

## **Mass Customization and Footwear**

### **2.1 The Mass Customization Paradigm and its Production Revolution**

Manufacturing has been the prime driver in the evolution of society from one that is agriculturally centred to one that is industrially centred. However, manufacturing has also evolved through time, and several paradigms can be identified as described in Table 2.1. [2]. One of the main trends in today's market is that of 'mass customization'. This represents a new market paradigm that is changing the way consumer products are designed, manufactured, delivered and recycled.

Manufacturing technology started with an artisan at work making a single product for a single customer, and as such was well recognized as craft production, as illustrated in Fig. 2.1.

Manufacturing continued to evolve in the late 1800s during the Industrial Revolution, pioneering mass production at the beginning of the twentieth century. Today this market of mass production is changing and moving towards the new paradigm of mass customization. It is thus recognized that the current and future manufacturing challenges are returning to those of the original craft production age, but with the added advantages and complexities of using today's advanced manufacturing systems and technologies. Therefore, one view of mass customization could be as having the ideals of craft production expressed through modern industrial technology.

As identified by [3], mass customization aims to offer goods and services that are more tailored to customers specific needs and tastes, which implies having the capability of linking the efficiency and economy of scale of mass production with the possibility of manufacturing small batches and batches of one of very diversified and personalized products.

Table 2.1. Evolution of production paradigms

Paradigm	Craft production	Mass production	Flexible production	Mass customization	Sustainable production
Started	~1850	1913	~1980	2000	2020?
Society needs	Customized products	Low cost products	Variety of products	Customized product	Clean products
Market	Very small volume per product	Demand > supply Steady demand	Supply> demand Smaller volume per product	Globalization Fluctuating demand	Environment
Business model	Pull <i>sell-design-make-assemble</i>	Push <i>design-make-assemble-sell</i>	Push-Pull <i>design-make-sell-assemble</i>	Pull <i>Design-sell-make-assemble</i>	Pull <i>Design for environment-sell-make-assemble</i>
Technology enabler	Electricity	Interchangeable parts	Computers	Information technology	Nano/bio/material Technology
Process enabler	Machine tools	Moving assembly line	FMS <sup>1</sup> robots	RMS <sup>2</sup>	Increasing manufacturing

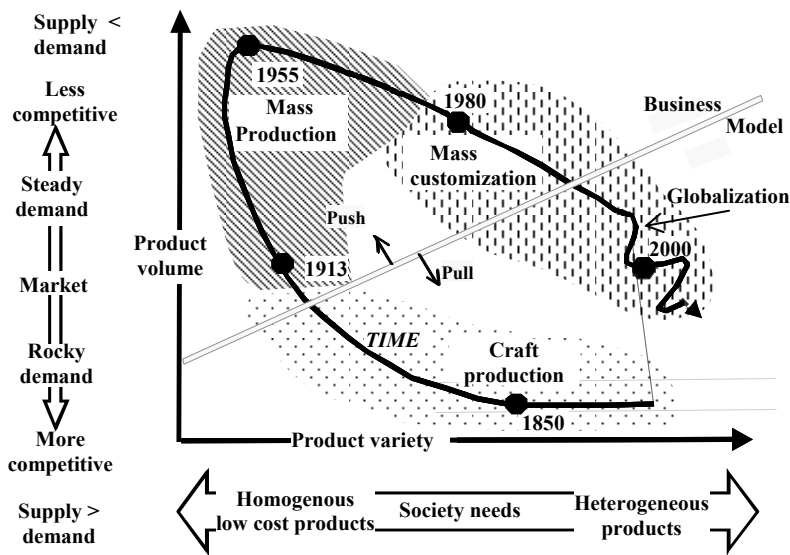


Figure 2.1. Evolution of manufacturing technology

<sup>1</sup> FMS = Flexible Manufacturing System

<sup>2</sup> RMS = Reconfigurable Manufacturing System

This places a very strenuous challenge to the entire company organization, whose procedures and management approaches then require a thorough revision, especially in manufacturing. This is certainly true for shoe production; as footwear manufacturing is increasingly confronted with a progressive reduction in the size of production batches. Combined with the variability of styles, this tends to overstretch the traditional work organization and, with a demand for minimizing delivery times, manufacturing support systems do not as yet approach the levels of flexibility and quick response required for the production of mass customized products. However, since a noticeable demand for such products is becoming evident among shoe consumers, footwear companies will soon have to confront these kinds of technical challenges.

## **2.2 The Footwear Business at the Start of a New Millennium**

Making shoes is neither an easy task neither a simple business. It necessitates high skill and a lot of diverse knowledge in many aspects that may affect the quality, the aesthetics and the functions of a shoe, but, more importantly, it requires a lot of work, which makes shoemaking a typical labour-intensive activity. Shoemakers of the past, as well as those who are still continuing this tradition today, know very well what this means in terms of the time needed to produce a pair of shoes and the complexity of handling the manufacturing and assembling of all its different parts.

