounds, et. al, 1994].

For the purpose of this research, value is what people are willing to pay for a good or service, expecting some benefits and sacrifices, to meet certain needs.

2.2.2 Customer perceived value.

According to Parasurama, a customer will feel satisfaction once he/she had made a comparison process in which he/she compares the expectation for the product and the perceived performance. The customer will feel satisfied when the product's performance is equal to what was expected (confirming). If the products goes beyond to what he/she expected, the customer will feel very satisfied (positively disconfirming), if it goes below what was expected, the customer will feel disappointed or dissatisfied (negatively disconfirming). Satisfaction arises in two dimensions: a cognitive process where the customer compare the product (value perceived) against some comparison standards (value expected); and an effective state of mind, where the feeling of satisfaction takes place. Consequently, some satisfaction scales tap the cognitive dimensions of satisfactions, while others capture its effective nature. The extent to which a satisfaction scale focuses on the cognitive or the affective dimension, however, should have an impact in terms of both, [Eggert and Ulaga, 2002].

One of the most difficult tasks is to identify what customers truly value. In the pursuit of competitive advantage, companies are egger to identify the demands and values of current and potential customers [Mentzer, et. al, 1997].

Three common elements of customer perceived value have been identified:

1. The multiple components of value;
2. The subjectivity of value perception;
3. And the importance of competition.

First, the components of value are the trade-off between benefits and sacrifices that customers perceived when dealing with the supplier. Perceived benefits are those physical and services attributes, and the technical support available on a given situation i.e. the benefit for a customer when he/she has a computer problem could be the technical support at the service center that helps him/her to solve that problem. Perceived sacrifices are usually described in monetary terms i.e. if the solution to the computer problem was cheap or expensive. Second, value is a subjective issue. The same product could have different value or attributes for different customers. Finally, value is relative to competition. Delivering a better trade-off between benefits and sacrifices in a product or service, i.e. offering better value than competition, will help a company to create sustainable competitive advantage [Eggert and Ulaga, 2002].

Defining customer benefits is to establish which ones a service delivery system tries to convey to customers. The definition of customer benefits usually involves customer learning in order to bring the voice of customers into the service delivery system. The information to be collected may include: (1) operation mission and goals from top management; (2) customers' voice in response to questionnaires, such as "why do you want

to experience the service delivery system?"; (3) customers' needs and wants (from individuals or based on industrial consumption trends) for services with regard to current and future economic and technological environment; and (4) benchmarking data in case of operating the same service business as other organizations [Jiao, et. al, 2003].

It can be stated that value is a reasoned process of comparing a product with a standard, being the standard the expected value and the result is the satisfaction degree, [Eggert and Ulaga, 2002]. Instead, satisfaction is an affective evaluation response. Satisfaction is a post-purchase construct, and therefore the customer satisfaction must exceed or at least equals his/her expectations. If it exceeds, the customer will be very satisfied and will purchase more of the product. If it equals, the customer will feel the product satisfies a need or desire.

Now that value and perceived value has been defined, it is necessary to present how Mass Customization offers to increase customer's perceived value and increase satisfaction.

3. Mass Customization.

Today, a new way of doing business is emerging, one in which companies are offering a wider variety of products, and items are made according to the clients' specifications and needs, instead of homogeneous mass produced products. Now the products life cycles and development cycles has shortened drastically [Pine, 1993]. This is called Mass Customization (MC). MC improves profitability of the company by increasing the customers' perceived value, cost reduction, and lead time reduction. Therefore, by offering higher value-added products, Mass Customization enhances premium profits by giving the customer what he/she expects [Jiao, et. al, 2003]. With higher profits as well as a better

understanding of customer requirements, the company can provide even more variety and customization, which further splits the market. Because it is outdistancing its competitors in variety and customization, market fragmentation allows, once again, to better satisfy its customers' individual wants and needs, and so on [Pine, 1993].

Mass customization offers to fulfill the needs of each specific customer at a reasonable price for a product or service. In other words, Mass Customization offers to create value for the customer. If this occurs, the customer will feel satisfied and may continue purchasing the company's products.

Mass customization consists in developing, producing, marketing, and delivering affordable goods and services through flexible processes with enough variety and customization that nearly everyone finds exactly what they want [Pine, 1993].

A way to achieve customer satisfaction is by adopting Mass Customization. This approach enhances profitability through a synergy of increased customer-perceived value and cost reduction in production and logistics. Therefore, MC inherently makes high value-added products and services possible through premium profits derived from customized products [Jiao, et. al, 2003].

Mass Customization is to provide products according to individual customers' needs and producing those with principles of mass production. The key issue in Mass Customization is customer focus. This means that product design, organization, manufacturing systems and everything related to the product, must fulfill the needs of strategic customers [Partanen and Haapasalo, 2004].

MC offers the best way to satisfy individual consumer's unique needs and wants while yielding profit to companies. The basic idea behind Mass Customization is the effort of reaching segment units efficiently and profitably. The efficiency and profitability is based on the optimal segment size, which depends on the company resources and the market situation. The core of Mass Customization lies in the ability to perceive and capture unsatisfied market niches and, subsequently, to develop the technological infrastructure and technical capabilities to meet the diverse needs of target customers [Jiang, 2000].

Mass Customization is to provide personalized products at reasonable prices. This means, to offer unique products in a mass-production, low cost, high volume production environment [Duray, 2002]. In other words, Mass Customization is to give the customer what they desire, at a price that they are willing to pay.

Mass Customization is the ability to provide customers with anything they want profitably, at the time they want it, at the place they want it, and at any way they want it using flexible processes and organizational structures to produce varied and often individually customized products and services at the low cost of a standardized, mass production system. The fist part of the definition is an ideal of the goal that Mass Customization searches for; while the second is a practical one and the way companies can achieve it [Hart, 1995].

Mass Customization is a production mode for customized products supplied to the individual customer in random quantity, or multi-variable small batch markets, based on the high efficiency, cost and speed of mass production system, via the recombination of product structures and manufacturing processes, using a series of modern information, manufacturing and management technologies [Yang and Li, 2002].

Mass customization is the ability to provide uniquely individualized products and services satisfying any requirement, but in a cost-effective way, allowing firms to operate at maximum efficiency, while quickly meeting customers' orders [Radder and Louw, 1999].

Mass customization is a solution to the fast changing customers' demands and new market realities while still enabling firms to capture the efficiency advantages of mass production. Mass customization meets the requirements of increasing heterogeneous markets by producing goods and services to match individual customer's needs with near mass production efficiencies [Piller, 2003].

Table 1 shows the different concepts that each author uses to define Mass Customization.

Definition of Mass Customization								
	Pine	Jiao, et. Al	Partanene and Haapasalo	Jiang	Duray	Hart	Yang and Li	Radder and Louw
Enhance profitability	x	x		x				
Increase customer perceived value		x						
Cost reduction	x	x		x	x	x		
Customized products	x	x	x		x	x	x	x
Principles of Mass production			x		x	x	x	x
Reach a segment unit				x				
Use of Flexible processes	x					x	x	
Organizational structure						x		
Variety of products	x					x		
Recombination of product structure							x	
Quick responsiveness								x

Table 1. Definition of Mass Customization by author.

Table 1 presents what Mass Customization is, but not what it requires or how to achieve it. In the following section, it is presented the requirements of MC.

4. Mass Customization requirements.

Mass Customization is obtained when the customer is involved at some point of the process in order to set a specific production order, without a high increase in cost. The basic difference between simple customization and Mass Customization is that MC uses modular systems in order to obtain economies of scale.

Mass customization achieves low costs by the application of a single process to produce a greater variety of products or services more cheaply and more quickly. Flexible manufacturing systems enable companies to increase variety and quick response to changes in demand. Also the use of just-in-time delivery, lean production techniques, early manufacturing involvement, increases the flexibility and responsiveness, ergo the variety and customization without parallel increases in costs [Pine, 1993].

A company adopts MC if it follows the two critical identifiers: The first identifier is the point of customer involvement in the design process, and it is used to establish the degree of customization. The second identifier is what makes possible that customization becomes economic: modularity [Duray, 2002]. Modularity is used as the critical aspect for gaining scale volume in MC. Customer involvement provides customization, while component modularity restricts the range of choice, decreasing the possible variety of components and thus allowing for repetitive manufacturer.

MC requires not only customer involvement and modularity, but also the use of information technology to provide the quick responsiveness need to offer the variety of products associated with MC at an efficiency that is comparable with mass production system [Jiao, et. al, 2003].

On the other hand, it is mentioned that the use of postponement and standardized elements, methods and modules are needed to offer MC, besides information technology and quick responsiveness [Partanen and Haapasalo, 2004].

Market segmentation is also needed in order to efficiently satisfy the segmented market niche and the use of optimal segment size. In other word, to find out the optimal variety of options offered to similar customers [Jiang, 2000].

Something that it is extremely important is the usefulness of Mass Customization. MC is only necessary when customers demand it, or when the turbulence of the competitive environment makes the adoption a competitive advantage [Hart, 1995]. Otherwise, it may not be a good move for the company. This author also states that if the shift is needed, the organizational structure must be prepared for the changes.

MC does not only require what it has been mentioned, but also the necessity of flexibility in the product design [Yang and Lie, 2002; Dubrescu and Reich, 2003]. Without the continuous improvement, organizational commitment and Innovation and coordination in the company, the advantage gained by adopting MC cannot be sustained [Radder and Louw, 1999].

Mass Customization also requires a logistics and supply chain approach. MC is a paradigm shift where the companies are now customer oriented. Delivering a product or service that meet a single customer unique need is a challenge that must be overcome. Apart from the mere transport of products and goods, MC includes the steering and control of production lines, the holistic information flow within and without production and the planning of the entire supply chain [Schenk and Seelmann-Eggebert in Rautenstrauch, et al. 2002].

Table 2 shows the requirement mentioned by different authors. As it can be seen on the table, that modular production systems, mass efficiency and customer involvement are the most important requirements for MC, reason why they are examined in detail.

Mass Customization Requirements	Pine	Jiao, et. Al	Partanen and Haapasalo	Jiang	Duray	Hart	Yang and Li	Dobrescu and Reich	Radder and Louw
Use of modular production systems	x	x	x		x	x	x	x	x
Information technology	x	x	x	x		x	x		
Quick responsiveness	x	x	x			x	x		x
Variety		x		x	x			x	
Mass efficiency	x	x		x	x	x	x	x	x
Exploration of customer's needs	x	x		x	x	x	x	x	x
Postponement			x					x	
Standardized elements			x					x	
Standardized methods			x		x			x	
Standardized modules			x					x	
Market segmentation				x					
Organizational structure						x			x
Flexibility of product design							x	x	x
Organizational commitment									x
Continuous improvement									x
Innovation and coordination									x

Table 2. Mass Customization requirements accordingly to different authors.

4.1 Customer involvement and exploration of their individual needs.

Mass Customization starts when companies understand customer's individual needs and ends when these needs are fulfilled in a low-cost, fast-response manner. The achievement of time-to-market depends on the integration of the value chain for the product development process, from product design to product delivery [Jiao, et al 2003] Customers may be involved in these processes as co-designers, so companies can satisfy their individual needs [Tseng and Jiao, 1998].

Mass customization offers to fulfill almost everyone's needs. Using market segmentation, it is possible to identify customer's needs, and reach an optimal segment size

to satisfy as many clients as possible. This way, a variety of products may be offered to different market segments, in an economical way [Jiang, 2000]. If the market environment is turbulent enough, then identifying and fulfilling a segment's market's needs will buster the company's revenues [Hart, 1995]. The personal and information integration of the value chain can help to understand customer's individual needs, and therefore to offer a unique product that meets his/her requirement [Radder and Louw, 1999; Simchi-Levi, et al, 2000].

The product's uniqueness depends on the degree of customer involvement in the process. The production process is defined in a narrow view with only four stages: Design, Fabrication, Assembly and Distribution [Duray, 2002, Duray, et al, 2000 and Lampel and Mintzberg, 1996] or Design, Manufacturing, Distribution and Customer [Alford, et al, 2000]. If the customer is involved in the early stage of design, the product will be highly customized, but if he/she is involved at the final assembly stage, the degree of customization will not be as great [Duray, 2002].

In order to satisfy customer's personal needs, companies must develop product families or product platforms so that the variety of products can be achieved at an economical way [Dobrescu and Reich, 2002; Jiao, et al, 2003; Yang and Li, 2002].

4.2 Use of Modular production systems.

In order to provide a cost-effective unique product, MC requires a modular approach to achieve economies of scale. A modular approach reduces the variety of components and at the same time allows a great combination of final products. Modularity allows part of the product to be made in volume as standard modules with product distinctiveness achieved through combination or modification of the modules [Duray, 2002].

Modularization offers the advantage of increasing the possible combinations of final products available for the customer to choose. Modularization also allows reducing cost if is implemented correctly, customizing only the module or modules that is different for the customer and producing the remaining as a standard production [Schenk and Seelmann-Eggebert in Rautenstrauch, et al. 2002].

Modern management technology, combined with advanced manufacturing technology allows to agile respond to customers demand. This combination and the adoption of design for a product family and technology concurrently in order to fabricate universal and exchangeable modules, makes possible the launch of products rapidly [Yang and Li, 2002].

The use of modular production systems is made easier if the design is also taken into account on the customization process. Design for Mass Customization (DFMC) consider the cost, reliability, and market acceptance of the product and the economies of scope and scale at the early design stage of product realization. Also, DFMC include not only sales and marketing, but also production, distribution and service [Jiao, et al, 2003]. It helps production by sorting product information by product families. DFMC, or Design for variability [Dubrescu and Reich, 2003], develop product families with common platforms that are shared by all the products whose variant satisfies a specific segment market. The essence of product platforms bases on the fact that the modules are reusable among the range of designs offered, and therefore the variety of components to be differentiated are minimized. The use of product platforms minimizes the cost of new derivative product because the development of the initial product architecture can be obtained at an incremental cost. It can be inferred that some end products of the same family will use *common* modules. These common modules are called building blocks. The building blocks

form the base products that provide common functions to increase the product portfolio. Building blocks form the basis for reusability and flexibility in generating variant products. It is commonality that reveals the difference of the architecture of product families from that of a single product. While modularity resembles decomposition of product structures and applies to describing module (product) types, commonality characterizes the grouping of *similar* module (product) variant under the umbrella of specific module (product) types characterized by modularity. Functional commonality manifests itself through functional classification [Jiao, et al, 2003].

In order to achieve the economies of scale, mass customization uses a modular production system, where basic modules or components are controlled in a push basis until an order is placed [Partanen and Haapasalo, 2004]. Once the order has been placed, the differences are made in a pull basis. The key of the effectiveness of MC is the postponement of the differentiation task [Freitzinger and Lee, 1996].

The reduction in the high cost of implementing Mass Customization is obtained when the manufacturers develop product families with a common platform that is shared by all the diversity of products [Dobrescu and Reich, 2003]. Without this, the costs may increase and the benefits may not be perceived. This diversity of designs is created to meet different customers' demands. The variant are created by adding different modules or components to the platform. At the same time, designers create products composed of modules that are standardized as much as possible across products. By adopting standardized modules and common platforms, the diversity of products can be performed as late as possible in the manufacturing process.

The success of MC depends basically on three aspects: quick responsiveness, variety and economy of scale. This means that MC needs to balance the features, cost and schedule. This balance is achieved if three major technical challenges are followed: *Maximizing reusability, product platform and Integrated product life-cycle* [Tseng and Jiao, 1998].

4.2.1 Maximizing reusability.

In order to gain economics of scale, maximizing the amount of repetitions is essential. By doing so, the efficiency of mass production can be achieved, as well as efficiencies in sales, marketing and logistics. But Mass Customization provides a wider range of products, with different characteristics and sometimes different designs. This product proliferation naturally increases variety and brings variability into the equation. This engenders design variations and process changeovers, which seemingly contradict the pursuit of low cost and high efficiency of mass production. Such set up represents a challenge for manufacturers because it is needed to ensure stability so it can provide the widest range of customers and changing product demands while building upon existing process capabilities, experience, and knowledge. By optimizing reusability across internal modules, tools, knowledge, processes, components, etc. the low cost advantage and mass efficiency can be expected to maintain the integrity of the product portfolio and the continuity of the infrastructure [Jiao, et al, 2003].

4.2.2 Product platform.

The success and effectiveness of a firm's new product generation is based in two aspects:

1. The ability to create successful new product over an extended period of time, and
2. The attractiveness of these products to the target market niches.

Therefore, the essence of Mass Customization is to maximize the match of the internal capabilities with external market needs [Jiang, 2000; Pine, 1993].

In terms of Mass Customization, a product platform provides the technical basis for accommodating customization, managing variety and leveraging core capabilities to optimize flexibility and foster a customer-focus and product-driven business [Tseng and Jiao, 1998].

4.2.3 Integrated product life-cycle.

The reduction of the time-to-market depends on the integration of the entire product development process spanning from customer needs to product delivery. An Extended Enterprise approach and Concurrent Engineering methodology are important for the integration of the product development life-cycle from an organizational perspective. This wider approach must include sales and service. On the other hand, the design process should take into account various product life-cycle concerns, such as functionality, cost, schedule, reliability, manufacturability, to name just a few. In other words, MC requires not only the integration across the product development horizon, but also the provision of a context-coherent integration of various viewpoints of the product life-cycle [Jiao, et al, 2003].

4.3. Mass production efficiency

Maximizing reusability, the use of product platforms and design for mass customization enhance the use flexible manufacturing and thus lean manufacturing techniques, which lower costs and achieve mass production efficiencies.

The segmentation of the market niche and the identification of customer's needs of each segment allow offering a variety of products with unique characteristics for each segment providing greater value for the customer. This will improve sales and the continuous identification of new needs will split again the market, and so on.

It has been mentioned how Mass Customization offers to increase customer's perceived value at the cost of a mass production system. This is an advantage by itself but it is now necessary to describe the different business models of Mass Customization that a company can follow in order to achieve the competitive advantage. Different models proposed in the literature will be analyzed and then compared to each other to determine the differences, benefits and drawbacks of each one.

5. Mass Customization business models

Eight different strategies or archetypes were identified in the literature. Each of those provides an explanation of how customer involvement, modularity or both interact to set a specific type of mass customization.

The first strategy presented, identified four types of customization depending on the product presentation and whether the product change or not. These types are *collaborative customization, adaptive customization, cosmetic customization and transparent customization* [Gilmore and Pine, 1997].

- ***Collaborative customization.*** This type of customization involves the customer to design the best fitting product. This is achieved by conducting a dialogue with individual customers and helping him/her to identify his/her needs; and then, from the different modules, to customize one to fulfill the specific needs. Examples of this approach are house contractors, because they help customers to define their own layouts according to specific parameters.

- ***Cosmetic customization.*** This type of customization offers a standard product that can be present differently to different customers. The product does not change, only the way it is presented to different customers. Examples of this approach are the caps and sweatshirts with the customer's name woven on it.

- ***Adaptive customization.*** This type of customization takes place after sale. The product is standard but it has the technology and flexibility to be customized according to the customer's specific needs, at different moments. Cellular phones are examples of this approach, because it has the technology to change the ringing sound, the welcome screen, and even the face of the phone. All of these changes are after sale and performed by the customer.

- ***Transparent customization.*** This is the less likely approach of customization. This type of customization provides customers with unique orders of products or services, without letting them to know that the product has been customized for their individual needs. Because there is not customer involvement, their needs are assumed according to purchase patterns. An example is Amazon.com by offering similar products that fits with the profile of the buying habits of the customer.

As it can be seen, in this archetype the product may or may not change, the customer may or may not be involved and the representation of the final product may or may not be the same.

Gilmore and Pine's cosmetic customization, which is the simplest way to provide customization, can be performed in the last echelon of the supply chain. On the other hand, transparent customization does not involve customers into the process, nor production modules. Although this is a way for satisfying individual needs, the customer does not express them explicitly.

Another model is presented by Ross [1996] He identifies five strategies for customization based on two parameters: the nature and the degree of variation. Although he does not explain the strategies, he does provide examples of each type and a simple explanation can be given. These strategies are:

- ***Core Mass Customization***. The customer can modify core elements. This is similar to Gilmore and Pine's Collaborative customization. An example of this company is Panasonic's National Bicycle Industrial Co.

