Bringing the Competitive Advantage of Mass Customization into Mass Production

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J. C. Astiazarán, J. A. Lakunza
Mass Customization Research Team / Design and Production Process Business Unit
Ikerlan S.Coop. Technological Center
M. A. Amenabar
Managing Director

Abstract

The aim of this paper is to present and discuss how to bring the competitive advantage of Mass Customization into Mass Production.

The Technological Center Ikerlan carried out an applied research project in a small cutting tool manufacturer, Zubiola, which serves both catalogue tools and customized tools. Having shifted from the Mass Production paradigm towards Mass Customization, at the moment Zubiola combines successfully Mass Customization and Mass Production.

The paper describes the case study of Zubiola, performs an analysis of the main indicators and presents some possible criteria in order to extend this success to other business and companies.

Keywords: Mass Customization, Personalization, Mass Production.

1 INTRODUCTION

1.1 Research Topic

From the middle eighties, Mass Customization has been spreading from academic world to the industrial world [1] [2] [3]; in the last years more and more companies are adopting the Mass Customization paradigm.

These companies have followed two approaches. For the business offering pure personalization to their customers, Mass Customization provided the possibility of improving the efficiency of their process while maintaining the level of personalization. On the other hand, those companies offering a more or less wide product catalogue switched from a catalogue personalization (market segment oriented offer) to a customized offer, without risking their former Mass Production efficiency [4].

Evolution from Mass Production to Mass Customization is not an easy task [5]. Is it worthy enough for every company to take this way? There are markets, products and situations that do not seem suitable for the Mass Customization paradigm. The company must keep its product catalogue, which is getting wider and wider day after day.

Therefore some questions arise: Are Mass Production and Mass Customization antagonistic? Can Mass Production benefit from Mass Customization principles and technologies? Under which boundary conditions will enterprises try pure Mass Customization and Personalization? When should they stick with the Mass Production paradigm?

1.2 The structure of the paper

First of all, we will describe the methodology used in this research. After describing the case, we will perform an analysis of the main indicators, and its relationship with the adopted strategy: revenues, costs, lead time, fulfilment ratio and stocks.

Finally, we will present and discuss the major findings in this case of bringing the Competitive Advantage of Mass Customization into Mass Production, and we will propose some possible criteria to extend this success to other business and companies.

2 METHODOLOGY

This is a case study research, based in the results of an applied research project.

At the beginning of this applied project we identified the metrics of the project, its performance indicators. When carrying out the project, these metrics were evaluated and recorded. When the project ended, the indicators served to determine the degree of successfulness of the project.

This case study research has used these indicators. After analysing them, we tried to link the actions, the effects and the adopted strategy. Finally we extracted possible criteria and conclusions to extend this success to other business and companies.

3 ZUBIOLA: CASE STUDY

3.1 The company and the product

Zubiola [6] is a small company producing woodworking-cutting tools: cutter-heads, cutters, drills and saws. Founded in 1959, Zubiola offers a wide catalogue with more than 2,500 references. Their range of customers goes from family business as carpenters to big companies as furniture builders and sawmills. Anyway, usual orders are small orders, with few items each time.
Apart of standard cutting tools, the customers need and ask for special tools, with particular requirements as dimensions (diameter, width, teeth number, angles…) and/or different forms of the produced wood parts (profiles).

3.2 Strategic approach
In the late eighties the company faced a challenging position. At that time, multinationals began to enter the Spanish market, buying established companies and lowering prices: in fact, big companies were better suited than Zubiola for Mass Production, and some of them produced the cutting tools in developing countries, with much lower wages than in Spain. At the same time the customers of customized tools began to left Zubiola, due to long lead-times, quality problems and high prices… and sometimes costs were higher than the prices!

Thus, Zubiola needed and established a new strategy: it will focus in tailored tools, but producing them under the Mass Production conditions: quality, lead-time and cost. Some years later they realized they were doing Mass Customization.