More than a century ago, when the first machines appeared and shoemaking evolved from a craftsman activity into an industrial one, large numbers of workers were needed to produce the higher quantities of shoes that the industrial production made possible and that an expanding market required, in particular, in the economically developed countries. With time, with the advent of better work organizations and of more modern machines, the situation improved. A typical “indicator” of the importance of the labour force was the increase in the average number of pairs produced daily by each direct worker, yet at a much slower pace than in other industries that were undergoing similar transformations in the same times.

During the last 40 years, with the widespread adoption of information and communication technologies, computers and process automation, progress was certainly made and shoemaking did in fact modernize, particularly in terms of quality of the manufactured products, flexibility of production, level of control on the various processes, consistency and constancy of the quality of the delivered products and so on. Yet it still requires a large number of workers to achieve an acceptable production throughput that can support industrial scale operations. Perhaps this kind of statement is less of a general nature than a few decades ago; certain kinds of shoe typologies and their respective constructions are more easily performed than others (like, for instance, making a pair of sneakers in comparison to producing high quality Goodyear welted shoes), they require a smaller number of manufacturing steps and they lend themselves to an improved usage of automated machines and of unattended processes. These kinds of shoes, either for their high quality or for the high level of automation in their manufacturing process, are among those that are still produced in areas like Western Europe and

Latin and North America; moreover, labour demands concentrate in some of the phases in which a typical shoe manufacturing process is structured (such as the so-called cutting and upper stitching phases), which has generated another typical shoe making phenomenon: subcontracting and delocalization of the most labour intensive phases of the production process.

It is important to understand why and how the footwear business has changed and evolved in the last 50 years. Labour, we have learnt, is very relevant to shoe production (both in terms of the number of workers and of the skill they need to have to perform their task), and, consequently, labour cost is certainly a very relevant factor in determining the total manufacturing cost of a shoe and, eventually, in fixing the final price. So shoe makers have always struggled to keep their labour costs to a minimum.

This is what has triggered the subcontracting and delocalization phenomenon of shoe producers, who became more exposed to endogen factors (more attentive consumers always asking for a higher quality at a competitive price) and exogen factors (competitors from other countries which were capable of delivering similar products at a better price), and therefore had to look for means of keeping their competitive position; moving the most labour-intensive phases of production to lower wage countries seemed, to shoemakers as to other goods producers, the easiest and faster solution.

While there is no doubt that this was the easy way out to what was becoming an impellent survival problem, certainly this did not turn out to be, strategically thinking, the most clever move one could have thought of. This has generated a “caravanning” effect with the big shoe companies of the more economically developed countries (first of all the United States) progressively moving their production facilities to third world or developing countries, where salaries and wages were lower and where an abundant workforce was available; as wages started to grow in those countries too and the workforce became less available, these companies then had to relocate to other countries which were, at the time, the low wage champions. This phenomenon is typical of products whose content involves less innovation. It can be avoided through attention to such things as the demands of the end consumer, with innovative materials, or modern processes; all factors that can reduce the labour component of the product price.

With time, rather than some of the processing steps, the entire manufacturing process was subcontracted; and that implied installing in the target countries fully fledged manufacturing facilities, transferring technologies, work methodologies, knowhow and skill. In a few decades, in those countries where resources (both natural and human) were readily available, students became better than their teachers and started to compete with them in international markets. Or, worse, with other shoemaking countries that had no direct responsibility in this transformation. Perhaps other factors have played a role, as it is in the nature of the economy and of industrial evolution that labour-intensive manufacture is typical of developing countries with an abundant workforce and for which work is a “social asset” (rather than a cost to be controlled) but bound to disappear from those that are economically developed. Nevertheless, these factors are to be kept in mind when analyzing shoe production today.

In order to understand all this, we have to look at numbers, and numbers, of

course, change with time. So, rather than considering absolute numbers, it is better to focus attention on the evolution, *i.e.* on how numbers change with time and the underlying trends. There are many figures to support this analysis, but two that are particularly relevant to the footwear world are:

- the world yearly consumption of shoes
- the world footwear production

Finding reliable data such as the world yearly consumption of shoes is not easy. The most recent data presented in 2005 indicate an annual world consumption of shoes (in 2003) of roughly 16.9 billion pairs.<sup>3</sup> During the period from 1993 to 2003 the level of consumption grew at an average annual rate of 3.21%, with sustained growth in areas such as Asia (5.0%), the Middle East (3.25%) and North America (2.09%). In other areas of the world growth was modest (*e.g.* Western Europe, at 0.36%). As we will see later, the analysis of volumes is only one aspect of consumption - values will also need to be considered.