- ***Post-production Mass Customization.*** Here a customizing service converts a standard product into a customized one. Ross presents as an example the business software package providers with integrated companies, such as MRP2 or ERP's. Here, the software is fully developed and fit to specific customer's requirements by enabling or disabling functions of the software.

- ***Mass retail customization.*** Customization takes place at the retailer. Ross set as an example the fences makers. The American drug stores are another example;

the doctor writes an individual prescription for the patient and the drug store collects the different components of the medicine to fulfill the prescription.

- ***Self customizing products.*** The product is customized by the customer according to his/her individual needs. An example is PC software. This is similar to Gilmore and Pine's Adaptive Customization.

- ***High variety push.*** This type of customization consist on providing a wide variety of similar products, that only change in dimension, colors, surface finishing or materials. An example is the wristwatches from Swatch.

Ross also mentions levels of customization, being the lowest degree the one he classifies as cosmetic, which consist in offering a number of colors, surface finishing or material. The middle degree is selectable functional options and the highest degree is core customization.

Lampel and Mitzberg [1996] set a continuum between Pure Standardization and Pure Customization, identifying these way five strategies. These five strategies, to simplify the model, have four stages: design, fabrication, assembly and distribution. Customization starts with the downstream activities, closer to the marketplace where an individual order is placed, and then the information is spread upstream. Standardization starts the other way around, beginning by the design stage and then continues downstream until it reaches a common market. The five strategies are:

- ***Pure standardization.*** There are no distinctions between products and/or different customers. The customer has the trade-off between price and uniqueness. He/she must adapt with what is available or switch to another product. There is no

influence of the customer into the value chain process. Usually, a push production system is followed by the companies that use this strategy.

- ***Segmented standardization.*** In this strategy, companies start visualizing differences between buyers, but they are classified as market segments or customer cluster. Thus, the product sold is basically the same, with small differences for each cluster. There is a narrow range of features available to modify the product. The customer is not involved in the process. In fact, a basic product is designed and then modified to cover various products dimensions, but not at the request of the customer. Segmented standardizations strategy offers a greater variety to choose from but does not involve the customer, so they do not influence much over design or production decisions.

- ***Customized standardization.*** This strategy uses modular components to satisfy different requirements by assembling standardized components at made-to-order. This way, customized standardization allows to each customer to get his/her own configuration, but restricted to available components.

- ***Tailored customization.*** This strategy uses a "cut-to-fit" approach. Here, a prototype product is presented to customer, and then, he/she adapts it to his/her personal needs. In this strategy, the customization takes place in the fabrication stage, but design is not customized.

- ***Pure customization.*** This strategy is the antithesis of pure standardization. Here, customers are involved since design stage; therefore the final product is a presentation of his/her personal requirements. An example of this strategy is used by architects when designing a house according to the customer's wishes.

Lampel and Mitzberg [1996] use a value chain approach to describe each strategy and the point where customer are involved. An important characteristic of this strategy is that as customization evolve, so does the communication process, allowing upstream and downstream information flows.

Alford, et al, [2000] present three strategies for Mass Customization in the automotive industry, classified as core, optional and form customization, depending on two main characteristics: the production volume and the point of differentiation. Thus, the strategies' descriptions are:

- ***Core customization.*** In this strategy, the customer is involved even into the design process of the vehicle. This strategy better fits in low-volume luxury cars. There are some core elements that the customer may not change if the vehicle is designed for a specific market requirement.
- ***Optional customization.*** This strategy allows customers to choose among a variety of options that meet their requirements, but does not affect the design of the vehicle. The customer is involved in the manufacturing process as the vehicle is assembled according to his/her specific requirements.
- ***Form customization.*** This strategy takes place at the distributors and consists on changes requested for the customer that can be incorporated at the dealer's center. This strategy allows limited changes at the vehicle, but also includes customization in terms of sale.

Alford, et al. [2000] present their study to a specific industry, and also mention how can the industry apply it. They give a value chain perspective, and also the specific market segment on which each strategy should focus.

Duray, et al. [2000] use a bi-dimensional approach to describe the archetype presented. They use the point of customer involvement and the point where modularity begins. They use a narrow view of the value chain, with only four stages, similar to Lampel and Mitzberg [1996] and Alford, et al. [2000]. These stages are: *design, fabrication, assembly and use.* By using this dual approach, they define four archetypes of customization:

- ***Fabricators.*** In this archetype, both customer involvement and modularity take place at the design and fabrication stages. Because customer is involved in the design stage, modules are fabricated to satisfy these requirements. This is similar to Lampel's and Mitzberg's pure customization. Examples of this are the Adidas tennis shoes. Adidas offers to customize the product according to the footprint of the customer.

- ***Involvers.*** The customer is involved in the design and fabrication stages, but modularity does not take place until assembly and use. This approach allows customer to set their requirements but no new modules are fabricated. Customization is achieved by combining standard modules to meet the specification of the customer. In other words, from an array of components, customers can configure his/her product. Examples of this are Taylormade golf clubs, which are made cut-to-fit.

- ***Modularizers.*** Modularizers involve customers during the assembly and use stages, but uses modular components since design and fabrication stages. This

means that companies use modular or standard components for fabrication, and the customer only combines existing components to differentiate his/her product. Examples of this are training courses. The customer select from a predefined set of courses which one wishes to take, the length to complete them and the dates of the courses.

- ***Assemblers.*** The followers of this strategy bring both customer involvement and modularity at the fabrication and use stages. This companies use modular components to offer a wide variety of products to customers, which set an order to be assembled. Assemble-to-order manufacturers may be considered mass customizers if the customer chooses the product form a predetermined set of features. Dell computers can be associated with this type of customization.

Another author [Pine, 1993] presents five methods to achieve customization. These methods are:

- ***Customize services around standardized products and services.*** This method allows to mass production products to be customized before being sent to customers. The customization takes place on marketing and/or delivery, and because it is the last echelons of the company's value chain, is the easiest and most popular stage to start customization.

- ***Create customizable products and services.*** This method is similar to Adaptive customization from Gilmore's and Pine's model. The product is produced as a standard product, but it has the technology or characteristic to fit each customer's needs. In this method, the product is developed for customization, although it is produced as a standard-mass-production product. This author

present as an example the Gillette Sensor razor machine, which "automatically adjust to the contour of your face" as they proclaim.

- ***Provide point-of-delivery customization.*** In this method the customization takes place at the point-of-sale. Using this method, the company provides customization right in the point and moment where the customer needs it. This method uses the postponement as a strategy to provide the fastest way possible the customization process. Examples of this are the T-shirt that are customized when the customer name is woven in it, or a Heat-applied logo is put in the garment.

- ***Provide quick responsiveness throughout the value chain.*** In this method, the entire value chain must respond quickly enough to satisfy customer's needs. This quick responsiveness begins the transition to mass customization, because it enhance the flexibility needed to mass customized products. The quick responsiveness is by itself the method to provide what the customer wants.

- ***Modularize components to customize end products and services.*** This method uses modular components to configure a variety of products to meet the customer's wants and needs. The use of modular components creates interchangeable parts that can be used across products and services.

Another author [Spira, 1993] presents an example of a company that performs mass customization to satisfy its customer's needs. This company, Lutron Electronics Co. Inc., performs customization in four different ways:

- ***Assemble of standard components into a variety of unique configurations.*** This method is the standard production system that Lutron uses to manufacture its products.

- ***Perform additional custom work.*** If the customer requires additional customization.

- ***Provide special services.*** This method is used if the customer requests for special characteristics, such as custom-matching a paint sample.

- ***Provide custom packaging.*** The package can be customized to different customers.

Finally, MacCarthy, et al [2003] mention that in the literature reviewed, the archetypes underestimated two distinguished factors and omitted a third one. These factors are:

- *Temporal relation between activities.* The relationship existed between design, fabrication and assembly is a common way to differentiating non make-to-stoke manufacturers. They realized that there are three temporal relationships to be accounted for. Firstly there is design and validation per product family where these processes are completed before any customer place an order for a product. Secondly there is the per order situation when the customer is involved during each order fulfillment cycle. Thirdly there is the per product relationship where design and validation take place at the prompting of the customer but prior to (repeat) orders being placed for that product.

- The second factor is whether the technological resources used in order fulfillment are *fixed or modifiable.*

- The third factor is whether an enterprise customizes a product on a once-only basis or whether they customize on a call-of basis, in which they accept a customization commission if repeat orders are likely.

After that, the authors proposed five methods to provide customization depending on the interactions of six processes: order taking and coordination, product development and design, product validation and manufacturing engineering, Order fulfillment management, Order fulfillment realization, and Post-order process. These methods are:

- ***Mode A: Catalogue Mass Customization***. A customer places an order according to a pre-engineered catalogue of variants. The order is fulfilled and produced using standard order fulfillment processes. In this mode there are no engineering processes to develop new components or design new modules. Customer select from a pre-specified range and the products are manufactured by the order fulfillment activities that are in place.

- ***Mode B: Fixed resource design-per-order Mass Customization***. In this mode, the customer requirements are fulfilled by engineering a customer specific product and produced through standard order fulfillment processes. This means that it may be needed to design the components to fulfill the requested order, but the processes are standard. Once the customer places one order for the product, there is no expectation of repeat orders. In this mode there is some degree of product engineering for each order, unless a customer's wishes happen to match a previous order, in which case the product design is reused. Because the order fulfillment process is standard all designs must be suitable for the process.

Therefore it is important the product development process is aware of the process capabilities.

- ***Mode C: flexible resource design-per-order Mass Customization.*** In this mode, when the customer places an order, this is fulfilled by engineering a customer specific product, and produced through modified order fulfillment processes. This means that the customer design the product required and the process is flexible enough to fulfill the order. The customer places one order for the product and there is no expectation of repeat orders. In this mode products are engineered per order and the order fulfillment process may be modified per order.

- ***Mode D: Fixed resource call-off Mass Customization.*** A customized product is designed for a customer, to be manufactured via standard order fulfillment processes in anticipation of repeat orders. This means that the customer can configure his/her product and this will be manufactured using standard processes.

- ***Mode E: Flexible resource call-off Mass Customization.*** This mode is the same as Mode D except that the order fulfillment activities are modifiable. A customer order is fulfilled by engineering a customer specific product, and produced through modified order fulfillment processes. There is an expectation of repeat orders.

6. Strategies comparison.

In the literature review presented by some authors [MacCarthy, et al 2003; Da Silveira, et al., 2001] a comparison is made for different strategies. Here are presented those strategies and compared one to each other.

The beginning step consisted in comparing the generic level of customization. To perform this, it was taken a previous study as the basis [Da Silveira, et al, 2001]. Originally, four strategies were included, and in this study are presented those strategies and other four found in the literature research stage. To classify the remaining four, the original strategies were analyzed using the same logic. Table 3 shows this classification.

MC Generic Levels	Gilmore and Pine	Lampel and Mitzberg	Pine	Spira	Ross	Alford, et al	Duray, et al	MacCarthy, et al
8. Design	Collaborative; transparent	Pure customization			Core Mass customization	Core customization	Fabricators; Involvers	Mode B; Mode C
7. Fabrication		Tailored customization						Mode A.
6. Assembly		Customized standardization	Modular production	Assembly standard components		Optional customization	Modularizers; Assemblers	Mode D; Mode E
5. Additional custom work			Point of delivery customization	Additional custom work	Post-production customization			
4. Additional services			Customized services; providing quick responsiveness	Provide additional services				
3. Package and distribution	Cosmetic	Segmented standardization		Customizing packaging	Mass retail customization	Form customization		
2. Usage	Adaptive		Embedded customization		Products self-customizable			
1. Standardization		Pure standardization			High variety push			

Table 3. Classification of Mass Customization Strategies.

The following step consisted in identifying what was considered by each author to formulate the strategy presented. Table 4 shows what each author considers to formulate

the strategy presented. As it can be seen, only product changes and customer involvement are considered by all authors. On the other hand, degree of variation, high variety of products, information flow, temporal relation between activities, order fulfillment technological resources and repetitiveness are considered only once by different authors.

Mass Customization Strategies								
	Pine	Gilmore and Pine	Ross	Lampel and Mitzberg	Alford, et al.	Duray et al.	MacCarthy et al.	Spira
Customer involvement	x	x	x	x	x	x	x	x
Modular production systems	x			x		x	x	x
Product changes		x	x	x	x	x		x
Customization provider	x	x			x			
Supply Chain integration	x			x			x	
Degree of variation			x					x
Customization levels			x		x			
Information flow	X			x				
Production volume					x			
Temporal relation between activities							x	
Order fulfillment technological resources							x	
Repetitiveness							x	

Table 4. Mass customization strategies by author.

Gilmore's and Pine's model suggest that mass customization can be achieved by changing the product without the knowledge of the customer. In addition, they do not mention the use of modular production systems explicitly although it can be inferred when the examples are mentioned. These two premises go against the definition of MC, even though offer to satisfy customer's individual needs at a reasonable price. Nevertheless, this strategy is the simplest to understand, and perhaps also to implement, because it is based on two characteristics: whether the product changes or not; and if the representation of the product suffers any change.

On the other hand, Ross's model presents a strategy where the company offers a high variety of product in an attempt to satisfy the individual needs. This increases the number of SKU's and the variability of the supply chain. In addition, this model does not present

either a value chain perspective or supply chain integration, and he never mentions the use of modular production systems. Although, he presents strategies that no one else does, such as post-production mass customization and mass retail customization, which are also ways to satisfy customer needs.

Lampel and Mitzberg's model is the first to present a value chain perspective and modular production systems. Indirectly, they consider an integration of the supply chain with the information flowing upstream and downstream to satisfy customer's needs. They also present different strategies depending on the point of customer involvement. On the other hand, the model is based mainly on the degree of customer involvement and does not take into consideration how the modular production system affects customization.

Alford's, et al's model is the only one that is presented for a specific industry. This model also includes the customization provider, and is the first one to mention the production volume, although just to differentiate the type of car to be produced. They also have a value chain perspective, although the explanation provided is too simple for the importance of the industry. Even though they present a way to apply mass customization, they do not mention how the supply chain should respond to it.

The model presented by Duray, et al. is the most complete and at the same time more complex than the previously ones presented. They define a bi-dimensional model based on the point where modularity starts and the point of customer involvement. This gives a reference for the type of production systems needed to implement mass customization, and the degree of standardization required in order to achieve it. Nevertheless, this model does not present a way to integrate the supply chain.

The first archetype in the literature is the one presented by Pine. These are strategies to make the shift to mass customization. Pine's model to create customizable products and services it is not a mass customization strategy because it does not involve a unique customer, but instead the ***market segment*** takes part previously in the research and development of the product. This archetype provided by Pine is a path to become mass customizers. Instead of presenting strategies, he presents the evolution that companies must follow to become mass customizers.

Spira's archetype is an implementation of Mass Customization. He presented the methods that Lutron Electronics Co, uses to provide customized products and the benefits it has obtained. Again, these strategies do not provide supply chain integration, or a value chain perspective. But it is an example of how mass customization can be implemented.

A characteristic that is missed on the strategies presented is the repetitiveness of the purchase. So far, Mass customization has been defined as a one-time, one-product purchase, but this is not necessarily true. MacCarthy's et al model includes for the first time the repetitiveness of the purchase and introduces the time relationship among activities of the value chain. They also include the technological resources needed to complete the order fulfillment process. This model considers the processes required to implement mass customization and the interrelationship existed between these processes. Again, this model is the first one to present the interrelationships existed among processes in the supply chain.

The production volume for an individual product has not been identified as an important factor to determine if the product can be classified as mass customized, especially if the customer is not the final consumer of the product. In this order, a further research of this topic is suggested.

The integration of the supply chain to provide the quick responsiveness and the time-base competition is not mentioned deep enough to set the know-how for implementing mass customization. Each industry and even each company should integrate its supply chain differently; nevertheless, the bases for the know-how of the implementation should be addressed.

7. Conclusions.

Mass Customization allows companies to achieve competitive advantage, because it offers to fulfill individual needs, increasing the perceived value over a product. Nevertheless, Mass Customization is not for every company or for all products. Companies must realize if the customer demands for personalization prior to begin the transition process, otherwise, the transition may lead to bankruptcy.

If mass customization is for the company and for the product, then it is important to offer the proper approach of personalization, so that the risk of failure can be minimized and at the same time, the manufacturing cost reduced and sales increased.

The strategies herein mentioned are not recipes of success, but approaches to provide mass customization. The final approach depends on the environment of each company, and it should take into consideration not only the allowed degree of customer involvement or the use of modularity, but also it must consider the entire value chain, from suppliers' suppliers through the final customer, and in some cases, even the disposal of the product. It has to consider the suppliers' ability to respond fast enough to the demand changes, with the desired quality and quantity. On the other side, the company has to promote the

capability to fulfill individual requirements and to improve the point-of-sale's skills to sell a unique product.

It also has to include the company's ability to become agile to deal with fast changes. Mass customization offers to satisfy individual needs, and these change faster than the speed of adapting to the changes.

Mass customization is a way to achieve competitive advantage, especially for the first mover, but it must be followed with continual improvement of the processes, the products and the organization. Mass customization cannot sustain competitive advantage if the company does not keep close to the changes of the customers' individual needs and wishes.

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Chapter 2

The Mexican Companies' Implications by Implementing Customization strategies. An Exploratory survey

There was not a study that analyzes the implications of implementing customization strategies in Mexican companies. This study is presented to identify the stand point of Mexican companies that offer customization.
In this study it was analyzed the Mexican companies implications to provide customization strategies. It was found that Mexican companies are at the beginning stage of customization, providing customization, mainly because the customer demands for a non-standard product rather than for the company strategy.
In this study are presented the benefits, negative consequences, difficulties in the supply chain and barriers by implementing customization strategies. The results were then compared against a similar study[1] performed in the United Kingdom in 1996. This was mainly to compare the standing points.

1. Introduction

Mass customization consists on satisfying customer's individual needs at a competitive price similar to those products of mass production without the trade-off of the standard product. Mass customizers can offer similar prices than mass producers because they achieve economies of scale by adopting modular production systems and lean manufacturing principles. An advantage that mass customizers can offer is that the response time of an individualized product is lower than the one offered by mass producers.

A way to achieve customer satisfaction is by adopting Mass Customization. This approach enhances profitability through a synergy of increased customer-perceived value

[1] Acknowledgement. We would like to thank to Dr. Pär Alhström and Dr. Roy Westbrook for letting us use the study they performed in the United Kingdom as part of our research. This study could not be completed without their help.

and cost reduction in production and logistics. Therefore, MC inherently makes high value-added products and services possible through premium profits derived from customized products [Jiao, et. al, 2003].

There are several strategies to provide customization, depending on where the customer is involved, [Lampel and Mitzberg, 1996], whether the product or the presentation of the product change, [Gilmore and Pine, 1997]; where the intersection of customer involvement and modularity occurs, [Duray, et al, 2000], the step on which the company stands to offers customization, [Pine, 1993]; whether the fulfillment process is fixed or variable [MacCarthy, et al, 2003], and so on.

The purpose of this research is to identify the implications that Mexican companies have had by implementing customization strategies. After that, those results will be compared with the results presented in a similar research performed by Ahlstöm and Westbrook [1999] in the United Kingdom. This last study was performed in 1996 and published in 1999 presenting a view of the state of Mass Customization in the United Kingdom. In order to perform a one-on-one comparison, the study of Ahlström and Westbrook was used as guideline for this research. This comparison can not be taken as a gap between the companies, because of the time difference, rather as a comparison on the standing points for both countries as customization refers.

This research has two main objectives: *To identify the most used method to provide customization* and *to analyze the benefits, negative consequences, difficulties found in the supply chain and barriers to increase the customization degree.*

This research also seeks to find the market conditions in which Mexican companies operate, such as the increasing speed of change of the customers' requirements, or the

demand for non-standardized products. Furthermore, we also present the methods used to provide customization, the benefits and negative consequences of having adopted customization strategies, the difficulties found in the supply chain to offer customization and the barriers that affect the increase of customization. Additionally to the research performed by Alhström and Westbrook, this research seeks to identify the integration degree that companies have with customers and suppliers.

This research includes seven sections: General conditions, methods used to provide customization, benefits of implementing customization, negative consequences, difficulties in the supply chain for implementing customization, barriers for implementing customization and, finally, the integration degree with customers and suppliers.