And for the product-mix Zubiola made the following decisions:

- **Cutter-heads** (high level product). To concentrate, and try to attract customers from the lower segment of cutters.
- **Cutters** (medium level product). To maintain, while trying to redirect customers to cutter-heads.
- **Drills** (low level product). To maintain.
- **Saws** (high level product). To concentrate.

Zubiola was and is a founder partner of Ikerlan [7], a Technological Research Center in the Basque Country. In order to put its strategy working, Zubiola asked for the collaboration of Ikerlan.

So, with the help of Ikerlan, Zubiola reengineered all the business processes: bidding, order-capture, design, manufacturing, expeditions… Through mastering of design and technology, know-how of the product, intensive use of Information and Communication Technologies… the company reached its objectives, and by 1994 Zubiola was the leader in customized tools in the Spanish market.

3.3 **Kind of Mass Customization applied**
Depending on the product and the business strategy, different types of Mass Customization can be appropriate [9]. In this chapter we will describe the kind of Mass Customization applied in Zubiola, and why.

Products of Zubiola are composed of the main part, the body, and the cutters. These cutters can be welded (cutters, drills and saws) or locked (cutter-heads). In the latter the product has more parts, holders and screws, to hold the cutters.

In the past some attempts of standardization were made in Zubiola; but they failed, due to the difficulty to find standard parts. In fact, the only standard parts found were holders and screws. The conclusion was that Zubiola’s products were totally special, and that was not possible to get any level of standardization further that holders and screws.

This time the job began with an analysis of what made products different. The result: diameter and number of cutters (affecting the body), and the width and shape of the profile (affecting both the body and the cutters); all of them were customer’s requirements.

Having the product so little number of parts, the variability of the requirements affected the whole product, and from the very beginning. There was no way to solve the problem with an assembly-to-order approach.

So, we tried a different approach, based on the design theory set by Ikerlan several years ago [9] [10], and applied widely since then. The focus of that approach is to use the designer’s point of view instead of the production one.

And what is the difference? In the production world product is considered as a collection of components or parts, but from the designer’s point of view design is a combination of technical solutions that, together, solves the customer’s requirements.

Some design features build each of these technical solutions, each of them affecting different parts. Depending on the product, these technical solutions can affect to a single design feature or to a whole assembly.

Therefore, instead of analysing the different components of the products of Zubiola, and trying to standardize them, the first step consisted in breaking up the products of Zubiola in design subsystems, and historical realizations were examined just to find which technical solutions were used in the past.

After discovering which were the technical solutions used in the past by the designers, a second step was to analyse them in terms of performance, difficulty, costs, reliability… and, then, chose the technical solutions to be used in the future.

The third step was to develop them: to decide the design criteria, set the standards, set the related processes (manufacturing, assembling, controlling….) and so on.

Finally, last but not least, we used Information Technologies to put these design decisions in electronic format, in the form of rules of a computer system. As a result, design rules could be applied in a sure and quick way. To get this purpose, a commercial CAD system was adapted, just to allow the automatic design of the whole cutting tool from the customer’s requirements.

This automatism works in two ways: while the CAD model is built form the customer’s requirements, technical specifications of the cutting tool are created and stored in a data-base.

Then, auxiliary utilities can produce automatically all the technical documentation needed to produce the cutting tool: blueprints of the assembly, the body and the cutters (this one for the supplier); bill of materials; NC programs for the lathes, the machining centres, the EDM machine and the sharpening machines; control sheets and so on.

The advantages of the chosen approach are the following:

- the main one, this approach worked well when other approaches had failed (standardization of parts, for example).
• The chosen product structure (design subsystems and technical solutions) worked very well not only in the design field, but also in the technical documentation: each technical solution has its translation in the CAD model, and in the blueprints, bill of materials, NC programs, control sheets...