One interesting analysis would be to relate annual consumption of shoes to total world population; this indicator would tell us how many pairs of shoes are consumed per person per year. If data on footwear consumption are difficult to assess, then statistics on the world population are even more difficult to obtain. Nevertheless, taking the US Census Bureau data<sup>4</sup> as our point of reference, we can calculate the number of pairs of shoes consumed per person in 2003. This suggests a value of 2.7. The same calculation for 1993 indicates a value of 2.2 pairs of shoes per person per year. In other words, in ten years the world population grew by something like 20%, whilst the percapita consumption of shoes increased by almost 23%,<sup>5</sup> which seems to indicate a rate of growth in consumption only marginally higher than the growth of the population.

What this analysis tells us is that growth in shoe consumption is sustained by the growth of the world population, and that such growth is concentrated in developing countries. Consumption is growing in countries where two factors are at work:

- population growth
- a developing economy with an increase in the size of social segments whose purchasing power covers necessities and also allows for the purchase of several pairs of shoes each year.

The United States appears to be an exception. Whilst the USA does not have a fast-growing population, it nevertheless shows high growth in shoe purchases. There may be two reasons for this:

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<sup>3</sup> Data for 2003 presented at the second World Footwear Congress (WFC), held in Brussels in April 2005.

<sup>4</sup> Total world population in 2003 according to the US Census Bureau, updated 26 April 2005, was 6,303 billion.

<sup>5</sup> Again based on shoe consumptions data presented at the World Footwear Congress of April 2005.

- America is devoted to consumption
- a high level of immigration, particularly from Latin America, is present.

In regions such as Western Europe, where there is no population growth and consumption is modest, there was only a small increase in shoe purchases in the decade 1993–2003. To summarize, the demand for shoes grows every year at a relatively slow rate, mostly sustained by developing economies with a growing population. All this calls for a mature market, where footwear companies find it more difficult to establish and maintain a competitive advantage.

**Table 2.2.** Top ten consuming regions of the world (2003) (Source: WFC 2005)

Region	Q <sub>2003</sub>	Share <sub>2003</sub>	Growth <sub>1993-2003</sub>	Δ 03/93
Western Europe	1,841	10.87%	0.36%	108
Eastern Europe	960	5.66%	0.85%	-3
Middle East	757	4.47%	3.25%	248
Africa	786	4.64%	1.07%	136
Asia Pacific	9,326	55.05%	5.00%	3,731
North America	2,429	14.34%	2.09%	390
Latin America	842	4.97%	0.93%	73
World	16,940	100.00%	3.21%	4,683

Regional shoe consumption has changed noticeably in the decade 1993–2003: Table 2.2 shows the top ten consuming regions in the world and the share each one of them took of annual shoe production (in 2003), as well as the evolution of such consumption in the decade 1993–2003.

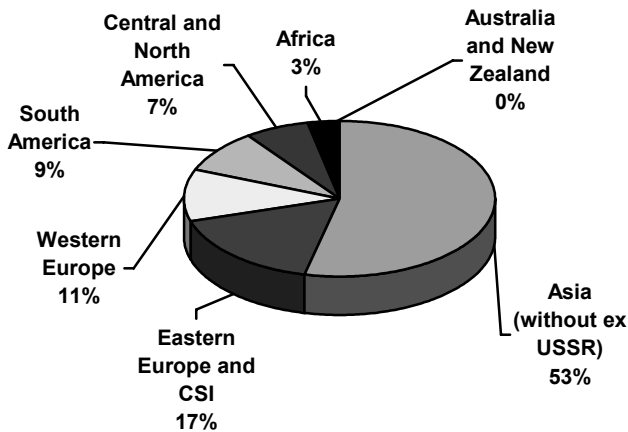
With such a shoe consumption scenario, it has to be expected that production will run parallel. In fact, statistics indicate that, for the year 2003, there was a total world production of almost 17 billion pairs of shoes, with an annual growth rate, over the decade 1993–2003, of 3.34%. That enabled production to keep up with the increase in consumption and in the level of demand that we have discussed so far.

Asia takes 72.3% of this world production with an average annual growth of 4.9%; its share of the world production has increased at an annual rate of 1.57% in the same period. Western Europe represents no more than 4.58% of world production and its share over the total has decreased at a rate of 7.5% over the decade. A more impressive loss than the already noticeable Asian growth rate (Europe's share sank more than the Asian share soared).

Once more what is noteworthy of the current scenario is how much this picture has changed over time; if we go back another few years with respect to 1993, we can see in Fig.2.2 a breakdown of world production in 1989 and notice the predominance of Asian production-accounting for about 55% of the total (no

disaggregated figures for China are available for that year). In addition, two aspects are worth mentioning:

- Europe (Western Europe and Eastern Europe and CSI) represented 28% of the world shoe production. This was the year of the dissolution of the USSR when a lot of big state-owned shoe factories still existed in the Soviet regions producing millions of pairs of shoes every year.
- Central and North America (which meant primarily the United States) accounted for 7% of the world production, equivalent to a few hundred million pairs of shoes in that year.