2. Research method

There was no information available about the effect of implementing mass customization in Mexican companies. The only reference to the matter is the Alhström and Westbrook study performed in the United Kingdom. Because of this, an exploratory survey was addressed. The survey was answered by those companies that, according to what it is known about them, use one or several of the methods presented in the study previously mentioned. This is the main difference between the two studies, and an important one. Another characteristic that these companies should have had was the ability to offer personalized products. In order to have the widest extension possible, the survey was made with the support of the Virtual University of Monterrey Tech.

The survey was sent to all Campuses of the scholar system applied on each city. A total of *115 surveys were sent* out of which ***87 usable ones were returned***, a response rate of

76%. The companies that correctly fulfilled the survey were from a range of industries. However, the main part of the companies (70 percent) came from manufacturing (43 percent); services (14 percent) and commercial (13 percent). Table 5 shows the results.

Sector	Percentage
Manufacture	43%
Services	14%
Commercial	13%

Table 5. Industries distribution

The survey was prepared to be answered by the Production Manager, the Logistics Management or the equivalent person within the company with the knowledge to respond to the specific questions asked in the survey.

According to the Secretary of Economy, manufacturing sector refers to those companies whose main product is tangible and suffers some changes in the processes. Service sector refers to those companies whose main product is intangible; and commercial companies are those that their main activity is the trade of products or services.

The surveys were sent to small, medium and large companies in order to have a representative sample. The classification of the size was related to the number of employees that the company had at the moment of the survey, using the parameter that the Secretary of Economy provides to classify the size of a company.

Being an exploratory survey, this was kept relatively short. Most items asked the respondents to rank issues about their customization methods and subjects around it. In most of the sections, respondents were asked to rank from 1 through 7 -where 1 always represents the most important implication and 7 the least important- a predetermined set of characteristics. Ranking scales generate only ordinal data, which are not analyzable by ordinary parametric statistics, [Emory and Cooper, 1991] but we decided to use ranking

scales to be able to compare results. Again, these characteristics were taken from Alhström's and Westbrook's research.

The design of this research has its limitations. First, using the Virtual University, the universe of the sample was reduced to only those cities were Monterrey Tech has Campuses. Second, the lack of available information about the companies' production systems and strategies made difficult to find companies that exactly match with the characteristics needed, reason why there were so many rejected (24 percent).

The manner on which the data are summarized is, to some extent, left to the discretion of the researcher, since no standard method exists [Emory and Cooper, 1991]. The identification of the most used method to provide customization was possible by analyzing the proportions that each method had in the companies. In order to identify the resulted rank of the implications by method, the mean of the results given by the respondents was ranked. After doing that, an ANOVA analysis by method was performed to prove that the ranks given to each implication had not the same mean. In order to confirm the previous, a non-parametric analysis was performed using the Kruskal-Wallis analysis of medians [Hernandez, et al, 1998]. Additionally, implications were compared with all methods to identify which one are the most important and the subsequent importance.

After receiving the surveys, these were filtered by checking that the survey was complete and correctly answered. Those surveys that did not meet such requirements were rejected. The results of the analysis are presented in the following sections.

3. Survey results

This section contains the distribution of responses to questions in the survey addressing the link existed between mass customization implications and the companies.

3.1 General conditions.

In this section, the survey asked about the variability of the company's environment such as the fast changes of customer's requirements, the increasing demand for non-standardized products, the life time of the products compared to five years ago and if the company has plans for increasing the degree of customization. Also the companies' size distribution is shown in this section.

The respondent companies were distributed very similar at what size means. Table 6 shows that medium companies were the most, with 34 percent of the total usable surveys. Small companies represented 32 percent and large sized companies represented the lowest proportion with 26 percent. The remaining 7 percent were companies that did not express their size. The graphic of the company's size can be found in Appendix A

Size	Percentage
Small	32%
Medium	34%
Large	26%
Unknown	7%

Table 6. Company's size distribution

At the question regarding the company's believes if the customer's requirements are changing faster now than five years ago, 91 percent of the respondents answered affirmatively. In contrast, only 37 percent have identified that the product life-cycle is now shorter than it was five years ago.

When respondents were questioned if they have detected an increasing demand for non-standardized products, the answer was that 66 percent believed so. Nevertheless, 76 percent of respondents plan to increase the degree of customization offered to customers. The graphic of the company's perception can be found in Appendix A

3.2 Method to provide customization

This section of the study presents the methods used for Mexican companies to provide customization. The methods from which the respondent could choose from were: *assembly of core elements, materials processing, increase range of stock, make products self-customizing, information content modification, another company provides services around product, retailers provide services around product and other.* These methods were the same used on the study performed in the United Kingdom. Because the lack of knowledge about mass customization in the industry, each of these methods was explained in the survey, so the respondents could have a better understanding of the method implied.

In this survey, it was asked to respondents about the current method or methods used to provide customization. If the company uses more than one method, it was asked to rank the methods in order to identify the one most used. Contrary to Alhström's and Westbrook's research, this does not include the method planed to use in the future.

Table 7 shows the respondent's results of the method used to provide customization. It's important to mention that the sum of methods exceeds the amount of surveys received because about 78 percent of respondents mention that the company uses more than one method to provide customization. 61 percent of the respondent companies use between two

and three methods to provide customization; 22 percent uses only one method and the remaining 17 percent uses more than three methods.

Method	Current
Assembly of Core Modules	18
Material processing	63
Increase range of stock	31
Make product self-customizing	15
Information content modification	26
Another company provides service around product	32
Retailer provides service around product	16
Other	9

Table 7. Method use for provide customization.

The companies that are in the manufacturing sector and use material processing as the method to provide customization represent 52 percent of the total companies that use this method. Table 8 shows the distribution of the manufacturing, service and commercial companies by method to provide customization. Letter ***A*** means that only one method is used to provide customization; letter ***B*** represents that between two and three methods are used; and letter ***C*** indicates that more than three methods are used. The distribution of the remaining sectors are shown in appendix A

	A			B			C	
Method	Commercial	Manufacturing	Services	Commercial	Manufacturing	Services	Manufacturing	Services
Assembly of Core Modules	0	2	0	1	5	0	5	1
Material processing	1	5	0	4	21	5	7	4
Increase range of stock	1	1	0	5	10	3	3	2
Make product self-customizing	0	0	0	1	4	0	4	1
Information content modification	0	0	1	4	5	3	4	4
Another company provides service around company	1	0	0	3	6	6	5	3
Retailer provides service around company	0	0	0	2	1	1	4	1

Table 8. Commercial, manufacturing and services distribution by method and number of methods

Because most of the companies use more than one method to provide customization, the results were classified to identify the proportion each method had. To do this, each method was filtered according to the rank given and after that all results with the same rank were summarized. This means that those methods ranked as number one, the frequency were summarized and found the proportion of respondents that ranked each method as number one. It was found that 48 percent of respondents classified ***material processing*** as the first method used to provide customization. Material processing is also the method that companies use no matter if it is the only method or if they use more than one.

Using the same analysis, we found that the second most important method were ***increased range of stock, information content modification, and the use of another company to provide service around the product,*** each one with about 14 percent of results giving rank 2. A third and fourth method to provide customization was identified using the same analysis. The third method is ***Make products self customizing*** and the fourth one is tied between ***assembly of core modules*** and ***other.*** The resulted ranks can be observed in table 9.

Method	Rank
Material processing	1
Increase range of stock	2
Information content modification	2
Another company provides service around company	2
Make product self-customizing	3
Assembly of Core Modules	4
Other	4
Retailer provides service around company	5

Table 9 Resulted rank.

3.3 Benefits of implementing customization

In this section, it is presented the Mexican companies' perceived benefits of implementing customization strategies. Each method was analyzed independently in order to find the most important benefit. The benefits were predefined and the respondents were asked to rank the benefits for each method they use to provide customization. Additionally, the benefits were compared against each other independently of the method use to provide customization in order to find which benefits is the best for Mexican companies that use customization strategies. This double analysis allows us in one hand, to rank the benefits for each method in order to compare against the UK results; and in the other, to identify which of the benefits are among the most important for Mexican companies.

The benefits presented were ***increased customer satisfaction, increased market share, increase customer knowledge, reduce order response time, reduce manufacturing cost, increase profitability, and other.*** The resulted mean was considered to be the resulted rank. We decided that the lower the mean, the more important benefit or better ranked.

Each method was analyzed in order to identify the resulted ranked benefits. The results of the ANOVA and Kruskal-Wallis tests shown that there was no statistical evidence to prove that the means or medians were the same, for any of the methods used to provide customization. The results of the test analysis are presented in Appendix B. Table 10 present the resulted benefits ranked with all the methods used by Mexican companies. As it can be seen, ***make product self customizing and retailer provides service around product*** are methods that were ranked similar, although there are no statistical evidence to prove that one method is better than any other. Figure 1 present the result of the ANOVA test for the methods. Also, the table shows that ***increased customer satisfaction*** is the most

important benefit, followed by ***increased market share*** and ***reduces order response time.*** Figure 1 present the results of the ANOVA test for the benefits. The implication ***Other*** was not taken into consideration because of the broad spectrum of answers.

Benefit \ Method	Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Other	Average
Increased customer satisfaction	1	1	1	1	1	3	1	2	1.29
Increased market share	6	5	2	3	3	5	3	1	3.86
Increased customer knowledge	5	6	5	4	2	6	5	5	4.71
Reduced order response time	3	4	3	2	4	2	2	4	2.86
Reduced manufacturing cost	2	3	6	4	6	1	5	6	3.86
Increased profit	4	2	4	4	5	4	4	3	3.86
Other	7	7	7	7	7	7	7	7	7.00

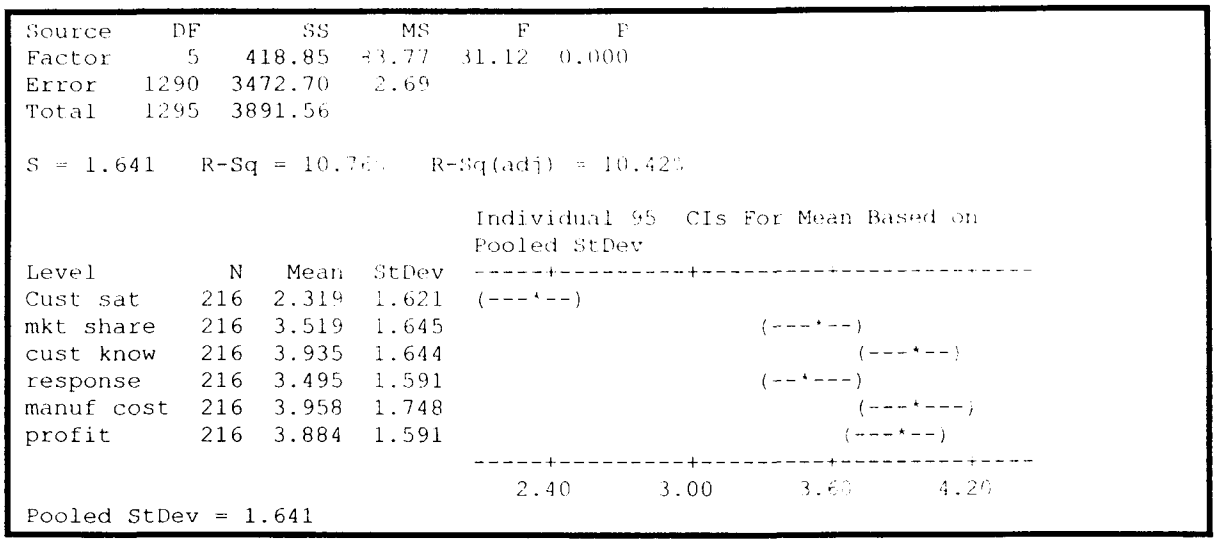
Table 10. Benefits ranked by Method of provide customization

```
Source     DF       SS     MS      F      P
Factor      7     0.11   0.02   0.00  1.000
Error    1354  4095.86   3.03
Total    1361  4095.96

S = 1.739   R-Sq = 0.00%   R-Sq(adj) = 0.00%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev  -----+---------+---------+---------+----
Assembly     150   3.507   1.725      (----------*----------
Material     390   3.521   1.731           (------*------)
stock        192   3.521   1.745        (---------*---------
self cust     90   3.511   1.737   (-------------*--------------)
Inf modif    168   3.530   1.758        (---------*----------
other comp   198   3.520   1.739        (---------*---------
retailer     108   3.509   1.732    (-------------*--------------)
Other         66   3.545   1.773  (----------------*----------------)
                                  -----+---------+---------+---------+----
                                     3.25      3.50      3.75      4.00
Pooled StDev = 1.739
```

Fig. 1 ANOVA test for methods

The differences in the mean between Table 10 and Figure 1 are because in table one the resulted ranks were averaged and in Figure 1 all results were tested. As it is shown in Figure 1, all methods present similar results, reason why it is not possible to state that one

method is better than any other. The resulted mean and standard deviation from the methods are practically the same.



```
Source     DF        SS      MS       F       P
Factor      5    418.85   83.77   31.12   0.000
Error    1290   3472.70    2.69
Total    1295   3891.56

S = 1.641    R-Sq = 10.76%    R-Sq(adj) = 10.42%

                                  Individual 95  CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev  -----+---------+---------+---------+----
Cust sat     216   2.319   1.621  (---*--)
mkt share    216   3.519   1.645                    (---*--)
cust know    216   3.935   1.644                            (---*--)
response     216   3.495   1.591                    (--*---)
manuf cost   216   3.958   1.748                            (---*---)
profit       216   3.884   1.591                          (---*--)
                                  -----+---------+---------+---------+----
                                     2.40      3.00      3.60      4.20
Pooled StDev = 1.641
```

Fig. 2 ANOVA test for the benefits

As Figure 2 shows, there is not statistical evidence to prove that the resulted means of the benefits are the same. This can be inferred from the P-value. It also can be concluded from Figure 1 that there are not significant difference between ***increased market share*** (mkt share) and ***reduce order response time*** (response). It is important to mention that Mexican companies do not identify ***increased customer knowledge*** (cust know) as an important benefit, rather it is ranked among the last. If companies do not identify increased customer knowledge as a benefit, it might mean that they are not prepared to satisfy future needs. On the other hand, if there is not an ***increase on profit*** (profit), the customization strategy might be misapplied.

Also as part of this study, respondents were asked to mark which improvement initiative had been implemented in the company. The options given were ***Total quality management, just-in-time, cellular manufacturing, business process reengineering, other***

or none. In general, only about 5 percent of respondents had not implemented any of the initiatives. The most common implemented is ***Total quality system*** with 33 percent.

3.4 Negative consequences brought by the implementation of customization

In this section it is presented the negative consequences that Mexican companies face due to the implementation of customization strategies. In this section and the following, the analyses performed are the same that were presented in section 3.3 Benefits of implementing customization.

It was asked to respondents to rank the negative consequences they perceived within their company by implementing customization strategies. The options provided were: ***Increased material costs, Increased manufacturing costs, Poorer on-time delivery, Supplier delivery performance, Increased order response time, Reduction in product quality and other.***

Each method was analyzed in order to identify the resulted ranking for the negative consequences as a result of implementing customization strategies. In order to prove that there were not the same mean or median, an ANOVA and Kruskal-Wallis test were performed and it was concluded that there is not enough statistical evidence to prove that the means and medians are the same. Those results are shown in Appendix C.

It can be seen in Table 11 the ranked results of the negative consequences that Mexican companies face when adopting customization strategies. The table shows the results for all methods used to provide customization. As it can be appreciated, no matter which method the companies use to provide customization, the ***reduction in product quality*** is the second

least negative consequence only above ***other,*** and ***increased material cost and increased manufacturing cost*** are the most important negative consequences. Also in this table, it can be seen that the ***Material processing*** and ***Make product self-customizing*** methods present almost the same results. The ANOVA test results for the negative consequences are presented on Figure 3. In this figure it can be seen that ***Poorer on-time delivery, Supplier delivery performance and Increased order response time*** have no significant difference to conclude that one is a more important negative consequence than the other.

The ANOVA test to compare which method presents a significant difference with the negative consequences is shown in Appendix C. The results indicate that there is no statistical evidence to prove that any method is different from the rest.

Negative Consequences \ Method	Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Other	Average
Increased material costs	3	1	1	1	2	4	1	1	1.75
Increased manufacturing costs	1	2	2	2	1	1	4	3	2.00
Poorer on-time delivery	4	3	5	3	4	3	2	5	3.63
Supplier delivery performance	2	4	3	5	5	5	5	3	4.00
Increased order response time	5	5	4	4	3	2	3	2	3.50
Reduction in product quality	6	6	6	6	6	6	6	6	6.00
Other	7	7	7	7	7	7	7	7	7.00

Table 11 Ranked results of negative consequences by implementing customization strategies.

In Figure 3 it can also be seen that there are not statistical evidence to prove that the means are the same, which means that the resulted rank are correct. This can be inferred form the P-value.

```
Source     DF       SS      MS       F      P
Factor      6  1851.48  308.58  111.12  0.000
Error    1491  4140.51    2.78
Total    1497  5991.99

S = 1.666   R-Sq = 30.90%   R-Sq(adj) = 30.62%


                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level            N   Mean  StDev  --+---------+---------+---------+-------
mat cost       214  3.023  1.883  (-*-)
manuf cost     214  3.098  1.740   (-*-)
ontime del     214  3.481  1.491       (-*-)
supplier perf  214  3.579  1.563        (-*-)
order resp     214  3.612  1.682        (-*-)
prod quality   214  4.874  1.678                        (-*-)
                                    --+---------+---------+---------+-------
                                    3.0       4.0       5.0       6.0

Pooled StDev = 1.666
```

Fig. 3 ANOVA test results for negative consequences

In section 4 General Results compared against UK results, the negative consequences presented by the Mexican companies will be discussed and some conclusions will be given.

3.5 Difficulties implementing customization extended to the supply chain

In this part it was asked to Mexican companies to rank the difficulties they have found when implementing customization strategies. These difficulties have internal and external implications and causes. It is not the purpose of this research to identify the causes, but only to rank the difficulties. The difficulties presented to respondents were: ***understanding customer wants, supply chain management, culture and organization change, changing business processes, information technology, distribution channels and others.***

To rank the results, the same analyses were performed as in section 3.3 and 3.4. The lower mean of each rank represent the overall first rank. The resulted ranked difficulties found for each method to provide customization is presented on Table 12. From the ANOVA and Kruskal-Wallis test for the methods can be conclude that there are not

statistical evidence to prove that the mean and medians are the same; therefore the given ranks are correct. The results of the tests are shown in Appendix D.

Difficulties in the SCM \ Method	Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Other	Average
Understanding customer wants	5	3	6	3	4	6	1	2	3.75
Supply Chain Management	2	1	1	2	5	2	2	3	2.25
Culture and Organization change	3	4	2	3	1	3	3	5	3.00
Changing business processes	1	2	3	1	2	1	4	1	1.88
Information technology	4	5	5	5	3	4	6	3	4.38
Distribution channels	5	6	4	6	6	5	5	6	5.38
Other	7	7	7	7	7	7	7	7	7.00

Table 12 Ranked difficulties found in the supply chain by method to provide customization

As Table 12 shows and Figure 4 confirms, the ***management of the supply chain, the culture and organization change*** and ***the changes on business processes*** are among the most important difficulties found in Mexican companies that provide customization. In the other hand, ***distribution channels*** do not present important difficulties. Figure 4 also shows that there is not statistical evidence to prove that the means are the same, which means that each difficulty is different has different wage.

The ANOVA test to compare which method presents a significant difference with the difficulties found in the supply chain to implement customization is shown in appendix D. The results indicate that there is no statistical evidence to prove that any method is different from the rest.

```
Source     DF       SS      MS       F       P
Factor      6  1954.36  325.73  120.67  0.000
Error    1491  4024.64    2.70
Total    1497  5979.00

S = 1.643   R-Sq = 32.69%   R-Sq(adj) = 32.42%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev   -+---------+---------+---------+---------
Cust wants   214   3.678   2.061          (-*-)
SCM          214   3.262   1.691    (--*-)
Cult change  214   3.341   1.645     (-*--)
Change BP    214   3.154   1.565   (--*-)
IT           214   3.734   1.633          (-*--)
Distr ch     214   4.136   1.649              (-*--
                                   -+---------+---------+---------+---------
                                  3.0       4.0       5.0       6.0
Pooled StDev = 1.643
```

Fig. 4 ANOVA test results for difficulties found in the supply chain to implement customization.