• the chosen product structure allowed to Zubiola the standardization of the design. Although the products and its parts can be very different, they share the same technical solutions.

• Evolution has been made easier in a double way. Product evolution in Zubiola now consists in just adding, improving or eliminating technical solutions from what could be called the Technical Catalogue of Zubiola. Besides that, sharing technical solutions among the products increases evolution performance.

• Finally, the chosen approach was applicable not only to customized tools, but to the catalogue ones. And this last advantage allowed Zubiola bringing the Competitive Advantage of Mass Customization into Mass Production.

3.4 Extension to Mass Production

As mentioned before, the strategy of Zubiola focused on customized cutting tools, producing them under the Mass Production conditions: quality, lead-time and cost. The underlying assumption was that, in these conditions, market answer would be very favourable.

Based in the small size (few cutting tools) of the orders, a second assumption was made too: for the sake of management simplicity, customers would prefer mixing customized tools as well as catalogue tools in the same order.

Both assumptions became true, making the strategy successful. The market answered quite well, and mixed both kinds of tools in their orders. The sales of customized tools increased, and so did the sales of catalogue tools.

After mastering the customized cutting tools using the Mass Customization paradigm, Zubiola faced one second problem. Although margins of customized cutting tools were correct, the profitability of the catalogue tools was not good enough: margins were small, or even negative. Prices were established by multinational companies, producing them by hundreds or thousands in countries with cheaper wages.

The first analysis showed a striking reality: thousands of references, very low selling ratios, a warehouse full of finished goods... most of them produced months or years ago!

Zubiola decided to change the strategy for the catalogue tools, and got rid off the old paradigms of Mass Production [11]: forecasting future sells, manufacturing by the many, huge stock of finished goods... So:

• they decided to deal with most of the references as if they were customized tools: no stocks, and applying a build-to-order approach. Considering that by that time, production lead-times were low, and quality was assured, there was no reason to keep references in stock. The only difference was that instead of being design-to-order, like the customized tools, they were build-to-order.

• only the best selling references would be produced under forecasting, but maintaining very much lower stocks.

Results were impressing! Stocks cut by four, reliability increased from %50 to %90 (less stock breakdown), and costs were kept well under the inflation rate.

4 DATA ANALYSIS

4.1 Analysis methodology

The data were collected in three different times: 1989, 1994 and 1997.

In 1989 all catalogue cutting tools were produced under the Mass Production paradigm, and quality, lead-time and cost of customized tools were not satisfactory at all.

Then we established the product families, and made the first analysis for each family: selling volume (units and revenues), direct costs, lead-time, fulfilment ratio and average stocks. In the same way, we analysed the cutting tools catalogue reference by reference, always under the same parameters.

We performed a similar analysis in 1994, when the customized cutting tools were produced under the Mass Customization paradigm: their quality, lead-time and cost of customized tools were satisfactory.

In this year, Zubiola began the second part of the project. They used the data of the catalogue tools in order to decide which of them were to be produced under the Mass Customization paradigm, and which will continue under the Mass Production paradigm. Objectives were fixed: quantity to produce each time, stock level...

Finally, we performed a last analysis in 1997, in order to determine the impact of the Mass Customization paradigm in the catalogue tools production. Three parameters were taken into account: lead time, direct costs and stocks (indirect costs).

Once the data was collected, we compared the results for the different families, looking for the differences and the possible causes. Last but not least, we analysed the influence of both technologies (Manufacturing Technologies and Information and Communication Technologies) in bringing the Competitive Advantage of Mass Customization into Mass Production.

4.2 Analysis results

Sold units

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Customized</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutter-heads</td>
<td>320</td>
<td>500</td>
<td>2,500</td>
</tr>
<tr>
<td>Cutters</td>
<td>2,490</td>
<td>2,300</td>
<td>2,500</td>
</tr>
<tr>
<td>Drills</td>
<td>190</td>
<td>175</td>
<td>200</td>
</tr>
<tr>
<td>Saws</td>
<td>1,166</td>
<td>1,200</td>
<td>2,500</td>
</tr>
<tr>
<td>Total</td>
<td>4,166</td>
<td>4,175</td>
<td>7,700</td>
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</tbody>
</table>

The number of customized tools sold increased dramatically. This increase affected mainly the two goal products: cutter-heads and saws.