**Figure 2.2.** Shares of the annual shoe production in year 1989 (Source: SATRA)

In 1989, world shoe production polarized around two major manufacturing blocks: the Far East and the West (including Europe and the Americas), with the first predominant. There was open competition at that time, and the two blocks appeared to have equal chances. China was already a major contributor to the volume of Asian production, but had not yet moved into the spotlight. The reason is probably that China's exports of shoes were not such as to provoke the cries of alarm seen more recently.

Over the 14 years to 2003 (the most recent year for which consolidated figures are available), the picture has changed dramatically: Western and Eastern European countries (the latter mainly countries of the former Soviet block now on the verge of joining the European Union that have been capable of maintaining a relatively solid footwear industry<sup>6</sup>) now cover no more than 6.7% of world shoe production (in absolute terms approximately 1.1 billion pairs of shoes); North

<sup>6</sup> Some of these countries deserve a special comment; for instance, Romania, which in the last few years has become a decentralized manufacturing district of Italy, following moves by dozens of Italian shoe makers to place almost their entire production in the country.

America dropped to 1.9% of world production, having lost almost all of its manufacturing infrastructures and having dispersed its shoe making knowhow (with the exception of a group of companies maintaining manufacturing facilities in the United States).

The region that emerges as the declared winner of this world production battle is certainly Asia and the Pacific, which accounted for almost 80% of global shoe production in 2003. Two Asian tigers are leading the game: China is credited with 43.6% of world shoe production (7.4 billion pair of shoes made in 2003), followed by India with 22.1% (3.7 billion). To defend the performance of Western shoe producers, Brazil comes third with 3.59% of the world total, but next is Vietnam which, in less than ten years has been able to grow from an almost non-existent level of production to 3.24% (half a billion pairs of shoes in 2003), and then Indonesia (3.1%). We have to reach the sixth position to find the first European country, Italy with 2.15% of world shoe production (although an update of these figures based on the latest statistics for 2005 show a more negative picture). The complete list of the top ten shoe producing countries is presented in Table 2.3.

This table provides a basis for an analysis of the footwear business that is different to the one that would have been able to make only 15 years ago, where the bipolar situation of 1989 has been replaced by a more complex, three centre picture that is correspondingly more difficult to explain and to interpret. In order to perform such an analysis, we must also consider how import and export flows have been established in the past years.

In the last year of the decade considered, almost 7.1 billion pairs of shoes were exported from producing countries. Exports increased over ten years at an average rate of 4.37%. Regions other than Latin America have experienced a positive growth rate. Asian exports account for almost three quarters (75.4%) of total world exports, with an annual increase in excess of 5%. Western Europe is the second exporting region, but its annual growth rate in the decade analysed only scored a very negligible 0.05%, which caused, not surprisingly, a loss of market share of 4.32% over the same period.

The leading exporting countries are, again, a small group of Asian nations (China, Vietnam, Indonesia and Thailand). Among Western European countries, Italy and Spain are the most relevant exporters. But whilst some of the top four featured notable growth rates in the past decade, others, such as Italy, showed a decrease of around 2% per annum. It can be concluded that the big shoe producers are also big exporters, absorbing an ever-increasing quota of world footwear exports. Western countries are also exporters but their overall share is decreasing. These countries are rapidly losing their competitive advantage in favour of big producers and of those with low labour costs, with an evident shrinking of both absolute production and export volumes.

Quantities (in this case, numbers of pairs) are normally used to measure and analyze aspects such as production or export flows; they are directly related to the production throughput of a certain manufacturing system. The higher the volumes, the higher the size and the number of the factories and, hence, the number of workers employed. It is an indicator that can show how much an industrial sector can contribute to the global workforce of a nation. But it is not in itself a sufficient indicator of how much the same production contributes, for example, to the



national gross product or to the net trade balance of the same sector. For these kinds of analysis, the value of production is a second very important parameter to be considered.