3.6 Barriers to increase the degree of customization.

In this section it is presented the resulted ranks of the barriers that Mexican companies found in order to increase the degree of customization. The respondents were asked to rank a list of fourteen different barriers. The barriers included ***inflexible factories, product would be too costly, information technologies, change management, management skills and abilities, understanding customer wants, supply from stock, product not customizable, design for customization, workforce skills and attitudes, suppliers, customers do not want it, distributors/retailers, and other.***

The results of the barriers for each method are shown in Table 13. It can be seen from the table that ***change management*** is the most important barrier that Mexican companies present to increase the degree of customization. ***Product would be too costly, Information technologies and management skill and abilities*** are among the second most important barriers to increase customization. It can also be seen that companies, regardless of the method they use to provide customization, have felt that ***customers do not want***

customization is not an important barrier to increase the degree of customization offered to their customers.

Barriers to increase customization \ Method	Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Other	Average
Inflexible factories	7	8	7	7	9	5	8	12	7.88
Products would be too costly	1	4	1	1	6	2	11	3	3.63
Information technologies	9	4	5	4	4	8	2	1	4.63
Change management	5	1	2	2	2	1	3	6	2.75
Management skills and abilities	2	2	4	7	1	3	4	8	3.88
Understanding customer wants	11	7	9	12	2	5	4	4	6.75
Supply from stock	2	6	3	3	10	10	8	10	6.50
Products not customizable	10	11	12	9	8	12	10	6	9.75
Design for customization	4	8	8	8	7	9	12	4	7.50
Workforce skills and attitudes	8	10	10	11	5	4	7	2	7.13
Suppliers	6	3	6	5	11	5	4	8	6.00
Customers do not want it	13	13	13	13	11	13	13	11	12.50
Distributors/retailers	12	12	11	10	13	11	1	13	10.38
Other	14	14	14	14	14	14	14	14	14.00

Table 13. Ranked barriers to increase the degree of customization by method

```
Source     DF       SS      MS      F      P
Factor     13  11190.6   860.8  68.76  1.000
Error    2982  37332.4    12.5
Total    2995  48523.0

S = 3.538   R-Sq = 23.06%   R-Sq(adj) = 22.73%

                                        Individual 95% CIs For Mean Based on
                                        Pooled StDev
Level            N    Mean   StDev  ----------+---------+---------+---------
Inflexible     214   7.238   3.964          (-*-)
too costly     214   5.925   3.786       (-*-)
IT             214   6.140   3.379        (-*)
change mgm     214   5.103   3.240     (*-)
mgm skills     214   5.776   3.166       (-*-)
cust want      214   6.883   3.626            (-*)
stock          214   6.850   3.867           (*-)
not custble    214   8.327   3.660                (-*-)
DFC            214   7.238   3.324           (-*-)
wkf skills     214   7.369   3.473            (*-)
suppliers      214   6.659   3.700         (-*-)
cust dont      214   9.780   3.573                    (-*-)
Dist/retailer  214   8.659   3.792               (-*-)
                                       ----------+---------+---------+---------
                                      5.0       7.5      10.0      12.5
Pooled StDev = 3.538
```

Fig. 5 ANOVA test results for barriers to increase the degree of customization.

Figure 5 also shows that there are not statistical evidence to prove that the implications means are the same, which means that the rank are correct. This can be inferred from the P-value.

The ANOVA and Kruskal-Wallis analyses for the mean and median of the barriers to increase the customization degree are displayed in Appendix E. These tests show that there is not enough statistical evidence to prove that the means or medians are equal in any of the methods. Also in Appendix E is presented the analysis to prove if any method is different from the rest.

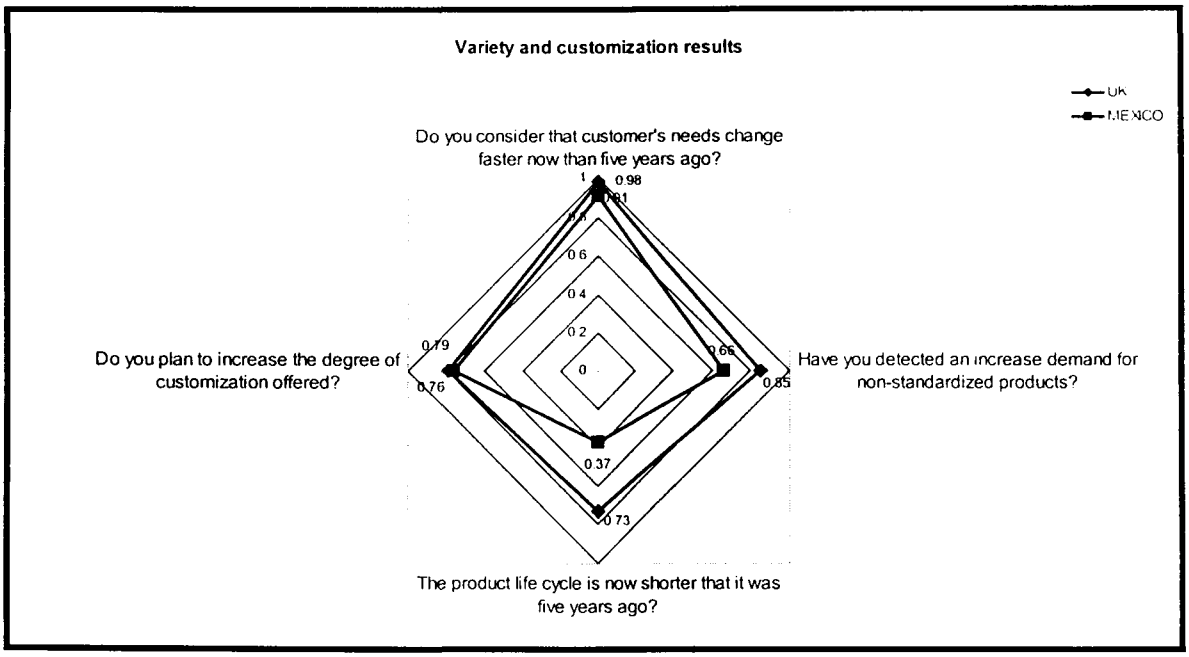
4. General results compared against UK results.

This research is based on a similar study performed in the United Kingdom by Alhström and Westbrook in 1996 and published in 1999. As a result, a comparison between the results in Mexican Industries and those obtained in United Kingdom is followed. This section presents the comparison of the main results.

The study performed in the UK it had lower respondents, which may lead to variation in the results. Nevertheless, the results are used to compare against those results obtained in this study.

The variety of products and customization comparison shows an important difference. Only 66 percent of Mexican companies have detected that the customers are demanding more products non-standardized, against 85 percent of UK industries. Another important difference is that 73 percent of the UK companies have perceived that the products life-cycle is shorter, against Mexican industries, where only 37 percent perceived so. In Graphic 1 clearer results can be seen. These two are mayor differences between Mexican and British

Industries, especially about the life-cycle, because it indicates that British companies are more aware of the changes not only for non-standardized products, but also that they desire new products faster. On the other hand, both Mexican and British companies, perceive that customer needs are changing faster than before almost at the same percentage. In addition, both Mexican and British companies have very similar interest in provide a higher degree of customization.



Graphic 1 Variety and customization analysis.

The methods used to provide customization are also different. While United Kingdome companies mentioned more frequently the ***assembly of core modules*** as the method to provide customization, Mexican companies preferred ***material processing.*** It is important to mention that in this study it was analyzed not only the method but also the rank. In other words, not only how many companies use a specific method, but also which one uses as the most important to provide customization. The study performed by Alhström and Westbrook does not mention anything about this topic.

In Table 14 it is presented the comparison between UK and Mexican companies regarding the associated rank to each benefit. The benefits found by implementing customization strategies have some differences. Even though Mexican and British companies perceive as the most important benefit the ***increase of customer satisfaction***, ***increased market share*** is not the second most important benefit for Mexican companies as it is for British contra parts. In addition, ***increased profit***, which is among the last benefits in the rank for UK companies, it is between the middle for Mexican ones. ***Reduce order response time*** also has significant differences. Mexican companies perceive it as the second most important benefit, UK companies do not perceive it as important. A statistical analysis was performed to prove the significance differences between the results.

Benefit \ Method		Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Average
Increased customer satisfaction	**Mexico**	1	1	1	1	1	3	1	1.3
	UK	1	1	1	2	2	1	3	1.6
Increased market share	**Mexico**	6	5	2	3	3	5	3	3.9
	UK	2	2	3	1	1	2	1	1.7
Increased customer knowledge	**Mexico**	5	6	5	4	2	6	5	4.7
	UK	3	3	4	3	3	3	4	3.3
Reduced order response time	**Mexico**	3	4	3	2	4	2	2	2.9
	UK	4	5	2	5	4	4	4	4.0
Reduced manufacturing cost	**Mexico**	2	3	6	4	6	1	5	3.9
	UK	5	4	5	6	6	5	4	5.0
Increased profit	**Mexico**	4	2	4	4	5	4	4	3.9
	UK	6	7	6	4	5	7	4	5.6
Other	**Mexico**	7	7	7	7	7	7	7	7.0
	UK	7	6	7	7	7	5	1	5.7

Table 14. Compared benefits

Figure 6 shows the results of the Kruskal-Wallis analysis for the reduced order response time for both countries. As figure 6 shows, the reduced response time are different for Mexican and United Kingdom companies. The P-value proves this statement.

```
Kruskal-Wallis Test on Data

Country    N  Median  Ave Rank      Z
Mexico     7   3.000      10.4   2.62
UK         7   2.000       4.6  -2.62
Overall   14                7.5

H = 6.86  DF = 1  P = 0.009
H = 7.26  DF = 1  P = 0.007  (adjusted for ties)
```

Fig. 6 Kruskall-Wallis analysis of reduced order response time

Table 15 presents the result of the negative consequences that both Mexican and United Kingdom companies had to deal by implementing customization strategies. As the table shows, there are similar results for the negative consequences. British companies perceived ***increased material cost*** as the most negative consequence and Mexican companies believe that ***increased manufacturing cost*** is the most negative, tied with ***increased material cost.***

Negative Consequences \ Method		Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Average
Increased material costs	Mexico	3	1	1	1	2	4	1	1.9
	UK	2	1	1	1	1	1	4	1.6
Increased manufacturing costs	Mexico	1	2	2	2	1	1	4	1.9
	UK	1	1	2	3	2	2	1	1.7
Poorer on-time delivery	Mexico	4	3	5	3	4	3	2	3.4
	UK	5	5	3	2	3	3	1	3.1
Supplier delivery performance	Mexico	2	4	3	5	5	5	5	4.1
	UK	3	4	4	6	6	5	1	4.1
Increased order response time	Mexico	5	5	4	4	3	2	3	3.7
	UK	5	7	5	4	5	4	4	4.9
Reduction in product quality	Mexico	6	6	6	6	6	6	6	6.0
	UK	5	3	5	4	4	7	4	4.6
Other	Mexico	7	7	7	7	7	7	7	7.0
	UK	3	6	7	7	7	6	4	5.7

Table 15. Compared negative consequences

Table 16 present the difficulties to increase the degree of customization found in both Mexican and United Kingdom companies. The difficulties to implement customization extended to the supply chain had also different results. British companies found that ***understanding customer wants*** is what causes the most difficulties to implement customization, while Mexican companies believe that ***Managing the supply chain*** presents more difficulties, very close with ***changing business processes***, which is a middle difficulty for British companies. ***Distribution channels*** were among the last of the ranked difficulties in both countries. ***Culture and organization change*** is ranked as a middle difficulty by both Mexican and United Kingdom companies. This is something for further research, due to the interaction of human activities are more developed in the United Kingdom than it is in Mexico.

Difficulties in the SCM \ Method		Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Average
Understanding customer wants	Mexico	5	3	6	3	4	6	1	4.00
	UK	1	1	2	3	1	1	2	1.57
Supply Chain Management	Mexico	2	1	1	2	5	2	2	2.14
	UK	2	2	1	2	3	2	1	1.86
Culture and Organization change	Mexico	3	4	2	3	1	3	3	2.71
	UK	4	3	3	1	2	4	4	3.00
Changing business processes	Mexico	1	2	3	1	2	1	4	2.00
	UK	5	4	4	4	4	3	4	4.00
Information technology	Mexico	4	5	5	5	3	4	6	4.57
	UK	3	6	6	5	5	6	4	5.00
Distribution channels	Mexico	5	6	4	6	6	5	5	5.29
	UK	6	5	6	6	6	5	2	5.14
Other	Mexico	7	7	7	7	7	7	7	7.00
	UK	7	7	5	7	7	7	7	6.71

Table 16. Difficulties in the supply chain comparison

Figure 7 present the Kruskal-Wallis test for ***Culture and Organization change***. The figure shows that there is enough statistical evidence to prove that both Mexican and United Kingdom companies have the same results. The P-value proves the statement. Also it can be seen that the medians are the same.

```
Kruskal-Wallis Test on Data

                    Ave
Country    N  Median  Rank      Z
Mexico     7   3.000   6.8  -0.64
UK         7   3.000   8.2   0.64
Overall   14           7.5

H = 0.41   DF = 1   P = 0.523
H = 0.46   DF = 1   P = 0.500   (adjusted for ties)
```

Fig. 7 Kruskal-Wallos test for Culture and Organization change.

Table 17 shows that ***Inflexible factories*** have different results for Mexican and United Kingdom companies. The same happens for ***Management skills and abilities, product not customizable and suppliers.*** The barriers that present similar results are ***Information technologies, understanding customers' wants,*** and ***workforce skill and attitudes***

Barriers to increase customization \ Method		Assembly of Core Modules	Material processing	Increase range of stock	Make product self-customizing	Information content modification	Another company provides service around product	Retailer provides service around product	Average
Inflexible factories	Mexico	7	8	7	7	9	5	8	7.29
	UK	6	2	1	3	9	1	3	3.57
Products would be too costly	Mexico	1	4	1	1	6	2	11	3.71
	UK	3	1	5	1	2	4	1	2.43
Information technologies	Mexico	9	4	5	4	4	8	2	5.14
	UK	4	6	3	6	6	2	6	4.71
Change management	Mexico	5	1	2	2	2	1	3	2.29
	UK	1	4	6	8	3	9	8	5.57
Management skills and abilities	Mexico	2	2	4	7	1	3	4	3.29
	UK	8	3	7	10	6	3	10	6.71
Understanding customer wants	Mexico	11	7	9	12	2	5	4	7.14
	UK	2	10	2	9	1	11	9	6.29
Supply from stock	Mexico	2	6	3	3	10	10	8	6.00
	UK	10	11	4	4	4	13	4	7.14
Products not customizable	Mexico	10	11	12	9	8	12	10	10.29
	UK	9	5	9	13	4	6	13	8.43
Design for customization	Mexico	4	8	8	8	7	9	12	8.00
	UK	5	7	10	2	8	10	2	6.29
Workforce skills and attitudes	Mexico	8	10	10	11	5	4	7	7.86
	UK	7	8	7	10	9	5	10	8.00
Suppliers	Mexico	6	3	6	5	11	5	4	5.71
	UK	9	9	11	6	9	7	6	8.14
Customers do not want it	Mexico	13	13	13	13	11	13	13	12.71
	UK	10	13	11	13	9	13	13	11.71
Distribuitors/retailers	Mexico	12	12	11	10	13	11	1	10.00
	UK	10	13	11	13	9	13	13	11.71
Other	Mexico	14	14	14	14	14	14	14	14.00
	UK	9	12	11	6	9	7	6	8.57

Table 17. Barriers to increase the degree of customization

5. Integration with customers and suppliers.

Additionally to the study performed by Alhström and Westbrook, this research presents the degree of integration between the companies' customers and their suppliers. As part of this study, respondents were asked to mark questions about the point of customer involvement in the customization process, the point where differentiation of products begins, the response time that the most important supplier offers to fulfill an order, the type of material that supplier fulfill, the integration degree with the most important supplier and the response time that the company offers to fulfill a customer order.

This research was performed independently of the previous and it is not part of this study to prove the existed correlation between the method to provide customization and the integration degree with customers and suppliers.

The fist question made to respondents was about the first point in the production process where customer is involved to provide customization. The results show that 52 percent of the companies' customer first involvement is at the design stage and 13 percent did it at the post-sale stage.

Another question was in regard to the point where differentiation occurs in the company. The results show that 57 percent of companies differentiate their product since the design stage, and only 5 percent responded that they do not differentiate the product. Fabrication is the second most important point where products are differentiated.

The integration degree that companies have with their suppliers is an important issue when customization strategies are followed. It this order, 48 percent of Mexican companies use a ***formal agreement*** with their most important supplier and 17 percent have a ***strategic***

alliance. It is important to mention that only 12 percent of respondents indicated that the supplier is the one who provides the lower price. 35 percent of the respondent's supplier delivers the order in less than one week, 29 percent between one and four weeks and 32 percent in a Just-In-Time basis.

Raw material represents 65 percent of the respondents' supplied product. Component parts represent only 9 percent. This indicates that the most important supplier deliver mostly raw material to the companies.

Finally, the respond time offered to customer was analyzed. The results indicate that 49 percent of the companies offered Just-In-Time deliveries to their customer, whilst only 12 percent offers to delivery the product in more than a month.

6. Conclusions and recommendations for further research.

Mexican companies present similar results no matter which method use to provide customization. The benefits present, the negative consequences, the difficulties and the barriers have similar results. This represent an important discovery, because it means that the companies that decide to make the shift to customization strategies can adopt any of the methods presented and expect to have similar results.

The reason of this exploratory research was to find the standing point of Mexican companies that use customization strategies. The results showed that these companies are in the beginnings of customization. Most of the companies (52 percent) are performing pure customization strategies [Lampel and Mitzberg, 1993] because they involve the customer since the design stage. And if this point of involvement is compared with the point where

the product is differentiated, it can be appreciated that the differentiation takes place in the design stage for most of the companies (57 percent).

Although this is a strategy to offer customized products that involve customer at the design stage and the product differentiate also at the design stage [Duray, et al, 2000] we can infer that in the case of Mexican companies, the customization is taking place mostly because the customer request an specific order with special requirements not included in standard products, and the company fulfill this request by providing a customized product. This can be inferred due to the analysis of the negative consequences brought by implementing customization strategies and the requirements needed researched on the literature. Mexican companies present as the most important consequence the increase in manufacturing cost, a consequence related with customize products without being prepared to offer a mass customization strategy. [Svensson and Barfod, 2002]

Mexican companies present different results than the British, mainly because the different perspectives about product change and product life-cycle. These differences give Mexican companies a different perspective about the strategy followed to offer customization. The product life-cycle might not be well understood by the Mexican managers, but it does represent a trend that it is not been taken into consideration. Only 37 percent of the respondent companies believed that the product life-cycle offered has not changed in the previous five years. This means that the same product has been offered to the market since five or more years ago. Due to the market opening Mexican people are becoming more demanding and the needs are changing, reason why foreign products are fulfilling those needs.

This vision of the product life-cycle without change may be because Mexican companies do not perceive ***customer knowledge*** as an important benefit, whilst British consider this issue as a middle rank benefit. Knowing what customer want is a way to trace a tendency and then fulfill customer specific requirements in the future. This is something that Mexican companies need to improve, in order to become more competitive in the markets they decide to be. Nevertheless, both Mexican and British companies feel that a benefit of implementing a customization is the ***increased customer satisfaction.*** This benefit can lead to increase on sales, but not necessarily at the long run, because customer satisfaction changes with time. And the ability to identify those changes is something that can help to stay competitive. A better knowledge of the customer helps to understand better is buying habits, and therefore offer to the customer a product that satisfies those buying necessities. This better knowledge will increase customer satisfaction and eventually, the customer will be loyal to the product or brand. This will improve revenues and the company will have the resources to know more about their customers. And this will become on a positive loop

Mexican companies also feel that both, ***manufacturing and material costs, has increased*** because of the implementation of customization strategies. British companies present same results, so we can infer that Mexican and British companies have had the same negative consequences. This is an important issue, because these costs should be kept similar to those of mass production systems. The way of the customization strategies has been implemented may be the cause of these increase in costs.