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<thead>
<tr>
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<tbody>
<tr>
<td>Catalogue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutter-heads</td>
<td>2,050</td>
<td>2,325</td>
<td>4,165</td>
</tr>
<tr>
<td>Cutters</td>
<td>5,800</td>
<td>4,300</td>
<td>4,490</td>
</tr>
<tr>
<td>Drills</td>
<td>3,620</td>
<td>3,175</td>
<td>3,510</td>
</tr>
<tr>
<td>Saws</td>
<td>14,980</td>
<td>16,265</td>
<td>24,880</td>
</tr>
<tr>
<td>Total</td>
<td>26,450</td>
<td>26,065</td>
<td>37,045</td>
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</table>
As with customized tools, the number of catalogue tools sold increased dramatically too. This increase affected mainly the same two goal products: cutter-heads and saws.

The evolution of the sold units has been this one:

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Customized</td>
<td>4,166</td>
<td>4,175</td>
<td>7,700</td>
</tr>
<tr>
<td>Catalogue</td>
<td>26,450</td>
<td>26,065</td>
<td>37,045</td>
</tr>
<tr>
<td>Total</td>
<td>30,616</td>
<td>30,240</td>
<td>44,745</td>
</tr>
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</table>

Revenues

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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Customized</td>
<td>429,960</td>
<td>478,325</td>
<td>1,050,500</td>
</tr>
<tr>
<td>Catalogue</td>
<td>1,248,000</td>
<td>1,324,005</td>
<td>2,049,385</td>
</tr>
<tr>
<td>Total</td>
<td>1,677,960</td>
<td>1,802,331</td>
<td>3,099,887</td>
</tr>
</tbody>
</table>

The data show that the strategy of Zubiola succeeded. Mass Customization resulted in increasing revenues for the customized tools, thanks to the improvements of quality and lead-time.

At the same time, better service in customized tools resulted in increasing revenues in catalogue tools, despite the concurrence of multinational firms.

The evolution of revenues in percentage (base 100% in the year 1989) has been the following one:

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Customized</td>
<td>100%</td>
<td>111%</td>
<td>244%</td>
</tr>
<tr>
<td>Catalogue</td>
<td>100%</td>
<td>106%</td>
<td>164%</td>
</tr>
</tbody>
</table>

As the figures show, thanks to the Mass Customization Zubiola has not only lost sales in catalogue items, but also has increased them.

In fact, growth of sales in catalogue items has been half the growth of the sales of customized tools.

Direct costs

The evolution of the direct costs of customized tools (base 100% in the year 1989) has been the following one:

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutter-heads</td>
<td>100%</td>
<td>111%</td>
<td>122%</td>
</tr>
<tr>
<td>Cutters</td>
<td>100%</td>
<td>108%</td>
<td>113%</td>
</tr>
<tr>
<td>Drills</td>
<td>100%</td>
<td>117%</td>
<td>133%</td>
</tr>
<tr>
<td>Saws</td>
<td>100%</td>
<td>102%</td>
<td>103%</td>
</tr>
</tbody>
</table>

For customized tools, in the analysed period of 8 years from 1989 to 1997, direct costs per unit have increased a 22% (cutter-heads), 13% (cutters), 33% (drills) and 3% (saws).