**Table 2.3.** Top ten shoe producing countries (Source: WFC 2005)

Country	Q <sub>2003</sub>	Share <sub>2003</sub>	Growth <sub>1993-2003</sub>	Δ 03/93
World	16,972	100.00%	3.34%	4,739
China	7,400	43.60%	7.31%	3,800
India	3,750	22.10%	4.45%	1,300
Brazil	610	3.59%	1.02%	27
Vietnam	550	3.24%	13.44%	415
Indonesia	520	3.06%	1.22%	180
Italy	365	2.15%	-3.71%	-162
Nigeria	355	2.09%	4.12%	120
Thailand	280	1.65%	-3.35%	-30
Turkey	280	1.65%	4.92%	125
Pakistan	250	1.47%	2.29%	65

It is then interesting to note that, if world export figures are analysed in terms of values (millions of US\$) rather than volumes (billions of pairs), we obtain a slightly different picture. China still keeps its prime role with 4.5 billion pair of shoes exported (equal to 63% of world exports), which in 2003 where 12,955 million worth of US\$ (only 25.7% of the world total in value); but Italy, which was third in the world top ten exporting countries (305 million pairs of shoes, equal to 4.3%), now jumps to the second place with export worth 8,479 million US\$, with a more relevant share of the global export pie (16.8%). So, values make a difference; not such that it can compensate for the enormous production and export gaps between Asia and other regions, but big enough for the footwear sector to contribute to the GNP of the leading producing countries. By comparing volumes and values of exports, one can obtain very interesting indications on the average “export price” (which in turn is strictly related to the manufacturing costs) per pair of the shoes coming from the different world regions. It can be concluded that Chinese shoes are exported at an average price per pair of US\$ 2.9, while in the second country (Italy) the price would be US\$ 27.8. Very noticeably, we are considering quite different kinds of shoes. Vietnam, which happens to be in third position as a shoe exporter, does not even appear among the top ten countries when values are considered. So, both Asians and Europeans are good at exporting shoes but, while the former are unbeatable in the volume production and pricing (or perhaps we should say “producing below cost”) of shoes that are simple to make and manufactured in large quantities the latter (Europeans) are good at making more elaborate products, with higher quality and with strong and recognizable brands, which are targeted at different market segments.

Having analyzed these figures with regard to exports, it is worth asking where all these exports go. So, how do import data compare with export data? World statistics for 2003 indicate that Eastern and Western Europe together account for a 38.5% world import share, while North America takes 31.5% of the global figure. The top ten importing countries are dominated by the United States, Japan and Germany as the three major importers of shoes. These are the countries which take the largest share of the yearly world production of shoes (in volume) and which absorb an enormous amount of footwear manufactured in regions such as Asia. A more detailed examination of the import-export flows would have indicated (not to our surprise) that the main outlet market for the billions of shoes produced in China is the United States. This is not unexpected if we considered that the tremendous shoe production growth in countries like China was due and in some respects planned as a consequence of the migration of shoe manufacturing to them from big countries like the United States.

More surprising, and certainly a reason for concern, is that if we look at the evolution of imports (growth rates over the past decades) we would notice a growth in the import of shoes in the European countries. For example, in traditional shoe making nations like Italy and Spain, shoe imports grew at between 8% and 10%, with the result that increasing amounts of Asian (mainly Chinese) shoes were consumed every year in countries with a long tradition in shoe making and a still-active footwear industry. In Italy, for example, which in recent years has managed to maintain its positive trade balance (difference between shoes exported and imported), for the first time in 2004 the amount of the shoes imported exceeded those exported, which created a negative trade balance. This occurred as a consequence of the progressive repositioning of Italian shoe production towards the upper segments of the market. However, the trade balance is still positive in value, and hence the picture that emerges is that of a footwear world made up of three major clusters, where each has a different view and all pursue different interests and goals. In the first of these clusters there are big producers and top exporters, with countries like China, India and Vietnam concentrating on maintaining leadership as major footwear producers and sustaining national economic growth. Despite some signs of a slow down in the rate of shoe production resulting in a more 'modest' annual growth of a few percent, this annual growth (in China, for example) is equal to the entire European production.

There are other factors to be considered: a slow but apparently constant increase in labour costs; the application of higher export duties; and the results of anti-dumping actions undertaken by European producers to force the Chinese to comply with international rules in terms of fairness of trade. But it will certainly take years before these factors have a tangible effect on the cost competitiveness of shoes manufactured in that part of the world. In conclusion, there is no evidence and no indication that Asia could lose its prime position in the near future as the "footwear factory of the world". The elimination of European import quotas at the beginning of 2005 gave another clear indication of how a hyper liberalized trade of shoes with no reciprocal actions to foster exports into China and the other Asian countries can worsen the situation. This can make the life of European producers more difficult, despite the growing interest and the unexploited potential of the wealthiest segments of the Asian countries for European shoes. The second of the

three parts is mostly represented by the United States, with some European nations falling into the same group (Germany and the United Kingdom). The case of the USA is paradigmatic: in 1968, by eliminating almost completely every kind of import tax or duty on shoes manufactured abroad, the USA made a choice as far as shoe production was concerned: they decided to stop being a shoe producing country and restructured the sector to satisfy their huge internal demand (per capita shoe consumption in the country was 7.4 pairs in 2004, which amounted to 2.2 billion of pairs of shoes, of which 98.4% were imported, with 83.5% from China). In a few years their annual shoe production sank from more than 600 million pairs to less than 50 million and more than 250,000 workers had to look for different jobs. It was a clear industrial policy that the United States is still coherently pursuing and strenuously defending.