The ***management of business changes and supply chain*** are important topics that Mexican companies need to improve in order to offer a higher degree of customization. The

integration of the supply chain includes not only the degree of formality with the supplier, or the customer, but also the Information Technology capabilities, the response time, the ability to quickly respond to changes and the Human Activities systems that interact in the supply chain. This is a very important part in order to offer a truly mass customization strategy, because the flexibility needed to quick respond to changes are not easy to obtain, and it requires the integration with suppliers and the use of information technology to know the customer order in real time. The time-base competition is mainly possible due to the integration of Information technology with suppliers and the information sharing in real time from the point of sale through the supplier. This gives all the entities the ability to respond effectively and efficiently to the market changes, and also helps to increase the flexibility of the supply chain. A mass customization supply chain must be effective and respond quickly enough to turbulence and changes. [Fisher, 1997]

It has been seen that Mexican companies use a formal agreement with suppliers and Just-In-Time approaches to customer. But even with this they present important negative consequences and difficulties to implement customization. Information technologies, management skills and workforce skills are among the middle rank barriers to increase the degree of customization, which means that they have some knowledge about this topics, but they might not been exploding the correct tools or abilities. The management skills are also very important, especially where people take place. The Human Activities Systems that interact in the supply chain to offer customization is also important. The human factor is a very important topic in the integration of companies, not only by merges or acquisitions, but also in partnerships and agreements. This interaction may lead to bankruptcy if it is not

well implemented. Especially in Mexican society the right or wrong implementation of the partnership may lead to very different results.

Mexican government in general and the Secretary of Labor in particular are making an effort to change the work culture to become Mexican companies into global competitors. This includes the workforce abilities and people skills not only for management but also for dealing with changes.

In this order, the effect that the human activities systems, information technologies and management skills have with the degree of customization offered is a topic for further research. It is also recommended a deeper research about the techniques to implement customization strategies in Mexican companies. The techniques used in the United Kingdom may be worthless in the Mexican environment due to different factors, such as cultural aspects and work culture.

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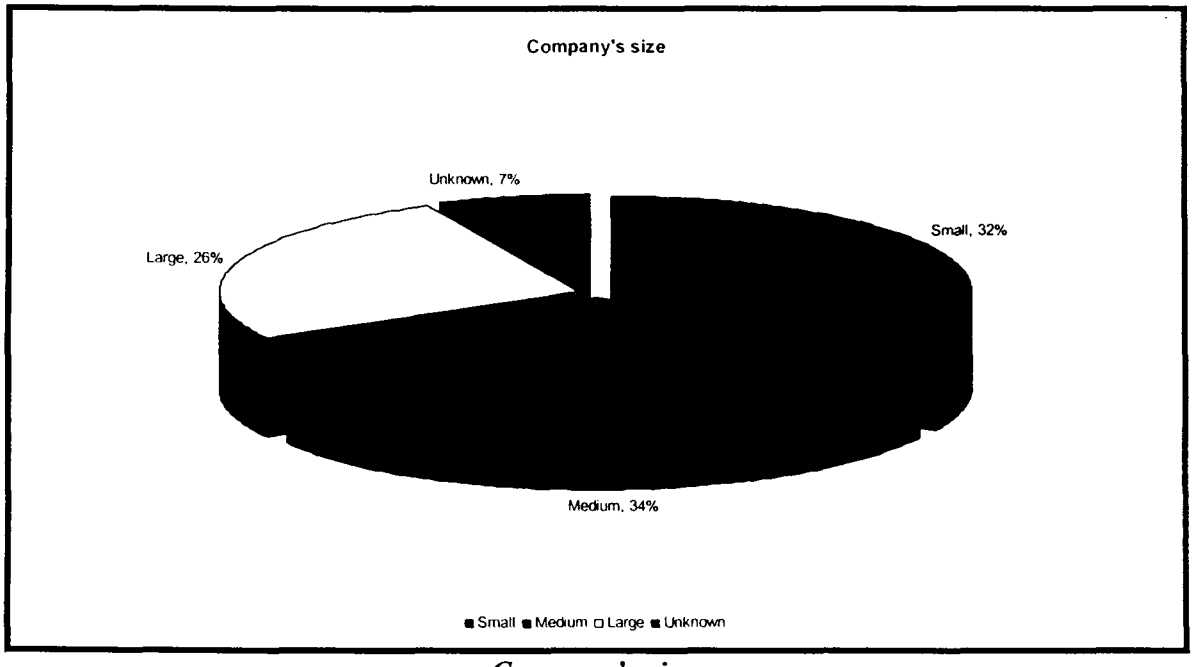
Appendix A

General Results

According to the Secretary of Economy, the size of a company depends on the number of employees signed at the Social Security Institute from the last update. The next table shows the distribution by sector.

Size	Industrial	Commercial	Services
Micro	0-10	0-10	0-10
Small	11-50	11-30	11-30
Medium	51-250	30-100	30-100
Large	More than 250	More than 100	More than 100

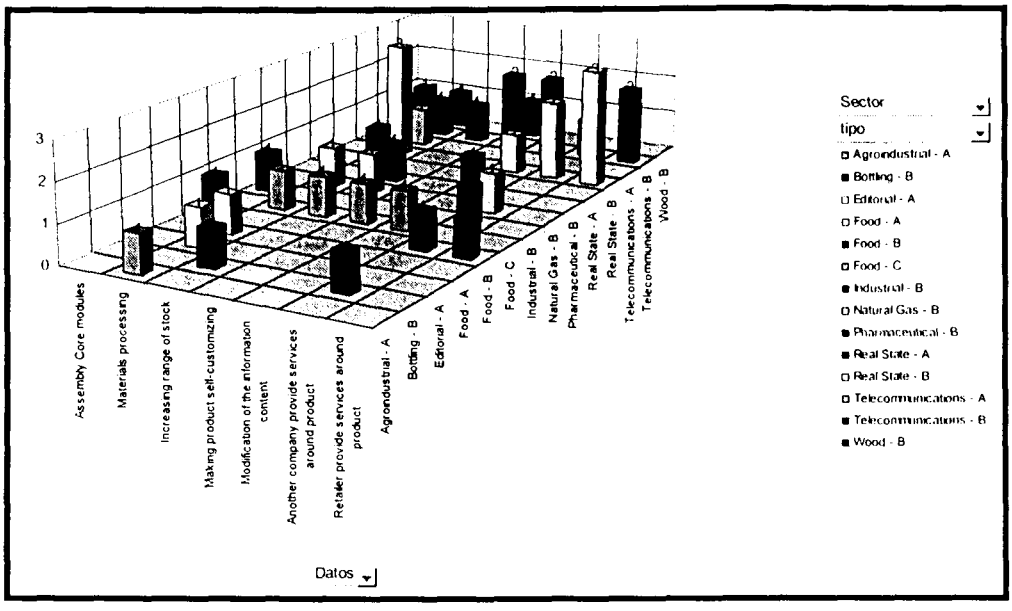
The graphic represent the respondents' results regarding to the company's size.



Company's size

The next graphic represent the perceived conditions on which companies operate. It was asked to respondents four questions:

- Do you consider that customer's needs change faster now than five years ago?
- Have you detected an increase demand for non-standardized products?
- The product life –cycle is now shorter than it was five years ago?
- Do you plan to increase the degree of customization offered?



Appendix B

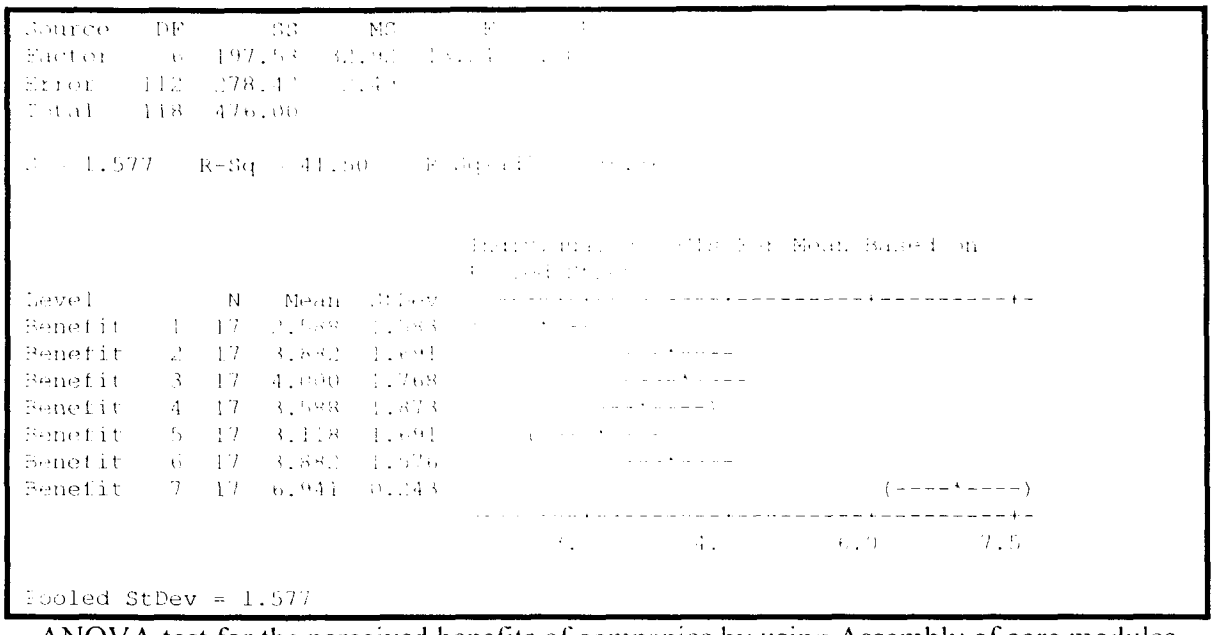
ANOVA and Kruskal-Wallis test for benefits perceived by implementing customization strategies.

This section present the test performed to analyze the mean and median of the surveys. The results were tested using ANOVA for means and Kruskal-Wallis for medians. In the following figures, the meaning for each benefit is:

Figure	Meaning
Benefit 1	Increased customer satisfaction
Benefit 2	Increased market share
Benefit 3	Increased customer knowledge
Benefit 4	Reduced order response time
Benefit 5	Reduced manufacturing cost
Benefit 6	Increased profit
Benefit 7	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all ANOVA tests were:

H0. All means are the same
H1. At least there is one mean different from the rest.



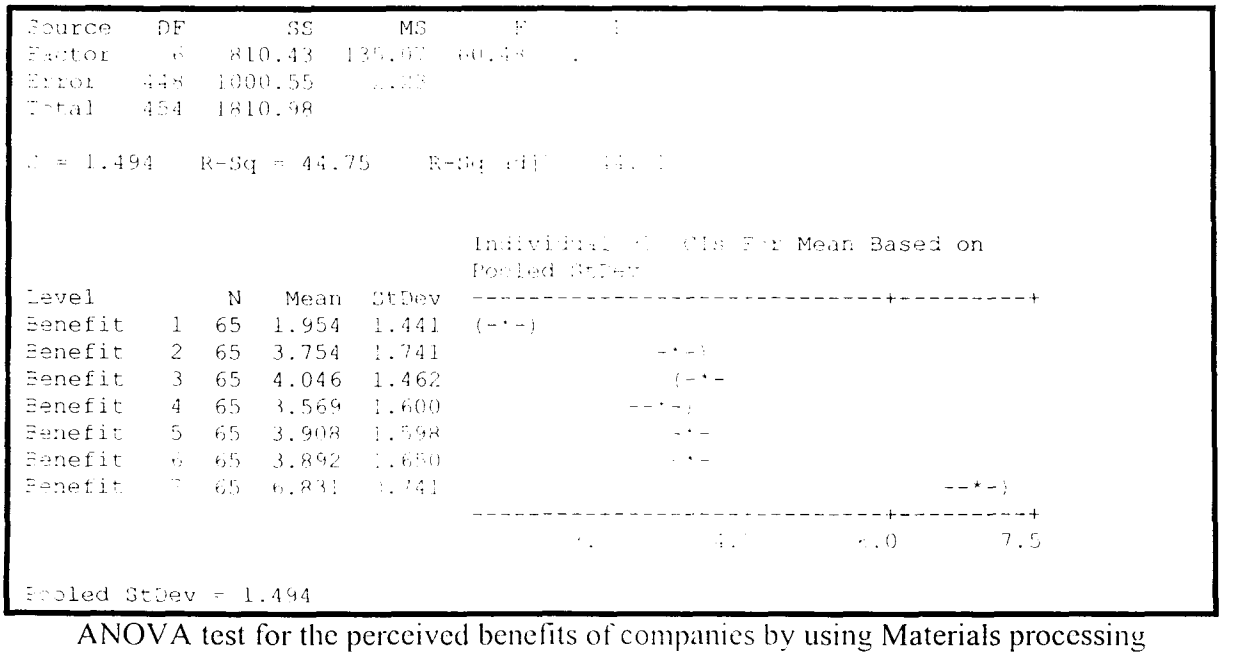
Source	DF	SS	MS	F	
Factor	6	197.53	32.92	[illegible]	[illegible]
Error	112	278.47	[illegible]		
Total	118	476.00			

[illegible] = 1.577 R-Sq = 41.50 [illegible]

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
Benefit	1	17	[illegible]	[illegible]
Benefit	2	17	3.882	[illegible]
Benefit	3	17	4.000	[illegible]
Benefit	4	17	3.588	[illegible]
Benefit	5	17	3.118	[illegible]
Benefit	6	17	3.882	[illegible]
Benefit	7	17	6.941	[illegible]
				4.5 6.0 7.5

Pooled StDev = 1.577

ANOVA test for the perceived benefits of companies by using Assembly of core modules method.



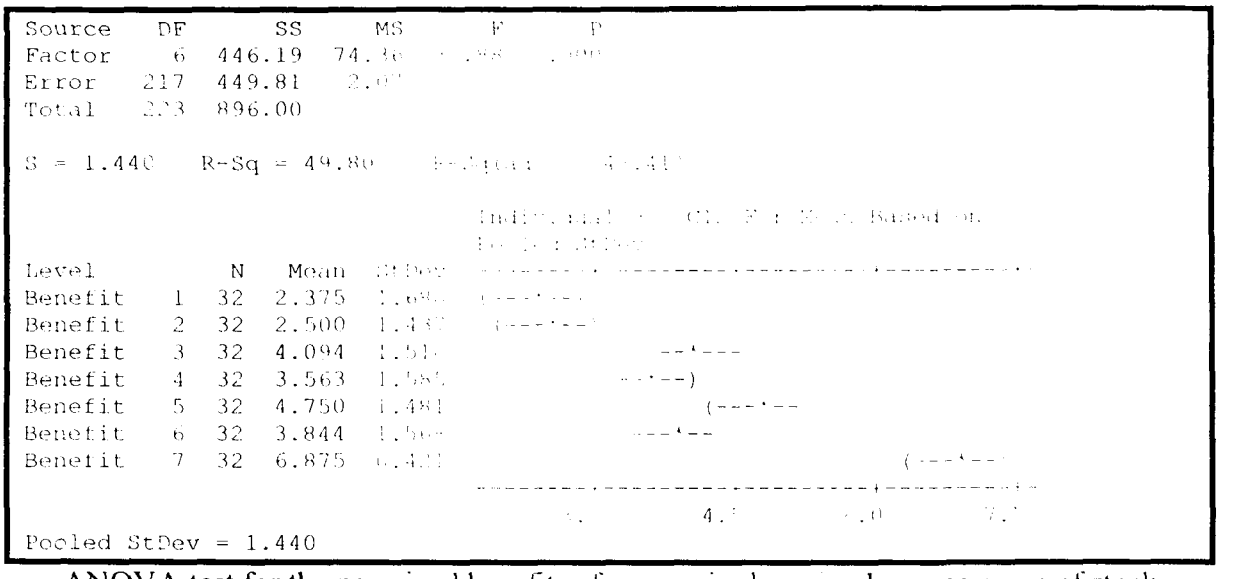
Source	DF	SS	MS	F	
Factor	6	810.43	135.07	60.48	.
Error	448	1000.55	[illegible]		
Total	454	1810.98			

[illegible] = 1.494 R-Sq = 44.75 R-Sq [illegible] [illegible]

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
Benefit	1	65	1.954	1.441
Benefit	2	65	3.754	1.741
Benefit	3	65	4.046	1.462
Benefit	4	65	3.569	1.600
Benefit	5	65	3.908	1.598
Benefit	6	65	3.892	1.650
Benefit	7	65	6.831	1.741
				4.5 6.0 7.5

Pooled StDev = 1.494

ANOVA test for the perceived benefits of companies by using Materials processing method.



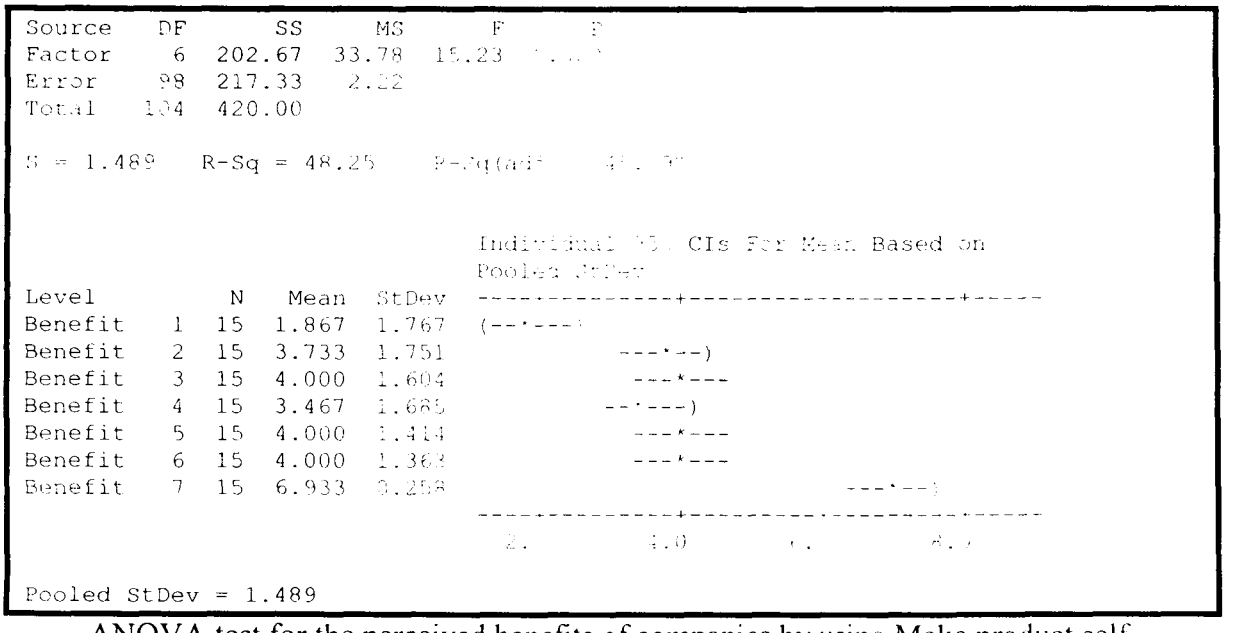
```
Source    DF       SS      MS       F       P
Factor     6   446.19   74.36   [illegible]  .000
Error    217   449.81    2.07
Total    223   896.00

S = 1.440    R-Sq = 49.80    R-Sq(adj)    [illegible]

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean  StDev  ----------+---------+---------+---------
Benefit    1  32   2.375  [illegible]  (---*---
Benefit    2  32   2.500  [illegible]  (---*---
Benefit    3  32   4.094  1.514              --*---
Benefit    4  32   3.563  [illegible]            --*--)
Benefit    5  32   4.750  1.481                    (---*--
Benefit    6  32   3.844  1.500              ---*--
Benefit    7  32   6.875  [illegible]                        (---*---
                          ----------+---------+---------+---------
                                  3.5       4.5       5.5       6.5

Pooled StDev = 1.440
```