The evolution of the direct costs of catalogue tools (base 100% in the year 1989) has been this one:

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutter-heads</td>
<td>100%</td>
<td>108%</td>
<td>121%</td>
</tr>
<tr>
<td>Cutters</td>
<td>100%</td>
<td>117%</td>
<td>125%</td>
</tr>
<tr>
<td>Drills</td>
<td>100%</td>
<td>113%</td>
<td>120%</td>
</tr>
<tr>
<td>Saws</td>
<td>100%</td>
<td>103%</td>
<td>105%</td>
</tr>
</tbody>
</table>

For catalogue tools, in the same period of 8 years from 1989 to 1997, direct costs per unit have increased a 21% (cutter-heads), 25% (cutters), 20% (drills) and 5% (saws).

The rises of direct costs were well below the inflation ratio of the period. That has been due to the benefits of the Mass Customization that allowed Zubiola to extend the benefits of the innovation in a secure and fast way to all the products, both customized and catalogue.

These figures do not reflect other cost reductions related with stocks: stock value, costs of obsolescence, warehouse management (less workers), warehouse space...

Lead time

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutter-heads</td>
<td>30 days</td>
<td>15 days</td>
<td>10 days</td>
</tr>
<tr>
<td>Cutters</td>
<td>30 days</td>
<td>15 days</td>
<td>10 days</td>
</tr>
<tr>
<td>Drills</td>
<td>20 days</td>
<td>15 days</td>
<td>10 days</td>
</tr>
<tr>
<td>Saws</td>
<td>20 days</td>
<td>15 days</td>
<td>10 days</td>
</tr>
</tbody>
</table>

Both types of cutting tools, customized and catalogue, are produced by the same production system.

So, when improving the system to assure the lead-time of customized tools, the lead-time of catalogue tools has been improved directly too.

Fulfilment ratio

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Average Ratio</td>
<td>50%</td>
<td>70%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Due to the same reason, improvements in the fulfilment ratio affected customized cutting tools and also catalogue cutting tools.

Stocks

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutter-heads</td>
<td>105,000</td>
<td>56,315</td>
<td>80,775</td>
</tr>
<tr>
<td>Cutters</td>
<td>226,800</td>
<td>84,000</td>
<td>47,250</td>
</tr>
<tr>
<td>Drills</td>
<td>21,000</td>
<td>8,402</td>
<td>4,970</td>
</tr>
<tr>
<td>Saws</td>
<td>234,486</td>
<td>103,609</td>
<td>83,997</td>
</tr>
<tr>
<td>Total</td>
<td>587,286</td>
<td>252,326</td>
<td>216,992</td>
</tr>
</tbody>
</table>

In absolute values, from 1989 to 1997 stocks have decreased by a factor of 2.70.

This factor varies depending upon the product: 1.3 for cutter–heads, 4.8 for cutters, 4.2 for drills and 2.8 for saws.

The reduction achieved has been impressive. But we must take into consideration that in the same period of
time revenues generated by catalogue products have increased by a factor of 1.65. That means that Zubiola got better sales while reducing stocks of finished goods.

To take a full view of the point, let’s have a look on the next figures. The table below shows the same evolution of the stocks, but in terms of percentage of catalogue cutting tools sales:

<table>
<thead>
<tr>
<th>Year</th>
<th>1989</th>
<th>1994</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutter-heads</td>
<td>43%</td>
<td>19%</td>
<td>13%</td>
</tr>
<tr>
<td>Cutters</td>
<td>65%</td>
<td>28%</td>
<td>14%</td>
</tr>
<tr>
<td>Drills</td>
<td>39%</td>
<td>16%</td>
<td>8%</td>
</tr>
<tr>
<td>Saws</td>
<td>39%</td>
<td>16%</td>
<td>8%</td>
</tr>
<tr>
<td>Total</td>
<td>47%</td>
<td>19%</td>
<td>11%</td>
</tr>
</tbody>
</table>

That makes an improvement of the Stock Rotation Ratio of catalogue products from 2,12 to 9,45.

But if the Stock Rotation Ratio is calculated in terms of total sales, the improvement goes from 2,86 to 14,29.