It is no surprise then that on all the occasions in which negotiations are undertaken (such as WTO, the Doha round and similar) to regulate international commerce they are against any decision to introduce taxes or duties that may limit the free and easy import of foreign shoes to the United States but also to other countries. The attitude of some big European buying groups, mostly interested in keeping high selling margins in a stable market by reducing to a minimum the purchase price of their articles, is not very different. It is not difficult to understand how this view of the market and this kind of attitude is a long way from the positions and interests of the third of these clusters.

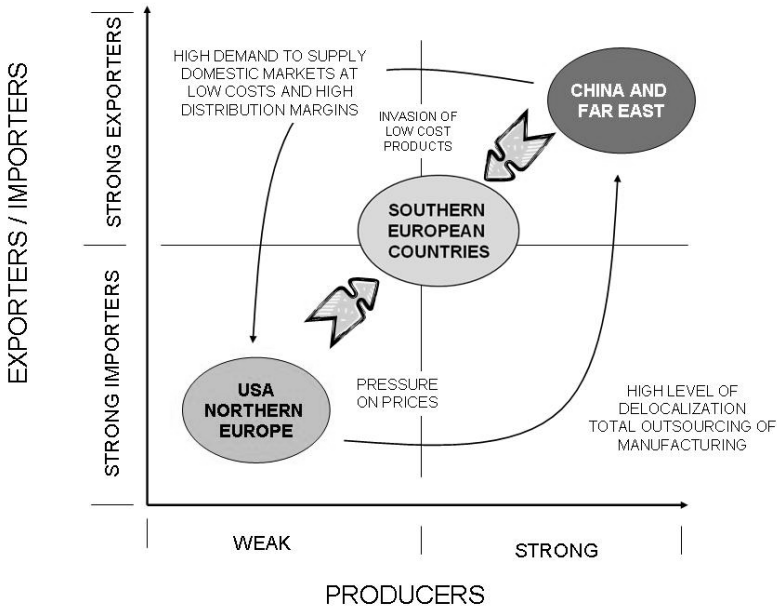
This third group includes traditional shoe producing countries, which are striving to maintain a relevant share of their production and to avoid losing their history and their knowledge on the product and its manufacturing processes. This group includes not only European nations such as Italy, Spain and Portugal but also Turkey and Brazil. All have been fighting to maintain their market position and to defend production, including creating trade barriers (import duties, quotas, antidumping fees and so on), as they face an invasion of far eastern products which menace their position in their markets. However, when they raise these kinds of barriers, it is not only against the Asian producers, they also find enemies among countries and organizations that are feeding big consumer markets (such as the United States, Germany and, in some respects, the United Kingdom) with shoes imported from the same areas. The interests of these countries are more likely to coincide with those of the Asian producers than with those of the other Europeans, which leaves the latter more or less alone to fight their battle. We need to ask, when the European shoe producers are actually fighting this battle in defence of their future, whether they are using the right weapons.

Therefore, on the verge of a new millennium, we can say that the European footwear business is dominated by the following critical driving factors:

- increasing competitive pressure from low labour cost producers
- excessive presence of fashion firms

### **Increasing Competitive Pressure from Low Labour Cost Producers**

This is the main factor that has forced European shoe companies to split their production processes into several steps, to relocate each one of them in different countries, choosing production sites in those areas where low labour costs are



**Figure 2.3.** The three clusters of world shoe production

achievable and, as we have already mentioned, widely adopted as the easiest cost-reduction strategy to face the competition. This strategy has also forced the companies to outsource more and more steps of their production processes, always looking for the cheapest place to install new facilities; so the old local and regional clusters have been replaced by global, interregional and international networks. Companies have been forced to set up international production networks and complex organizations to handle them; a transformation that not all enterprises have been capable of mastering.

The second consequence of this increased competitive pressure was the push towards diversification, mostly in terms of progressive repositioning in the upper segments of the market and in developing a capability of supplying higher and higher quality products. When the high quality upgrading takes place, delocalization and outsourcing has to be limited, due to the need to preserve the quality standards (high quality means high local content of input; low quality tends to be followed by outsourcing of a large percentage of production abroad); this once more demonstrated how the delocalization strategy, which had to be adopted to counterbalance the increasing price pressure from the low labour cost countries, does not prove to be adequate when other competitive assets, such as quality, service, flexibility become relevant.