ANOVA test for the perceived benefits of companies by using Increase range of stock method.



```
Source    DF       SS      MS       F       P
Factor     6   202.67   33.78   15.23  [illegible]
Error     98   217.33    2.22
Total    104   420.00

S = 1.489    R-Sq = 48.25    R-Sq(adj)    [illegible]

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean  StDev  ----------+---------+---------+---------
Benefit    1  15   1.867  1.767  (---*----
Benefit    2  15   3.733  1.751            ---*--)
Benefit    3  15   4.000  1.604              ---*---
Benefit    4  15   3.467  1.685            --*---)
Benefit    5  15   4.000  1.414              ---*---
Benefit    6  15   4.000  1.363              ---*---
Benefit    7  15   6.933  [illegible]                        ---*---)
                          ----------+---------+---------+---------
                                  2.5       4.0       5.5       7.0

Pooled StDev = 1.489
```

ANOVA test for the perceived benefits of companies by using Make product self-customizing method.

```
Source   DF      SS      MS      F      P
Factor    6  465.64   77.61  46.07  0.000
Error   189  318.36    1.68
Total   195  784.00

S = 1.298   R-Sq = 59.39%   R-Sq(adj) = 58.10%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev    +---------+---------+---------+---------
Benefit    1  28  1.964  1.453    (--*--)
Benefit    2  28  3.107  1.571          (---*--)
Benefit    3  28  2.464  1.478       (--*---)
Benefit    4  28  4.036  1.232                (--*--)
Benefit    5  28  5.000  1.414                     (--*---)
Benefit    6  28  4.607  1.100                   (---*--)
Benefit    7  28  6.821  0.548                                   (--*---)
                                    +---------+---------+---------+---------
                                   1.5       3.0       4.5       6.0

Pooled StDev = 1.298
```

ANOVA test for the perceived benefits of companies by using Information content modification method.

```
Source   DF      SS      MS      F      P
Factor    6  408.24   68.04  28.90  0.000
Error   231  543.76    2.35
Total   237  952.00

S = 1.534   R-Sq = 42.88%   R-Sq(adj) = 41.40%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev    ----+---------+---------+---------+-----
Benefit    1  34  3.206  1.702      (--*---)
Benefit    2  34  3.912  1.379           (--*---)
Benefit    3  34  4.706  1.447                (--*---)
Benefit    4  34  2.971  1.642   (---*--)
Benefit    5  34  2.941  1.808   (---*--)
Benefit    6  34  3.382  1.826     (---*--)
Benefit    7  34  6.882  0.537                              (---*--)
                                  ----+---------+---------+---------+-----
                                    3.0       4.5       6.0       7.5

Pooled StDev = 1.534
```

ANOVA test for the perceived benefits of companies by using another company to provide services around product.

```
Source    DF      SS      MS      F      P
Factor     6  222.11   37.02  15.63  0.000
Error    119  281.89    2.37
Total    125  504.00

S = 1.539   R-Sq = 44.07%   R-Sq(adj) = 41.25%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  --------+---------+---------+---------+-
Benefit    1  18  2.556  1.756  (----*----)
Benefit    2  18  3.333  1.414       (----*----)
Benefit    3  18  4.111  1.568             (---*----)
Benefit    4  18  2.944  1.589     (----*---)
Benefit    5  18  4.111  1.967             (---*----)
Benefit    6  18  4.000  1.609            (----*---)
Benefit    7  18  6.944  0.236                                (---*----)
                                  --------+---------+---------+---------+-
                                        3.0       4.5       6.0       7.5

Pooled StDev = 1.539
```

ANOVA test for the perceived benefits of companies by using retailer to provide services around product

```
Source  DF      SS      MS      F      P
Factor   6  149.64   24.94  11.02  0.000
Error   70  158.36    2.26
Total   76  308.00

S = 1.504   R-Sq = 48.58%   R-Sq(adj) = 44.18%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  ---------+---------+---------+---------+
Benefit    1  11  2.636  2.014   (-----*-----)
Benefit    2  11  2.545  1.128  (-----*-----)
Benefit    3  11  3.818  1.601         (-----*-----)
Benefit    4  11  3.636  1.804        (-----*-----)
Benefit    5  11  5.273  1.555                  (-----*-----)
Benefit    6  11  3.364  1.206       (-----*-----)
Benefit    7  11  6.727  0.905                              (-----*-----)
                                  ---------+---------+---------+---------+
                                         3.0       4.5       6.0       7.5

Pooled StDev = 1.504
```

ANOVA test for the perceived benefits of companies by using Other method.

This section presents the test performed to analyze the medians of the surveys. The results were tested using Kruskal-Wallis. In the following figures, the meaning for each benefit is:

Figure	Meaning
Ben 1	Increased customer satisfaction
Ben 2	Increased market share
Ben 3	Increased customer knowledge
Ben 4	Reduced order response time
Ben 5	Reduced manufacturing cost
Ben 6	Increased profit
Ben 7	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all Kruskal-Wallis tests are:

H0. All medians are the same
H1. At least there is one median different from the rest.

Kruskal-Wallis Test on datos

beneficio	N	Median	Ave Rank	Z
ben 1	18	2.000	36.5	-3.39
ben 2	18	4.000	59.5	-0.50
ben 3	18	4.000	65.5	0.25
ben 4	18	4.000	56.5	-0.88
ben 5	18	3.000	49.5	-1.76
ben 6	18	4.000	60.5	-0.38
ben 7	18	7.000	116.5	6.65
Overall	126		63.5	

H = 51.46 DF = 6 P = 0.000
H = 52.52 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the negative consequences companies perceived by using Assembly of core modules method.

Kruskal-Wallis Test on DATA

BENEFIT	N	Median	Ave Rank	Z
Ben 1	65	1.000	95.1	-8.80
ben 2	65	4.000	212.5	-1.03
Ben 3	65	4.000	231.5	0.23
ben 4	65	4.000	200.4	-1.83
ben 5	65	4.000	222.5	-0.36
ben 6	65	4.000	221.5	-0.43
ben 7	65	7.000	412.5	12.22
Overall	455		228.0	

H = 198.48 DF = 6 P = 0.000
H = 202.62 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the perceived benefits by using Materials processing method.

```
Kruskal-Wallis Test on Data

Benefit     N  Median  Ave Rank      Z
Ben 1      32   2.000      60.5  -4.90
Ben 2      32   2.000      64.5  -4.53
Ben 3      32   5.000     115.5   0.28
Ben 4      32   4.000      98.5  -1.32
Ben 5      32   5.000     136.5   2.26
Ben 6      32   4.000     107.5  -0.47
Ben 7      32   7.000     204.5   8.67
Overall   224              112.5

H = 108.78  DF = 6  P = 0.000
H = 111.05  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for the perceived benefits by using Increase range of stock method.

```
Kruskal-Wallis Test on Data

Benefit     N  Median  Ave Rank      Z
Ben 1      15   1.000      21.0  -4.40
Ben 2      15   4.000      49.0  -0.55
Ben 3      15   4.000      53.0   0.00
Ben 4      15   3.000      45.0  -1.10
Ben 5      15   4.000      53.0   0.00
Ben 6      15   4.000      53.0   0.00
Ben 7      15   7.000      97.0   6.04
Overall   105              53.0

H = 49.16  DF = 6  P = 0.000
H = 50.18  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for the perceived benefits by using Make product self customizable method.

```
Kruskal-Wallis Test on Data

Benefit     N  Median  Ave Rank      Z
Ben 1      28   1.000      41.5  -5.74
Ben 2      28   3.000      73.5  -2.52
Ben 3      28   2.000      55.5  -4.33
Ben 4      28   4.000      99.5   0.10
Ben 5      28   6.000     126.5   2.82
Ben 6      28   4.000     115.5   1.71
Ben 7      28   7.000     177.5   7.96
Overall   196              98.5

H = 113.46  DF = 6  P = 0.000
H = 115.82  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for the perceived benefits by using Information content modification method.

Kruskal-Wallis Test on Data

Benefit	N	Median	Ave Rank	Z
Ben 1	33	3.000	90.0	-2.41
Ben 2	33	4.000	115.0	-0.09
Ben 3	33	5.000	140.0	2.23
Ben 4	33	3.000	84.0	-2.97
Ben 5	33	2.000	79.0	-3.44
Ben 6	33	3.000	93.0	-2.14
Ben 7	33	7.000	211.0	8.82
Overall	231		116.0	

H = 97.54 DF = 6 P = 0.000
H = 99.57 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the perceived benefits by using another company to provide services around product method

Kruskal-Wallis Test on Data

Benefit	N	Median	Ave Rank	Z
Ben 1	18	2.000	37.5	-3.26
Ben 2	18	3.000	51.5	-1.51
Ben 3	18	4.000	65.5	0.25
Ben 4	18	3.000	44.5	-2.38
Ben 5	18	5.000	65.5	0.25
Ben 6	18	4.000	63.5	0.00
Ben 7	18	7.000	116.5	6.65
Overall	126		63.5	

H = 53.97 DF = 6 P = 0.000
H = 55.09 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the perceived benefits by using retailer provides services around product method

Kruskal-Wallis Test on Data

Benefit	N	Median	Ave Rank	Z
Ben 1	11	2.000	24.0	-2.40
Ben 2	11	2.000	23.0	-2.56
Ben 3	11	4.000	37.0	-0.32
Ben 4	11	4.000	35.0	-0.64
Ben 5	11	6.000	53.0	2.24
Ben 6	11	3.000	32.0	-1.12
Ben 7	11	7.000	69.0	4.80
Overall	77		39.0	

H = 36.18 DF = 6 P = 0.000
H = 36.92 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the perceived benefits by using other method.

Appendix C

The next figure presents the result of the negative consequences by method. As it can be seen, all methods present similar results.

```
Source     DF       SS    MS     F      P
Factor      7     1.03  0.15  0.05  1.000
Error    1276  4070.05  3.19
Total    1283  4071.07

S = 1.786   R-Sq = 0.03%   R-Sq(adj) = 0.00%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  ----+---------+---------+---------+-----
Assembly     108  3.630  1.822        (------------*-------------)
Material     396  3.578  1.786            (------*------)
stock        174  3.638  1.777          (----------*---------)
self cust     90  3.567  1.736    (--------------*-------------)
Inf modif    162  3.630  1.800          (----------*----------)
other comp   198  3.641  1.793            (---------*---------)
retailer     102  3.618  1.747       (-------------*-------------)
Other         54  3.630  1.825  (------------------*------------------)
                                  ----+---------+---------+---------+-----
                                    3.25      3.50      3.75      4.00

Pooled StDev = 1.786
```

ANOVA and Kruskal-Wallis test for negative consequences by implementing customization strategies.

This section presents the test performed to analyze the mean and median of the surveys. The results were tested using ANOVA for means and Kruskal-Wallis for medians. In the following figures, the meaning for each negative is:

Figure	Meaning
Negative 1	Increased material cost
Negative 2	Increased manufacturing cost
Negative 3	Poorer on-time delivery
Negative 4	Supplier delivery performance
Negative 5	Increased order response time
Negative 6	Reduction in production quality
Negative 7	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all ANOVA tests were:

H0. All means are the same
H1. At least there is one mean different from the rest.

```
Source   DF      SS      MS     F      P
Factor    6  155.06   25.84  9.02  0.000
Error   112  320.94    2.87
Total   118  476.00

S = 1.693   R-Sq = 32.58%   R-Sq(adj) = 28.96%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  -----+---------+---------+---------+----
Negative  1   17  3.412  2.181    (-----*----)
Negative  2   17  3.000  1.541  (----*----)
Negative  3   17  3.294  1.490    (----*----)
Negative  4   17  3.000  1.581  (----*----)
Negative  5   17  3.882  1.536       (-----*----)
Negative  6   17  5.235  1.751                 (-----*----)
Negative  7   17  6.176  1.667                       (----*-----)
                                  -----+---------+---------+---------+----
                                     3.0       4.5       6.0       7.5

Pooled StDev = 1.693
```

ANOVA test for the negative consequences companies perceived by using Assembly of core modules method.

```
Source   DF      SS      MS      F      P
Factor    6  647.98  108.00  40.85  0.000
Error   455 1203.02    2.64
Total   461 1851.00

S = 1.626   R-Sq = 35.01%   R-Sq(adj) = 34.15%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  --------+---------+---------+---------+-
Negative  1   66  3.045  1.810  (--*---)
Negative  2   66  3.152  1.657   (--*---)
Negative  3   66  3.242  1.510    (--*--)
Negative  4   66  3.424  1.618     (---*--)
Negative  5   66  3.682  1.619       (---*--)
Negative  6   66  4.924  1.842                (--*--)
Negative  7   66  6.515  1.256                        (--*---)
                                  --------+---------+---------+---------+-
                                        3.6       4.8       6.0       7.2

Pooled StDev = 1.626
```

ANOVA test for the negative consequences companies perceived by using Materials processing method.

```
Source   DF      SS     MS      F      P
Factor    6  288.41  48.07  17.99  0.000
Error   196  523.59   2.67
Total   202  812.00

S = 1.634   R-Sq = 35.52%   R-Sq(adj) = 33.55%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev    +---------+---------+---------+---------
Negative  1   29  2.034  1.375    (---*---)
Negative  2   29  3.172  1.872            (---*---)
Negative  3   29  4.345  1.632                    (---*---)
Negative  4   29  3.517  1.379              (---*---)
Negative  5   29  4.241  1.596                   (---*---)
Negative  6   29  4.517  1.550                     (---*---)
Negative  7   29  6.172  1.947                                (---*---)
                                    +---------+---------+---------+---------
                                   1.5       3.0       4.5       6.0

Pooled StDev = 1.634
```

ANOVA test for the negative consequences companies perceived by using Increase range of stock method.

```
Source   DF      SS     MS      F      P
Factor    6  175.12  29.19  11.70  0.000
Error    98  244.53   2.50
Total   104  419.66

S = 1.580   R-Sq = 41.73%   R-Sq(adj) = 38.16%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev    ------+---------+---------+---------+---
Negative  1   15  2.933  1.624    (-----*----)
Negative  2   15  3.200  1.821      (----*-----)
Negative  3   15  3.267  1.580      (-----*----)
Negative  4   15  3.933  1.907           (----*-----)
Negative  5   15  3.600  1.595         (----*----)
Negative  6   15  4.467  1.685              (-----*----)
Negative  7   15  7.000  0.000                          (-----*----)
                                    ------+---------+---------+---------+---
                                        3.0       4.5       6.0       7.5

Pooled StDev = 1.580
```

ANOVA test for the negative consequences companies perceived by using Make product self-customizing method.

```
Source   DF      SS      MS      F      P
Factor    6  264.81   44.14  16.35  0.000
Error   182  491.19    2.70
Total   188  756.00

S = 1.643   R-Sq = 35.03%   R-Sq(adj) = 32.89%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev   -+---------+---------+---------+--------
Negative  1   27  3.074  2.037     (-----*----)
Negative  2   27  2.889  1.672    (----*----)
Negative  3   27  3.370  1.245        (----*----)
Negative  4   27  4.074  1.439             (----*----)
Negative  5   27  3.111  1.717      (----*----)
Negative  6   27  5.259  1.534                       (----*----)
Negative  7   27  6.222  1.739                             (----*----)
                                   -+---------+---------+---------+--------
                                  2.4       3.6       4.8       6.0

Pooled StDev = 1.643
```

ANOVA test for the negative consequences companies perceived by using Information content modification method

```
Source   DF      SS      MS      F      P
Factor    6  222.39   37.06  11.88  0.000
Error   224  698.61    3.12
Total   230  921.00

S = 1.766   R-Sq = 24.15%   R-Sq(adj) = 22.11%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev   -+---------+---------+---------+--------
Negative  1   33  3.606  2.091         (----*----)
Negative  2   33  2.909  1.843    (----*----)
Negative  3   33  3.545  1.416       (-----*----)
Negative  4   33  3.758  1.621         (----*----)
Negative  5   33  3.455  1.804       (----*----)
Negative  6   33  4.576  1.621                 (----*----)
Negative  7   33  6.121  1.883                           (----*----)
                                   -+---------+---------+---------+--------
                                  2.4       3.6       4.8       6.0

Pooled StDev = 1.766
```

ANOVA test for the negative consequences companies perceived by using Another company provides services around product

```
Source   DF      SS     MS      F      P
Factor    6  168.47  28.08  10.23  0.000
Error   112  307.53   2.75
Total   118  476.00

S = 1.657   R-Sq = 35.39%   R-Sq(adj) = 31.93%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  -----+---------+---------+---------+----
Negative  1   17  3.059  1.952  (----*-----)
Negative  2   17  3.412  1.622    (-----*----)
Negative  3   17  3.118  1.317  (-----*----)
Negative  4   17  3.529  1.586     (-----*----)
Negative  5   17  3.235  1.602   (-----*----)
Negative  6   17  5.353  1.412                (-----*----)
Negative  7   17  6.294  1.993                      (----*----)
                                  -----+---------+---------+---------+----
                                     3.0       4.5       6.0       7.5

Pooled StDev = 1.657
```

ANOVA test for the negative consequences companies perceived by using retailer to provide services around product

```
Source  DF      SS     MS     F      P
Factor   6   62.67  10.44  3.09  0.011
Error   56  189.33   3.38
Total   62  252.00

S = 1.839   R-Sq = 24.87%   R-Sq(adj) = 16.82%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  -------+---------+---------+---------+--
Negative  1    9  3.222  1.716  (-------*--------)
Negative  2    9  3.444  2.506    (-------*-------)
Negative  3    9  3.778  1.394      (-------*-------)
Negative  4    9  3.444  1.130    (-------*-------)
Negative  5    9  3.333  2.291   (-------*-------)
Negative  6    9  4.556  1.740           (-------*--------)
Negative  7    9  6.222  1.716                   (-------*--------)
                                  -------+---------+---------+---------+--
                                       3.0       4.5       6.0       7.5

Pooled StDev = 1.839
```

ANOVA test for the negative consequences companies perceived by using Other method.

This section presents the test performed to analyze the medians of the surveys. The results were tested using Kruskal-Wallis. In the following figures, the meaning for each negative consequence is:

Figure	Meaning
Neg 1	Increased material cost
Neg 2	Increased manufacturing cost
Neg 3	Poorer on-time delivery
Neg 4	Supplier delivery performance
Neg 5	Increased order response time
Neg 6	Reduction in production quality
Neg 7	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all Kruskal-Wallis tests are:

H0. All medians are the same
H1. At least there is one median different from the rest.

Kruskal-Wallis Test on Data

Negative	N	Median	Ave Rank	Z
Neg 1	18	3.000	51.5	-1.51
Neg 2	18	2.500	43.5	-2.51
Neg 3	18	3.500	52.5	-1.38
Neg 4	18	3.500	45.5	-2.26
Neg 5	18	4.000	61.5	-0.25
Neg 6	18	6.000	86.5	2.89
Neg 7	18	7.000	103.5	5.02
Overall	126		63.5	

H = 42.14 DF = 6 P = 0.000
H = 43.02 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the negative consequences companies perceived by using Assembly of core modules method.

Kruskal-Wallis Test on Data

Negative	N	Median	Ave Rank	Z
Neg 1	66	2.500	168.7	-4.13
Neg 2	66	3.000	175.7	-3.67
Neg 3	66	3.000	181.7	-3.27
Neg 4	66	3.000	193.7	-2.48
Neg 5	66	4.000	210.7	-1.37
Neg 6	66	6.000	292.5	4.01
Neg 7	66	7.000	397.5	10.91
Overall	462		231.5	

H = 158.08 DF = 6 P = 0.000
H = 161.37 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the negative consequences companies perceived by using Materials processing method.

```
Kruskal-Wallis Test on Data

Negatives     N  Median  Ave Rank      Z
Neg 1        29   2.000      45.0  -5.64
Neg 2        29   3.000      78.0  -2.38
Neg 3        29   4.000     112.0   0.99
Neg 4        29   3.000      88.0  -1.39
Neg 5        29   5.000     109.0   0.69
Neg 6        29   5.000     117.0   1.49
Neg 7        29   7.000     165.0   6.24
Overall     203              102.0

H = 70.29  DF = 6  P = 0.000
H = 71.75  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for the negative consequences companies perceived by using Increase range of stock method.

```
Kruskal-Wallis Test on Data

Negatives     N  Median  Ave Rank      Z
Neg 1        15   3.000      36.1  -2.32
Neg 2        15   3.000      40.1  -1.77
Neg 3        15   3.000      41.1  -1.63
Neg 4        15   4.000      51.1  -0.27
Neg 5        15   4.000      46.1  -0.95
Neg 6        15   5.000      59.0   0.83
Neg 7        15   7.000      97.5   6.11
Overall     105              53.0

H = 43.03  DF = 6  P = 0.000
H = 43.93  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for the negative consequences companies perceived by using Make product self customizable method.