5 MAJOR FINDINGS

In this chapter we present and discuss the major findings in this case study of bringing the Competitive Advantage of Mass Customization into Mass Production.

Also we propose some possible criteria to extend this success to other business and companies. These criteria should be confronted with other case studies.

5.1 Catalogue wideness

The first finding relates the catalogue wideness with the interest of applying the Mass Customization paradigm [12][13].

In a Mass Production approach, batches are quite big in order to cut production costs. So, references are produced once a week, once a month. Taking into account these lead-times, build-to-order does not guarantee a good answer to the customers, so there is a need to keep references in stock.

With a wide product catalogue, the stock needed multiplies. And not only because the growing number of references, but due to the expanding production lead times: with so many references, they are produced once a month, two months... even once a year!

Effects are terrible: growing stocks, difficult management, awful levels of fulfillment, growing obsolescence ratios...

But once Mass Customization for customized tools was implemented, Zubiola was efficient even with batches of one unit, both in costs and quality.

Form most of the references of the catalogue, the new production lead-time was good enough. So, they decided to apply the Mass Customization paradigm to most of the catalogue products.

Customers did not realize that they were build-to-order, instead to being served from stock. Even more, build-to-order gave them a better service level than serving from stock.

In Zubiola, fulfilment ratio increased from 50% to 90% reducing stocks at the same time, just dealing with the less sold catalogue references with the Mass Customization paradigm.

In a few words, when applying Mass Production principles, having a wide catalogue means big stocks and very low Stock Rotation Ratio form most of the references, and that does not guarantee a good fulfilment ratio.

When the product catalogue is wide, applying the Mass Customization paradigm can improve dramatically the service level, and decrease linked costs for the less sold references.

5.2 Catalogue sales

Although moving from serving from stock to build-to-order can be a suitable alternative for most of the cases, build-to-order is not the most interesting option in all of them, and Mass Production principles must be applied. Identifying the main factors with great influence to determine the boundary between the two approaches is a challenging theme for every company.

Every catalogue follows the Pareto law: A few references correspond with most of the sales, and there are a lot of references with a sporadic demand.

When applying the Mass Production paradigm to these latter cases, stocks grow and the obsolescence ratio increases too; and the lead-time is not guaranteed at all. For all these references, moving from Mass Production to Mass Customization has improved efficiency.

But for the most selling references the Mass Production paradigm continues being valid. The question that arises is, which references should be produced under the Mass Production paradigm?

The limit depends basically on two factors, historical demand and manufacturing flexibility, represented by the economical batch.

In Zubiola, there are two economical batches: saws (15 units) and the rest of the products (2/3 units).

For saws there are two cases:

• References with less than 10 units sold per year. They are produced when needed (under demand), in batches of 15. The unsold references are kept in stock.

• Rest of references. They are served from stock. Batch size depends upon the monthly average orders.

Cutter-heads, cutters and drills are not served from stock. Production batches are calculated from real orders, not from forecasts. Depending on the historical sales, they produce a surplus of one or two units for stock.

With this approach, catalogue product stocks have divided by a factor of 5, and linked costs have also decreased: warehouse space, stock management, obsolescence of products...

From Zubiola’s experience we can state that the limit between build-to-order and serving-from-stock paradigms depends basically upon two factors: economical batch (reliant on manufacturing flexibility) and historical demand.

• when the economical batch is near one, a build-to-order approach is recommended. A concession to Mass Production practices can be the batch “surplus” of one or two units, always depending on historical sales.

• if an economical batch of a certain volume is necessary, and the historical sales are not bigger than this economical batch, the build-to-order approach should be preferred.
for the rest of the cases, serving-from-stock would be a suitable choice.

5.3 Process technologies
As noted before, there is a strong correlation between the production technologies and the more suitable kind of Mass Customization to be applied. In fact, more flexible process technologies allow better achievable levels of Mass Customization [12].