### Excessive Presence of Fashion Firms

If the first driving factor mentioned above can be considered an exogenous factor (generated from outside the geographic area of interest of the European footwear

companies), this second one is more of an endogenous nature. The increasing integration of footwear industry into the fashion industry has been dominated by a few multi-product oligopolies, which have exploited economies of scale and scope in activities such as distribution, marketing and branding across families of products. This has produced a concentration in distribution, a change in the production systems, a globalization of the production markets all supported by a dramatic spread of information technologies. As with delocalization, where producers tend to loose control of the manufacturing process, in this case they loose control of some other very crucial activities such as design, branding, marketing and distribution.

Caught between these two ponderous driving forces, European shoe producers (or manufacturers based in developed countries who want to maintain a relevant manufacturing basis in those countries) have to develop new strategies and to look for alternative market approaches to regain their competitive advantage. The ingredients of a recipe that could help Western producers to win back their market positions should include attention to the following: product quality; innovation in design and materials; flexibility of response to market demands; attention to individual consumer needs and provision of services rather than simply goods. Mass customization and product personalization involve most of the aspects mentioned above and can represent a repositioning strategy for this part of the footwear world. Its exploitation paths in footwear will be discussed in the next chapters of this book.

## 2.3 Mass Customization Made Simple (for Shoemakers)

Many different definitions of mass customization can be found in the technical literature and in the textbooks; it is not the purpose of this chapter to examine them in detail. A simple enough and adequate definition that is well suited to begin the analysis of its application to footwear is [4]: “Mass customization is the production of goods with a high degree of personalization with near industrial efficiencies”<sup>7</sup>. We intend to concentrate here on the specific ways such a “paradigm” is applied to the footwear business.

We used the term “business”, instead of production or design, to emphasize the pervading effects that derive from the adoption of the concept of customization; as we will explain, all the processes that constitute the shoe product life cycle are heavily affected by such a concept and they need to be rethought, reshaped and sequenced in a different way. What customization is about basically is involving the customer, or better still the “consumer”<sup>8</sup> in the value chain of the shoe; keeping this in mind, in the following chapters of this book, every time we use the term “customer”, we in fact mean the “consumer”, using, in the context of shoe mass customization, these two terms as synonymous. There are different ways of

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<sup>7</sup> p.3

<sup>8</sup> In shoemaking “customer” might have a misleading meaning, being the term mainly used by the shoe companies to indicate their clients, namely shops or retail chains, rather than the end users they build their shoes for

integrating the consumer in the value chain of the product, each one having a specific relation with the way the product is then developed, manufactured and sold (but not necessarily in this order).

In traditional mass production systems, end users (consumers) are not involved at all; the whole business is about manufacturing and *then selling* standardized products to customers who remain rigorously anonymous (the shoe factory does not know them individually; in general footwear companies tend to know very little about the real needs and demands of those who should be their reference consumers); goods are then *made to stock* (with all the related economical and cost efficiencies). Some “flavours” of customization can, to a minimal extent, be present also in mass produced shoes, but they all tend to satisfy classes or categories of consumers rather than individuals. We can have a soft customization when the consumer interaction point<sup>9</sup> is in sales or retail; this is the typical case of *match to order/locate to order* (which deals with the selection of existing standard products according to customer requirements) or *bundle to order*, for which existing products are bundled, based on situation of use, to customer requirements. Hard customization digs more deeply into the company structure and organization. In the case of *assemble to order*, that is assembling a customized product starting from standardized, pre-fabricated parts, consumer requirements affect the final assembling of the product, while for really *made to order* shoes, all components of the product are manufactured upon consumer’s specifications and requirements.

We could also think (although the application of this model to the footwear field appears, at least today, more questionable) of having the consumer involved in the very first steps of the product life cycle (design and development), in what can be called *development to order*, in which he or she co-designs the product together with the producer, followed by a customized made to order. Then the term customization refers to changing parts of a shoe according to the needs and demands of a consumer. Breaking with mass and variant production, customized shoes are only produced when an order is placed by an end-consumer. Shoes are then assembled to order, based on pre-fabricated materials and components (the degree of pre-fabrication may vary) or completely made to order for an individual consumer.