```
Kruskal-Wallis Test on Data

Negatives     N  Median  Ave Rank      Z
Neg 1        27   3.000      70.0  -2.56
Neg 2        27   2.000      65.0  -3.08
Neg 3        27   3.000      78.0  -1.74
Neg 4        27   4.000      97.0   0.21
Neg 5        27   3.000      71.0  -2.46
Neg 6        27   6.000     129.0   3.49
Neg 7        27   7.000     155.0   6.16
Overall     189              95.0

H = 64.51  DF = 6  P = 0.000
H = 65.85  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for the negative consequences companies perceived by using Information content modification method.

Kruskal-Wallis Test on Data

Negatives	N	Median	Ave Rank	Z
Neg 1	33	3.000	103.1	-1.19
Neg 2	33	2.000	80.1	-3.33
Neg 3	33	4.000	101.2	-1.38
Neg 4	33	4.000	108.2	-0.72
Neg 5	33	3.000	98.2	-1.66
Neg 6	33	4.000	135.2	1.78
Neg 7	33	7.000	186.0	6.50
Overall	231		116.0	

Kruskal-Wallis test for the negative consequences companies perceived by using another company to provide services around product method

Kruskal-Wallis Test on Data

Negatives	N	Median	Ave Rank	Z
Neg 1	17	3.000	44.0	-2.07
Neg 2	17	3.000	50.0	-1.29
Neg 3	17	3.000	45.0	-1.94
Neg 4	17	4.000	52.0	-1.03
Neg 5	17	3.000	47.0	-1.68
Neg 6	17	6.000	83.0	2.97
Neg 7	17	7.000	99.0	5.03
Overall	119		60.0	

H = 40.91 DF = 6 P = 0.000
H = 41.76 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for the negative consequences companies perceived by using retailer provides services around product method

Kruskal-Wallis Test on Data

Negatives	N	Median	Ave Rank	Z
Neg 1	9	4.000	25.0	-1.24
Neg 2	9	2.000	27.0	-0.88
Neg 3	9	4.000	30.0	-0.35
Neg 4	9	3.000	27.0	-0.88
Neg 5	9	4.000	26.0	-1.06
Neg 6	9	5.000	37.0	0.88
Neg 7	9	7.000	52.0	3.54
Overall	63		32.0	

H = 15.11 DF = 6 P = 0.019
H = 15.42 DF = 6 P = 0.017 (adjusted for ties)

Kruskal-Wallis test for the negative consequences companies perceived by using other method.

Appendix D

The next figure presents the result of the difficulties in the supply chain by method. As it can be seen, all methods present similar results.

```
Source     DF       SS     MS     F      P
Factor      7     0.95   0.14  0.04  1.000
Error    1276  3902.76   3.06
Total    1283  3903.71

S = 1.749   R-Sq = 0.02%   R-Sq(adj) = 0.00%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  -----+---------+---------+---------+----
Assembly     108  3.546  1.742       (------------*------------)
Material     396  3.558  1.744             (------*------)
stock        180  3.522  1.732          (---------*---------)
self cust     90  3.567  1.768       (--------------*-------------)
Inf modif    162  3.599  1.767            (----------*----------)
other comp   198  3.525  1.741          (---------*---------)
retailer      96  3.510  1.735    (-------------*-------------)
Other         54  3.593  1.817   (------------------*-----------------)
                                  -----+---------+---------+---------+----
                                     3.25      3.50      3.75      4.00

Pooled StDev = 1.749
```

ANOVA and Kruskal-Wallis test for difficulties found in the supply chain by implementing customization strategies.

This section presents the test performed to analyze the mean and median of the surveys. The results were tested using ANOVA for means and Kruskal-Wallis for medians. In the following figures, the meaning for each difficulty is:

Figure	Meaning
SCM 1	Understanding customer wants
SCM 2	Supply Chain Management
SCM 3	Culture and Organization change
SCM 4	Changing business processes
SCM 5	Information technologies
SCM 6	Distribution channels
SCM 7	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all ANOVA tests were:

H0. All means are the same
H1. At least there is one mean different from the rest.

```
Source   DF      SS     MS      F      P
Factor    6  180.78  30.13  11.09  0.000
Error   119  323.22   2.72
Total   125  504.00

S = 1.648   R-Sq = 35.87%   R-Sq(adj) = 32.64%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean  StDev  -----+---------+---------+----------
SCM 1  18  4.167  1.886          (----*----)
SCM 2  18  3.056  1.731  (----*----)
SCM 3  18  3.389  1.819    (-----*----)
SCM 4  18  2.944  1.862  (----*----)
SCM 5  18  3.556  1.504      (----*----)
SCM 6  18  4.167  1.425          (----*----)
SCM 7  18  6.722  1.179                              (----*----
                          -----+---------+---------+----------
                             3.0       4.5       6.0       7.5

Pooled StDev = 1.648
```

ANOVA test for the difficulties found in the supply chain using Assembly of core modules method.

```
Source   DF      SS     MS      F      P
Factor    6  568.18  94.70  33.85  0.000
Error   455 1272.80   2.80
Total   461 1840.98

S = 1.673   R-Sq = 30.86%   R-Sq(adj) = 29.95%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean  StDev  ------+---------+---------+---------+---
SCM 1  66  3.394  2.140    (--*---)
SCM 2  66  3.227  1.586  (--*--)
SCM 3  66  3.439  1.618    (---*--)
SCM 4  66  3.379  1.537    (--*---)
SCM 5  66  3.682  1.702      (---*--)
SCM 6  66  4.227  1.690           (--*---)
SCM 7  66  6.606  1.323                                (--*--
                          ------+---------+---------+---------+---
                              3.6       4.8       6.0       7.2

Pooled StDev = 1.673
```

ANOVA test for the difficulties found in the supply chain using Materials processing method.

```
Source   DF      SS     MS      F      P
Factor    6  313.20  52.20  20.12  0.000
Error   203  526.80   2.60
Total   209  840.00

S = 1.611   R-Sq = 37.29%   R-Sq(adj) = 35.43%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ------+---------+---------+---------+---
SCM 1  30  3.800  1.955         (---*---)
SCM 2  30  2.700  1.765  (---*---)
SCM 3  30  3.567  1.501        (---*---)
SCM 4  30  3.600  1.653        (---*---)
SCM 5  30  3.767  1.794         (---*---)
SCM 6  30  3.700  1.579         (---*---)
SCM 7  30  6.867  0.730                            (---*---)
                          ------+---------+---------+---------+---
                              3.0       4.5       6.0       7.5

Pooled StDev = 1.611
```

ANOVA test for the difficulties found in the supply chain using Increase range of stock method.

```
Source   DF      SS     MS     F      P
Factor    6  141.33  23.56  8.28  0.000
Error    98  278.67   2.84
Total   104  420.00

S = 1.686   R-Sq = 33.65%   R-Sq(adj) = 29.59%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ------+---------+---------+---------+---
SCM 1  15  3.533  2.232      (-----*----)
SCM 2  15  3.067  1.944    (----*-----)
SCM 3  15  3.533  1.727      (-----*----)
SCM 4  15  3.000  1.512  (-----*-----)
SCM 5  15  3.733  1.387       (-----*-----)
SCM 6  15  4.533  1.506            (-----*-----)
SCM 7  15  6.600  1.298                        (-----*-----)
                          ------+---------+---------+---------+---
                              3.0       4.5       6.0       7.5

Pooled StDev = 1.686
```

ANOVA test for the difficulties found in the supply chain using Make product self-customizing method.

```
Source   DF      SS     MS      F      P
Factor    6  274.55  45.76  17.41  0.000
Error   182  478.44   2.63
Total   188  752.99

S = 1.621   R-Sq = 36.46%   R-Sq(adj) = 34.37%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev   ---------+---------+---------+---------+
SCM 1  27  3.704  2.127             (---*---)
SCM 2  27  4.148  1.634                (---*---)
SCM 3  27  2.333  1.519   (----*---)
SCM 4  27  3.185  1.388        (---*---)
SCM 5  27  3.556  1.577           (---*---)
SCM 6  27  4.667  1.441                 (---*---)
SCM 7  27  6.444  1.553                          (---*---)
                          ---------+---------+---------+---------+
                                 3.0       4.5       6.0       7.5

Pooled StDev = 1.621
```

ANOVA test for the difficulties found in the supply chain using Information content modification method.

```
Source   DF      SS     MS      F      P
Factor    6  247.78  41.30  19.18  0.000
Error   119  256.22   2.15
Total   125  504.00

S = 1.467   R-Sq = 49.16%   R-Sq(adj) = 46.60%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev    -+---------+---------+---------+--------
SCM 1  18  4.667  1.455                    (---*---)
SCM 2  18  3.444  1.688           (----*---)
SCM 3  18  3.167  1.689          (---*---)
SCM 4  18  2.111  0.900    (---*---)
SCM 5  18  3.722  1.674             (---*----)
SCM 6  18  3.944  1.893              (----*---)
SCM 7  18  6.944  0.236                                  (---*----)
                          -+---------+---------+---------+--------
                         1.6       3.2       4.8       6.4

Pooled StDev = 1.467
```

ANOVA test for the difficulties found in the supply chain using Another company to provide services around products method.

```
Source  DF      SS     MS      F      P
Factor   6  146.60  24.43  11.54  0.000
Error   63  133.40   2.12
Total   69  280.00

S = 1.455   R-Sq = 52.36%   R-Sq(adj) = 47.82%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev   ---------+---------+---------+---------+
SCM 1  10  2.600  1.776   (----*-----)
SCM 2  10  2.700  1.337   (-----*-----)
SCM 3  10  3.000  1.491     (-----*----)
SCM 4  10  3.600  1.506         (----*-----)
SCM 5  10  5.200  1.135                   (-----*----)
SCM 6  10  4.000  2.000           (-----*-----)
SCM 7  10  6.900  0.316                               (-----*-----)
                          ---------+---------+---------+---------+
                                 3.2       4.8       6.4       8.0

Pooled StDev = 1.455
```

ANOVA test for the difficulties found in the supply chain using the retailer to provide services around products method.

```
Source  DF      SS     MS     F      P
Factor   6   66.00  11.00  3.55  0.006
Error   42  130.00   3.10
Total   48  196.00

S = 1.759   R-Sq = 33.67%   R-Sq(adj) = 24.20%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level  N   Mean  StDev   -----+---------+---------+---------+----
SCM 1  7  3.571  2.149         (------*------)
SCM 2  7  3.714  1.704          (------*------)
SCM 3  7  3.714  1.113          (------*------)
SCM 4  7  2.286  1.704   (------*------)
SCM 5  7  3.571  1.988         (------*------)
SCM 6  7  4.857  1.952                 (------*------)
SCM 7  7  6.286  1.496                        (------*------)
                          -----+---------+---------+---------+----
                             2.0       4.0       6.0       8.0

Pooled StDev = 1.759
```

ANOVA test for the difficulties found in the supply chain using Other method

This section presents the test performed to analyze the medians of the surveys. The results were tested using Kruskal-Wallis. In the following figures, the meaning for each difficult found in the supply chain is:

Figure	Meaning
SCM 1	Understanding customer wants
SCM 2	Supply Chain Management
SCM 3	Culture and Organization change
SCM 4	Changing business processes
SCM 5	Information technologies
SCM 6	Distribution channels
SCM 7	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all Kruskal-Wallis tests are:

H0. All medians are the same
H1. At least there is one median different from the rest.

Kruskal-Wallis Test on Data

SCM	N	Median	Ave Rank	Z
SCM 1	18	4.000	66.5	0.38
SCM 2	18	3.000	46.5	-2.13
SCM 3	18	4.000	52.5	-1.38
SCM 4	18	2.500	44.5	-2.38
SCM 5	18	3.500	55.5	-1.00
SCM 6	18	4.500	66.5	0.38
SCM 7	18	7.000	112.5	6.15
Overall	126		63.5	

H = 43.92 DF = 6 P = 0.000
H = 44.84 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for difficulties found in the supply chain using Assembly of core modules method.

Kruskal-Wallis Test on Data

SCM	N	Median	Ave Rank	Z
SCM 1	66	3.000	192.0	-2.60
SCM 2	66	4.000	180.9	-3.33
SCM 3	66	3.000	195.0	-2.40
SCM 4	66	3.000	190.9	-2.67
SCM 5	66	4.000	210.9	-1.35
SCM 6	66	5.000	247.2	1.03
SCM 7	66	7.000	403.6	11.31
Overall	462		231.5	

H = 138.39 DF = 6 P = 0.000
H = 141.28 DF = 6 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for difficulties found in the supply chain using Materials processing method.

```
Kruskal-Wallis Test on Data

SCM         N  Median  Ave Rank      Z
SCM 1      30   4.000      99.5  -0.58
SCM 2      30   2.000      66.5  -3.80
SCM 3      30   4.000      92.5  -1.27
SCM 4      30   3.000      93.5  -1.17
SCM 5      30   3.500      98.5  -0.68
SCM 6      30   4.000      96.5  -0.88
SCM 7      30   7.000     191.5   8.37
Overall   210              105.5

H = 76.34  DF = 6  P = 0.000
H = 77.93  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for difficulties found in the supply chain using Increase range of stock method.

```
Kruskal-Wallis Test on Data

SCM         N  Median  Ave Rank      Z
SCM 1      15   4.000      46.0  -0.96
SCM 2      15   3.000      39.0  -1.92
SCM 3      15   4.000      46.0  -0.96
SCM 4      15   3.000      38.0  -2.06
SCM 5      15   4.000      49.0  -0.55
SCM 6      15   5.000      61.0   1.10
SCM 7      15   7.000      92.0   5.36
Overall   105              53.0

H = 34.29  DF = 6  P = 0.000
H = 35.00  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for difficulties found in the supply chain using Make product self customizable method.

```
Kruskal-Wallis Test on Data

SCM         N  Median  Ave Rank      Z
SCM 1      27   4.000      86.9  -0.83
SCM 2      27   5.000      98.8   0.39
SCM 3      27   2.000      49.8  -4.64
SCM 4      27   3.000      72.8  -2.28
SCM 5      27   4.000      82.9  -1.25
SCM 6      27   5.000     112.9   1.84
SCM 7      27   7.000     161.0   6.77
Overall   189              95.0

H = 67.15  DF = 6  P = 0.000
H = 68.55  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for difficulties found in the supply chain using Information content modification method.

```
Kruskal-Wallis Test on Data

SCM          N  Median  Ave Rank      Z
SCM 1       33   5.000     132.9   1.57
SCM 2       33   4.000      93.9  -2.06
SCM 3       33   4.000      98.9  -1.59
SCM 4       33   2.000      65.7  -4.67
SCM 5       33   3.000     102.7  -1.23
SCM 6       33   4.000     106.9  -0.85
SCM 7       33   7.000     211.0   8.82
Overall    231             116.0

H = 95.18  DF = 6  P = 0.000
H = 97.16  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for difficulties found in the supply chain using another company to provide services around product method

```
Kruskal-Wallis Test on Data

SCM          N  Median  Ave Rank      Z
SCM 1       16   2.500      37.5  -2.53
SCM 2       16   2.500      40.5  -2.13
SCM 3       16   3.500      46.5  -1.33
SCM 4       16   3.500      47.5  -1.20
SCM 5       16   5.000      67.5   1.46
SCM 6       16   4.000      52.5  -0.53
SCM 7       16   7.000     103.5   6.25
Overall    112              56.5

H = 47.70  DF = 6  P = 0.000
H = 48.69  DF = 6  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for difficulties found in the supply chain using retailer provides services around product method

```
Kruskal-Wallis Test on Data

SCM          N  Median  Ave Rank      Z
SCM 1        9   3.000      23.0  -1.59
SCM 2        9   4.000      29.0  -0.53
SCM 3        9   4.000      31.0  -0.18
SCM 4        9   2.000      19.0  -2.30
SCM 5        9   3.000      29.0  -0.53
SCM 6        9   5.000      39.0   1.24
SCM 7        9   7.000      54.0   3.89
Overall     63              32.0

H = 21.48  DF = 6  P = 0.002
H = 21.92  DF = 6  P = 0.001  (adjusted for ties)
```

Kruskal-Wallis test for difficulties found in the supply chain using other method.

Appendix E

The next figure presents the result of the difficulties in the supply chain by method. As it can be seen, all methods present similar results.

```
Source     DF       SS     MS      F      P
Factor      7      9.6    1.4   0.10  0.999
Error    2774  39838.5   14.4
Total    2781  39848.2

S = 3.790   R-Sq = 0.02%   R-Sq(adj) = 0.00%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N   Mean  StDev  -----+---------+---------+---------+----
Assembly     234  7.205  3.821          (-------------*-------------)
Material     871  7.086  3.804             (------*-------
stock        351  7.023  3.774       (-----------*----------)
self cust    208  7.010  3.767    (-------------*-------------)
Inf modif    364  7.121  3.810          (----------*----------)
other comp   429  7.009  3.763       (---------*----------)
retailer     208  7.024  3.759    (-------------*-------------)
Other        117  7.145  3.788  (------------------*------------------)
                                  -----+---------+---------+---------+----
                                     6.65      7.00      7.35      7.70
Pooled StDev = 3.790
```

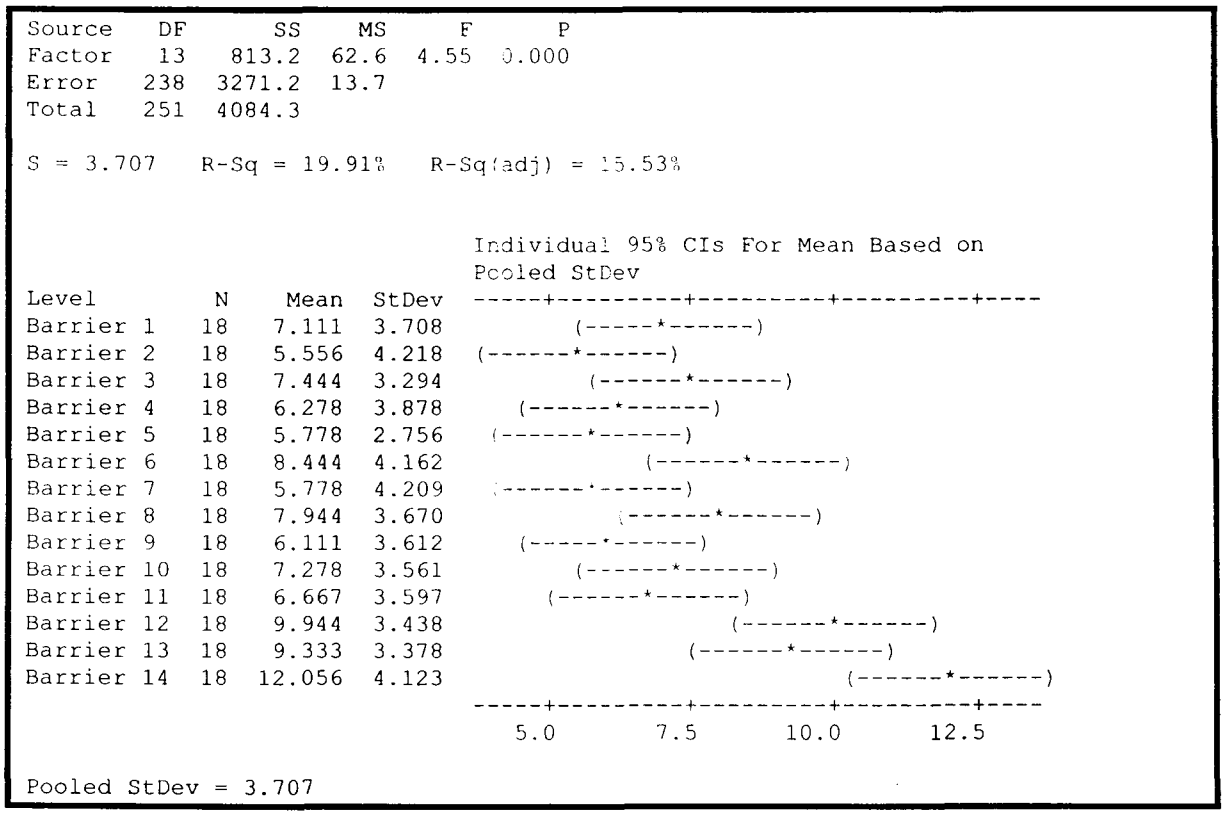
ANOVA and Kruskal-Wallis test for barriers to increase the customization degree by implementing customization strategies.

This section presents the test performed to analyze the mean and median of the surveys. The results were tested using ANOVA for means and Kruskal-Wallis for medians. In the following figures, the meaning for each barrier is:

Figure	Meaning
Barrier 1	Inflexible factories
Barrier 2	Products would be too costly
Barrier 3	Information technologies
Barrier 4	Change management
Barrier 5	Management skills and abilities
Barrier 6	Understanding customer wants
Barrier 7	Supply from stock
Barrier 8	Product not customizable
Barrier 9	Design for customization
Barrier 10	Workforce skills and attitudes
Barrier 11	Suppliers
Barrier 12	Customer do not want it
Barrier 13	Distributor/retailer
Barrier 14	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all ANOVA tests were:

H0. All means are the same
H1. At least there is one mean different from the rest.