The critical element in the process is the existence of auxiliary tools as dies, moulds, guides… linked to the existence of shapes and forms. Physical tools of this kind are expensive and have a long lead-time. And their setting times make management more difficult.

When physical tools are involved, Mass Customization tends to be assembly-to-order, and tries to standardize the parts. When the generic product is designed, basic items (parts, modules…) are designed too, and the company gets the tools to produce them. Costs and management of the tools forces the standardization of parts and components.

Depending on the flexibility of the production lines, these basic items could be manufactured and stocked. And when a customer places an order, engineering produces a design as a combination of existing basic items or components. The assembly line gets these basic items from stock, or they can be manufactured-to-order; finally, the product is assembled.

The decision between manufacture-to-order or stocking the components depends on the flexibility of the production lines, and this one depends on the required tools.

But when physical tools are not involved, Mass Customization tends to be engineering-to-order. The product can be designed in a parametric way: assembly, parts, process…

When a customer places an order, engineering produces a full design, creating new parts from the parametric ones. These parts are manufactured-to-order and, finally, the product is assembled.

About this particular aspect Zubiola found itself in a good position: its products were full parametric, so we did not find extremely difficult to elicit and implement the design rules.

Customers requirements are mainly numeric (digital). The only exception is the tool’s profile, but is quite easy to convert form analogical (a wood piece) to digital (points, lines and arcs).

Zubiola uses three main process technologies: metal cutting (lathe and machining centre), welding and sharpening. These three technologies are very flexible, requiring few tools, very easy to buy and use, and quite independent from the product.

Process technologies flexibility helped to implement the Mass Customization, both for the customized tools and for the catalogue tools. Numerical Control machinery has increased this simplicity.

5.4 Information technologies: automatization
Information technologies can play a triple role in the Mass Customization: commercial, design and manufacturing [12].

In the commercial side, Information technologies have created a model of what is possible to bid, and what is not. This model links customer requirements, technical feasibilities and costs. Now salesmen of Zubiola can bid being sure that what they are bidding is possible, and that they are giving the best bid Zubiola can do, technically and economically.

In the design side, Information technologies have created a model to keep the technical solutions Zubiola have decided to use. This model links customer requirements, design specifications and process. By the moment any designer of Zubiola can produce the best design technically and economically.

In the manufacturing side, Information technologies have created a model to keep the ways Zubiola have decided to manufacture its products. This model links customer’s design specifications, process parameters and operation parameters. For each design the Numerical Control programs, the virtual tools, are produced automatically.

From the case study of Zubiola, we can presume that the level of automatization allowed by Information Technologies depends on the product model complexity. When the product can be described by parameters, fully automatization can be possible. Problems arise when free forms (profiles, surfaces…) are involved. In these cases automatization is not so easy, and human interaction is necessary in some extend.

5.5 Information technologies: product and process models maintenance
As observed before, product and process models are essential [13].

They are built into the Information System of the company and, using the customer’s requirements, the system designs the customized item and creates the involved technical documentation: CAD models, blueprints, Bill of Materials, Numerical Control programs, Control Sheets…

Information Technologies are applying, in a secure and quick way, what is expressed in the product and process models.

In order to achieve excellence, the transparency of the computer models is a key factor. Senior designers, production engineers… must be able to check the rules, and be sure of the quality of the models used by the Information Technologies.

If these people were not able to look at the models, to check them, to maintain them directly, quality and consistency problems would arise.

When building the Information System, total transparency becomes a must. The role of an intermediate operator between the model and the model owners (senior designer, production engineers…) should be avoided.

5.6 Product evolution
Another major benefit of extending the Mass Customization paradigm to catalogue tools is making product evolution easier [13].

Manufacturing of catalogue items is made by means of designs, blueprints, bill of materials, Numerical Control programs… In a Mass Production paradigm, this technical documentation is enough.