```
Source   DF      SS    MS     F      P
Factor   13   813.2  62.6  4.55  0.000
Error   238  3271.2  13.7
Total   251  4084.3

S = 3.707   R-Sq = 19.91%   R-Sq(adj) = 15.53%


                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level        N    Mean  StDev  -----+---------+---------+---------+----
Barrier 1   18   7.111  3.708         (-----*------)
Barrier 2   18   5.556  4.218  (------*------)
Barrier 3   18   7.444  3.294          (------*------)
Barrier 4   18   6.278  3.878     (------*------)
Barrier 5   18   5.778  2.756   (------*------)
Barrier 6   18   8.444  4.162              (------*------)
Barrier 7   18   5.778  4.209   (------*------)
Barrier 8   18   7.944  3.670            (------*------)
Barrier 9   18   6.111  3.612     (------*------)
Barrier 10  18   7.278  3.561         (------*------)
Barrier 11  18   6.667  3.597       (------*------)
Barrier 12  18   9.944  3.438                   (------*------)
Barrier 13  18   9.333  3.378                 (------*------)
Barrier 14  18  12.056  4.123                           (------*------)
                                 -----+---------+---------+---------+----
                                    5.0       7.5      10.0      12.5

Pooled StDev = 3.707
```

ANOVA test for barriers to increase the customization degree using Assembly of core modules method.

```
Source   DF       SS      MS      F      P
Factor   13   3410.8   262.4  20.64  0.000
Error   924  11747.2    12.7
Total   937  15158.0

S = 3.566   R-Sq = 22.50%   R-Sq(adj) = 21.41%

                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level         N    Mean   StDev  ----+---------+---------+---------+-----
Barrier 1    67   7.284   4.170            (--*---)
Barrier 2    67   6.254   3.819         (--*--)
Barrier 3    67   6.269   3.427         (--*--)
Barrier 4    67   4.925   2.930  (---*--)
Barrier 5    67   5.612   3.261     (--*---)
Barrier 6    67   6.925   3.714        (---*--)
Barrier 7    67   6.433   3.759        (---*--)
Barrier 8    67   8.313   3.803                (--*---)
Barrier 9    67   7.239   3.416            (--*--)
Barrier 10   67   7.925   3.590              (---*--)
Barrier 11   67   6.179   3.733        (---*--)
Barrier 12   67   9.985   3.305                      (--*--)
Barrier 13   67   8.776   3.563                  (--*---)
Barrier 14   67  12.567   3.248                              (--*---)
                                 ----+---------+---------+---------+-----
                                   5.0       7.5      10.0      12.5

Pooled StDev = 3.566
```

ANOVA test for barriers to increase the customization degree using Materials processing method.

```
Source   DF      SS     MS      F      P
Factor   13  2489.4  191.5  19.08  0.000
Error   364  3653.1   10.0
Total   377  6142.5

S = 3.168   R-Sq = 40.53%   R-Sq(adj) = 38.40%


                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level         N    Mean   StDev  --+---------+---------+---------+-------
Barrier 1    27   6.667   3.584          (--*--)
Barrier 2    27   4.074   3.149  (---*--)
Barrier 3    27   5.926   2.921        (--*--)
Barrier 4    27   4.370   2.830   (--*---)
Barrier 5    27   5.481   2.310     (---*--)
Barrier 6    27   7.926   2.630            (---*--)
Barrier 7    27   5.000   4.243     (--*---)
Barrier 8    27   9.037   3.898               (---*--)
Barrier 9    27   7.815   3.114            (--*---)
Barrier 10   27   8.852   3.134               (--*---)
Barrier 11   27   6.407   3.434         (--*---)
Barrier 12   27  10.815   2.975                     (---*--)
Barrier 13   27   8.926   3.761               (---*--)
Barrier 14   27  13.704   1.203                           (--*---)
                                 --+---------+---------+---------+-------
                                 3.5       7.0      10.5      14.0


Pooled StDev = 3.168
```

ANOVA test for barriers to increase the customization degree using Increase range of stock method.

```
Source    DF      SS     MS      F      P
Factor    13   905.4   69.6   5.37  0.000
Error    210  2724.1   13.0
Total    223  3629.6

S = 3.602    R-Sq = 24.95%    R-Sq(adj) = 20.30%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level         N    Mean   StDev  ---------+---------+---------+---------+
Barrier 1    16   7.063   3.803          (-----*-----)
Barrier 2    16   4.938   3.492  (-----*-----)
Barrier 3    16   6.000   3.967     (-----*-----)
Barrier 4    16   5.000   2.944  (-----*-----)
Barrier 5    16   7.000   3.724        (-----*-----)
Barrier 6    16   8.375   3.442              (-----*-----)
Barrier 7    16   5.563   4.273    (-----*-----)
Barrier 8    16   8.063   3.549            (-----*-----)
Barrier 9    16   7.250   3.376         (-----*-----)
Barrier 10   16   8.313   3.572              (-----*-----)
Barrier 11   16   6.688   3.610        (-----*-----)
Barrier 12   16   8.625   3.998               (-----*-----)
Barrier 13   16   8.250   3.642              (-----*-----)
Barrier 14   16  13.250   2.745                                  (-----*-----)
                                  ---------+---------+---------+---------+
                                         6.0       9.0      12.0      15.0

Pooled StDev = 3.602
```

ANOVA test for barriers to increase the customization degree using Make product self-customizing method.

```
Source    DF      SS      MS      F      P
Factor    13  1694.4   130.3  10.55  0.000
Error    378  4669.6    12.4
Total    391  6364.0

S = 3.515    R-Sq = 26.63%    R-Sq(adj) = 24.10%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level         N    Mean   StDev  --------+---------+---------+---------+-
Barrier 1    28   7.857   4.240            (---*----)
Barrier 2    28   6.750   3.617         (---*----)
Barrier 3    28   5.429   3.756     (---*---)
Barrier 4    28   5.143   3.856    (---*---)
Barrier 5    28   5.000   3.220  (----*---)
Barrier 6    28   5.107   3.201    (---*---)
Barrier 7    28   8.714   3.113                (---*---)
Barrier 8    28   7.607   4.040           (---*----)
Barrier 9    28   6.964   3.294         (---*----)
Barrier 10   28   6.286   2.992       (---*---)
Barrier 11   28   8.286   3.149             (----*---)
Barrier 12   28   9.571   3.371                  (---*---)
Barrier 13   28   9.857   3.429                   (---*---)
Barrier 14   28  12.429   3.666                            (---*----)
                                  --------+---------+---------+---------+-
                                        6.0       9.0      12.0      15.0

Pooled StDev = 3.515
```

ANOVA test for barriers to increase the customization degree using Information content modification method.

```
Source   DF      SS     MS      F      P
Factor   13  2344.5  180.3  15.63  0.000
Error   448  5169.0   11.5
Total   461  7513.5

S = 3.397   R-Sq = 31.20%   R-Sq(adj) = 29.21%

                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level         N    Mean  StDev  --------+---------+---------+---------+-
Barrier 1    33   6.545  4.309        (---*---)
Barrier 2    33   5.455  3.483     (---*---)
Barrier 3    33   6.697  3.137        (---*---)
Barrier 4    33   4.667  2.758  (---*--)
Barrier 5    33   5.758  3.289     (---*---)
Barrier 6    33   6.515  3.842        (---*---)
Barrier 7    33   8.152  2.874             (---*---)
Barrier 8    33   8.909  3.273                (---*---)
Barrier 9    33   7.121  3.343          (---*---)
Barrier 10   33   6.152  3.483       (---*--)
Barrier 11   33   6.515  4.024        (---*---)
Barrier 12   33   9.879  3.903                   (---*---)
Barrier 13   33   8.758  3.734              (---*---)
Barrier 14   33  13.879  0.415                                (---*---)
                                 --------+---------+---------+---------+-
                                       6.0       9.0      12.0      15.0

Pooled StDev = 3.397
```

ANOVA test for barriers to increase the customization degree using Another company to provide services around products method.

```
Source   DF      SS    MS     F      P
Factor   13  1046.2  80.5  6.59  0.000
Error   210  2565.8  12.2
Total   223  3611.9

S = 3.495   R-Sq = 28.96%   R-Sq(adj) = 24.57%

                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level         N    Mean  StDev  -+---------+---------+---------+--------
Barrier 1    16   7.750  4.025           (----*----)
Barrier 2    16   8.688  3.497              (----*----)
Barrier 3    16   5.250  2.295    (----*----)
Barrier 4    16   5.500  3.882     (----*----)
Barrier 5    16   6.000  3.162      (----*----)
Barrier 6    16   6.063  2.695      (----*----)
Barrier 7    16   7.688  3.894           (----*----)
Barrier 8    16   8.563  3.502              (---*----)
Barrier 9    16   8.938  3.021               (----*---)
Barrier 10   16   7.125  3.557         (----*----)
Barrier 11   16   5.938  3.941      (----*----)
Barrier 12   16   9.000  4.099               (----*----)
Barrier 13   16   4.813  4.293   (----*----)
Barrier 14   16  13.438  2.250                          (----*----)
                                 -+---------+---------+---------+--------
                                3.5       7.0      10.5      14.0

Pooled StDev = 3.495
```

ANOVA test for barriers to increase the customization degree using the retailer to provide services around products method.

```
Source   DF      SS     MS     F      P
Factor   13   531.0   40.8  3.08  0.001
Error   112  1485.1   13.3
Total   125  2016.2

S = 3.641   R-Sq = 26.34%   R-Sq(adj) = 17.79%


                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level        N    Mean   StDev  --+---------+---------+---------+-------
Barrier 1    9   8.889   1.833             (-----*------)
Barrier 2    9   5.778   4.410    (------*-----)
Barrier 3    9   5.222   4.494  (------*------)
Barrier 4    9   7.222   3.768         (------*------)
Barrier 5    9   7.778   3.528          (------*------)
Barrier 6    9   6.000   4.472    (------*------)
Barrier 7    9   7.889   4.045           (------*-----)
Barrier 8    9   7.222   2.819         (------*------)
Barrier 9    9   6.000   2.646    (------*------)
Barrier 10   9   5.556   1.944   (------*------)
Barrier 11   9   7.667   4.272          (------*------)
Barrier 12   9   8.556   5.028             (-----*------)
Barrier 13   9   9.111   4.045              (------*------)
Barrier 14   9  13.556   1.014                        (------*------)
                                 --+---------+---------+---------+-------
                                 3.5       7.0      10.5      14.0

Pooled StDev = 3.641
```

ANOVA test for barriers to increase the customization degree using Other method

This section presents the test performed to analyze the medians of the surveys. The results were tested using Kruskal-Wallis. In the following figures, the meaning for each difficult found in the supply chain is:

Figure	Meaning
Barr 1	Inflexible factories
Barr 2	Products would be too costly
Barr 3	Information technologies
Barr 4	Change management
Barr 5	Management skills and abilities
Barr 6	Understanding customer wants
Barr 7	Supply from stock
Barr 8	Product not customizable
Barr 9	Design for customization
Barr 10	Workforce skills and attitudes
Barr 11	Suppliers
Barr 12	Customer do not want it
Barr 13	Distributor/retailer
Barr 14	Other

All test performed use a 95 percent confidence interval. The P-value (P in the figure) represents the decision criteria for accepting or rejecting the Hypothesis, which in all Kruskal-Wallis tests are:

H0. All medians are the same
H1. At least there is one median different from the rest.

Kruskal-Wallis Test on Data

Barrier	N	Median	Ave Rank	Z
Barr 1	18	7.500	118.5	-0.48
Barr 10	18	6.500	121.3	-0.32
Barr 11	18	7.500	110.6	-0.96
Barr 12	18	10.000	169.7	2.61
Barr 13	18	9.500	158.6	1.94
Barr 14	18	14.000	208.3	4.94
Barr 2	18	4.000	90.6	-2.17
Barr 3	18	7.500	124.5	-0.12
Barr 4	18	7.000	103.6	-1.38
Barr 5	18	5.000	94.3	-1.95
Barr 6	18	9.000	142.6	0.97
Barr 7	18	5.000	94.6	-1.93
Barr 8	18	8.500	133.4	1.42
Barr 9	18	5.000	100.4	-1.58
Overall	252		126.5	

H = 50.10 DF = 13 P = 0.000
H = 50.36 DF = 13 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for difficulties found in the supply chain using Assembly of core modules method.

Kruskal-Wallis Test on Data

Barrier	N	Median	Ave Rank	Z
Barr 1	67	7.000	456.5	-0.41
Barr 10	67	8.000	499.8	0.95
Barr 11	67	6.000	382.4	-2.73
Barr 12	67	11.000	638.1	5.29
Barr 13	67	9.000	557.0	2.74
Barr 14	67	14.000	809.5	10.66
Barr 2	67	6.000	387.4	-2.57
Barr 3	67	6.000	388.5	-2.54
Barr 4	67	4.000	298.1	-5.37
Barr 5	67	5.000	344.1	-3.93
Barr 6	67	7.000	432.5	-1.16
Barr 7	67	6.000	399.4	-2.20
Barr 8	67	9.000	525.9	1.77
Barr 9	67	7.000	453.8	-0.49
Overall	938		469.5	

H = 208.55 DF = 13 P = 0.000
H = 209.62 DF = 13 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for difficulties found in the supply chain using Materials processing method.

Kruskal-Wallis Test on Data

Barr	N	Median	Ave Rank	Z
Barr 1	27	5.000	167.0	-1.11
Barr 10	27	10.000	226.0	1.80
Barr 11	27	6.000	160.0	-1.46
Barr 12	27	12.000	279.0	4.42
Barr 13	27	10.000	228.0	1.90
Barr 14	27	14.000	357.0	8.27
Barr 2	27	3.000	97.0	-4.57
Barr 3	27	6.000	147.0	-2.10
Barr 4	27	4.000	105.0	-4.17
Barr 5	27	5.000	135.0	-2.69
Barr 6	27	9.000	201.0	0.57
Barr 7	27	4.000	122.0	-3.33
Barr 8	27	10.000	231.0	2.05
Barr 9	27	8.000	198.0	0.42
Overall	378		189.5	

H = 152.01 DF = 13 P = 0.000
H = 152.79 DF = 13 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for barriers to increase the customization degree using Increase range of stock method.

Kruskal-Wallis Test on Data

Barrier	N	Median	Ave Rank	Z
Barr 1	16	7.000	106.3	-0.40
Barr 10	16	9.000	126.3	0.88
Barr 11	16	7.000	100.3	-0.78
Barr 12	16	9.500	131.3	1.20
Barr 13	16	8.500	125.3	0.82
Barr 14	16	14.000	204.6	5.90
Barr 2	16	4.500	72.2	-2.58
Barr 3	16	7.000	89.1	-1.50
Barr 4	16	4.000	73.3	-2.51
Barr 5	16	6.000	105.3	-0.46
Barr 6	16	8.000	127.3	0.95
Barr 7	16	4.000	82.1	-1.95
Barr 8	16	8.500	122.3	0.63
Barr 9	16	7.000	109.4	-0.20
Overall	224		112.5	

H = 54.78 DF = 13 P = 0.000
H = 55.06 DF = 13 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for barriers to increase the customization degree using Make product self-customizing method.

```
Kruskal-Wallis Test on Data

Barrier     N  Median  Ave Rank      Z
Barr 1     28   8.000     206.7   0.49
Barr 10    28   6.000     162.4  -1.65
Barr 11    28   9.000     218.4   1.06
Barr 12    28  11.000     254.6   2.82
Barr 13    28  11.000     262.6   3.20
Barr 14    28  14.000     334.5   6.69
Barr 2     28   6.000     175.6  -1.02
Barr 3     28   5.500     138.5  -2.81
Barr 4     28   4.500     130.5  -3.20
Barr 5     28   4.000     126.4  -3.40
Barr 6     28   4.000     129.5  -3.25
Barr 7     28   9.500     230.5   1.65
Barr 8     28   8.500     199.5   0.15
Barr 9     28   6.500     181.5  -0.73
Overall   392              196.5

H = 103.57  DF = 13  P = 0.000
H = 104.10  DF = 13  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for barriers to increase the customization degree using Information content modification method.

```
Kruskal-Wallis Test on Data

Barrier     N  Median  Ave Rank      Z
Barr 1     33   7.000     200.0  -1.41
Barr 10    33   6.000     187.0  -1.98
Barr 11    33   6.000     199.0  -1.45
Barr 12    33  12.000     310.0   3.51
Barr 13    33  10.000     273.0   1.85
Barr 14    33  14.000     442.0   9.40
Barr 2     33   5.000     164.0  -3.01
Barr 3     33   7.000     205.0  -1.19
Barr 4     33   4.000     138.0  -4.17
Barr 5     33   6.000     174.0  -2.57
Barr 6     33   6.000     199.1  -1.45
Barr 7     33   8.000     253.0   0.96
Barr 8     33  10.000     278.0   2.07
Barr 9     33   7.000     219.0  -0.56
Overall   462              231.5

H = 143.18  DF = 13  P = 0.000
H = 143.91  DF = 13  P = 0.000  (adjusted for ties)
```

Kruskal-Wallis test for barriers to increase the customization degree using Another company to provide services around products method.

Kruskal-Wallis Test on Data

Barrier	N	Median	Ave Rank	Z
Barr 1	16	8.000	116.9	0.28
Barr 10	16	7.500	106.8	-0.36
Barr 11	16	4.500	87.7	-1.59
Barr 12	16	9.000	136.8	1.56
Barr 13	16	2.500	69.8	-2.74
Barr 14	16	14.000	207.5	6.08
Barr 2	16	9.500	132.0	1.25
Barr 3	16	5.500	76.5	-2.30
Barr 4	16	4.500	80.7	-2.04
Barr 5	16	6.000	88.7	-1.53
Barr 6	16	5.500	89.7	-1.46
Barr 7	16	8.500	115.9	0.22
Barr 8	16	9.000	129.9	1.12
Barr 9	16	10.000	136.0	1.51
Overall	224		112.5	

H = 63.82 DF = 13 P = 0.000
H = 64.15 DF = 13 P = 0.000 (adjusted for ties)

Kruskal-Wallis test for barriers to increase the customization degree using the retailer to provide services around products method.

Kruskal-Wallis Test on Data

Barrier	N	Median	Ave Rank	Z
Barr 1	9	9.000	75.3	1.01
Barr 10	9	6.000	44.5	-1.62
Barr 11	9	6.000	63.9	0.03
Barr 12	9	9.000	72.2	0.74
Barr 13	9	8.000	76.9	1.14
Barr 14	9	14.000	117.5	4.60
Barr 2	9	5.000	47.1	-1.40
Barr 3	9	5.000	42.2	-1.81
Barr 4	9	9.000	60.2	-0.28
Barr 5	9	9.000	65.4	0.16
Barr 6	9	5.000	49.0	-1.24
Barr 7	9	8.000	66.1	0.22
Barr 8	9	7.000	59.9	-0.30
Barr 9	9	6.000	48.7	-1.26
Overall	126		63.5	

H = 32.77 DF = 13 P = 0.002
H = 32.94 DF = 13 P = 0.002 (adjusted for ties)

Kruskal-Wallis test for barriers to increase the customization degree using Other method.