When the company evolves the product, creating new ways to translate requirements into specifications or new ways of manufacturing, to update all the technical documentation of the catalogue items is a cumbersome work. And, depending on the wideness of the catalogue and the scarcity of the resources, the less selling references will not get updated.

But, what happens when a Mass Customization paradigm is used in a catalogue environment?

Usually, Mass Customization is associated with Information Technologies tools that translate automatically requirements into design specifications,
and design specifications into drawings, process, operation parameters and Numerical Control programs. In consequence, if the company stores not only the technical documentation of catalogue items, but also the requirements, the use of Information Technologies helps updating this technical documentation in an easy way.

5.7 Change management
Finally, a last obstacle has been identified: the cultural resistance. Without doubt, every change in a company finds opposition, and Mass Customization is not an exception [14].

The main finding in this particular field was that the kind of opposition found relies heavily in the kind of Mass Customization chosen.

In 1989, when Zubiola decided to move into Mass Customization, the answer to the customers demanding customized tools was so unpleasant in terms of deadline, costs and even quality that everybody agreed that something might be done. Some people shown some criticism about the chosen approach, but the decision was widely accepted along the company.

The main resistance was found in the engineering team. Anyway, the Department Head was convinced and enthusiastic about the chosen approach, and the engineering team was quite small, so change was not especially difficult.

But, when Zubiola tried to adopt the Mass Customization paradigm for the catalogue items, most of the people resisted to the idea: commercial people, production people, warehouse people... all of them felt attacked in their NDA. The Management Team of Zubiola faced problems calming the people down, making them collaborate...

When trying to adopt the Mass Customization in a company, some resistance must be expected. But the kind of resistance, which kind of people, from which department... varies depending on the kind of Mass Customization.

When applying Mass Customization to customized items, engineering is the affected department; although disagreements and resistance happen, the rest of the organization likes and approves the idea. So, change management can be drive by the Engineering Director. But if Mass Customization is applied to catalogue items, all the organization reacts, and the Management Team, and specially the Manager Director must lead the change.

6 CONCLUSIONS
In this paper we have presented the case study of Zubiola, a small cutting tool manufacturer. Facing the concurrence of big companies with better prices in their catalogue, the company decided to compete in customized tools, offering a good lead time and standard quality at reasonable costs.

When the strategy revealed successful, they decided to bring the Competitive Advantage of Mass Customization into Mass Production, and succeeded too.

As the analysis has revealed, there have been a lot of benefits: better service, increasing revenues, contended costs, less stock, less stock outs, less obsolete products.

From this case study we have extracted some possible criteria in order to extend this success to other business and companies:

- The wider the product catalogue, the bigger the interest in build-to-order: less stock, less stock outs, increasing Stock Rotation Ratio, less obsolete products, better management...
- even in that case, not all the references should be build-to-order. Mass Customization simply changes the way the boundary between stock references and build-to-order references is established.
- the critical factor when choosing between build-to-order and assembly-to-order is the need of auxiliary tools. When physical tools as dies, moulds and so on are needed, assembly-to-order approach seems the right approach. If virtual tools, as NC programs, are available by using Information Technologies, build-to-order reveals itself as the most flexible approach.
- Information Technologies can allow the fully automatization of the design-to-order process, depending on the kind of the model. When the design can be expressed with parameters, fully automatization can be possible. If shapes and forms (profiles, surfaces...) are involved automatization would not be so easy.
- when building the Information System, total transparency becomes a must. The role of an intermediate operator between the model and the model owners (senior designer, production engineers...) should be avoided.
- the use of Mass Customization product models for mass Production catalogue items makes evolution of the product easier.
- Mass Customization means change, and change must be managed. Mass Customization affects to the engineering teams, but when applied to Mass Production, all the company gets affected.

These possible criteria are based upon a single case. In order to confirm these criteria, further research would be necessary confronting them with other case studies.

7 RELEVANT LITERATURE