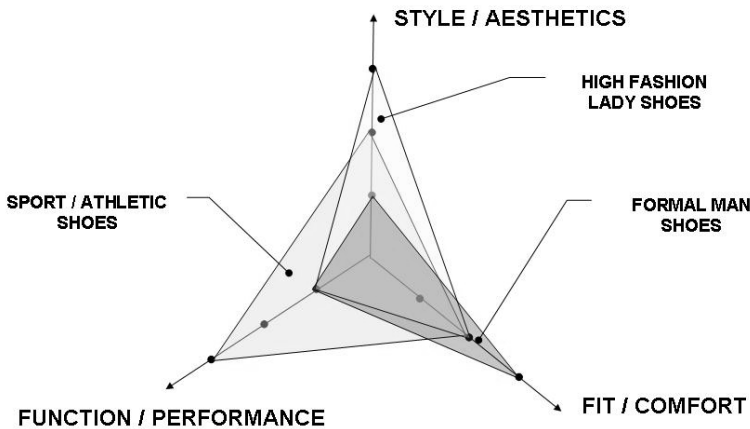
We can ideally think of three possible vectors along which the customization of a shoe could proceed: **style/aesthetics, fit/comfort and function/performance**. Customizing the aesthetics of a shoe can be a relatively simple task, if we keep in mind that it does not mean transforming consumers into shoe designers (which they themselves don’t want, as the outcomes of various market surveys indicated – see for instance [1]), but rather giving them the possibility of “building” or, more precisely, “configuring” their shoes by selecting their preferred option among a list of possible variants of the basic shoe design.

Fit and comfort involve more subtle and complex definitions (they are mostly defined by the last of a shoe, but also by the design of the upper, insole and outsole, the materials used in fabrication, *etc.*), which also imply a fair amount of subjective perception from the consumer standpoint; fit customization eventually deals with producing a shoe that consumers (and each individual consumer) will

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<sup>9</sup> The point at which the consumers enter the value chain of the product.

comfortably wear without any need to accept compromises, should they not know the real size of their feet or the size required not be available in the shop.



**Figure 2.4.** The three vectors of shoe mass customization

This way to customization does not only mean configuring the shoe from the aesthetic standpoint, but also applying some sort of dimensional adjustments to its building components. Then we have, ideally, functional customization, that is making a shoe for each individual consumer by “optimizing” its dimensional parameters, construction technique and materials in order to match the use consumers will make of their shoes (walking all day, driving most of the time, being seated at a desk and so on); this sort of customization, which implies a thorough knowledge of the biomechanical aspects of shoe - foot interactions, is for example used in sport shoes to enhance the performance of the athletes, but has not been yet thought of for normal consumers.

As the aspects mentioned above are those that can be customized in a shoe, such customization is then possible at different levels:

1. **Style Customization** - based on standard lasts<sup>10</sup> (and sizes) consumers can choose style options (colours, fabrics, leather, accessories) within constraints set by the manufacturer. This can be offered as a separate market option or be included in other customization levels.
2. **Best-Matched Fit** - the feet of each customer are examined (using devices called foot scanners) and matched to an existing library of lasts, insoles and soles with a much higher granularity than in today’s mass production systems. Additionally, some style customization may be possible.

<sup>10</sup> A “last” is a sort of model of the foot, made in plastic, on which shoes are designed and built.

3. **Custom Fit** - the feet of each customer are examined and his or her specific habits are analyzed and used to make an individual last, insole and sole. Additionally, some style customization may be possible.<sup>11</sup>

Each specific level of customization has a well-defined impact on the three main processes that build up the shoe product life cycle (sale, design and manufacturing); we can measure this impact in terms of “gross costs” for the company to go for customization, where “gross costs” refers to investments in technology, manpower, organization, promotion of the new concept, retail disintermediation and so on. Table 2.4 shows this cost factor in relation to the three degrees of customization.

Style customization (first level) has a very low effect on manufacturing (it remains more or less the same as in traditional production, besides the aspect of having to handle more manufacturing variants), while design (more variants/combinations will have to be studied) and sales (a new sale model will have to be implemented, possibly by de-intermediating the traditional sale network) are more noticeably affected.

**Table 2.4.** Cost factors for three levels of mass customized shoes

	<b>Design</b>	<b>Production</b>	<b>Sales</b>
<b>Style customization</b>	High	Low	High
<b>+ Best-matched fit</b>	Very high	High	Very high
<b>+ Custom fit</b>	Very high	Very high	Very high

If we add best-matched fit to style customization, things get more complicated: the impact on design and manufacturing increases, because now the design department and the shop floor will not only be confronted with a higher number of model/style variants, but also, very likely, with a wider range of last sizes and last fits (which are needed to increase the chances of matching the size and fit of the individual consumers<sup>12</sup>). Also on the sale side complexity grows with the need to equip the sales outlets with foot scanners to measure the feet of the consumers coming to the shop, which also implies training the sales personnel, not only on the new sales logic but also on the use of “high tech” devices.

<sup>11</sup> Best matched fit is also called, in traditional terminology, “semibespoke” while custom fit is equivalent to bespoke.

<sup>12</sup> An average footwear manufacturer would normally offer its shoes in something like ten sizes (a measure of the length of the shoe) and just one fit (a measure of the width of the shoe); a good indication of what can be assumed as the minimum necessary offer for customized shoes, would include at least twenty sizes (full and half sizes) and at least three fits; this means a six-fold increase in the range of lasts and shoes to be handled in production.



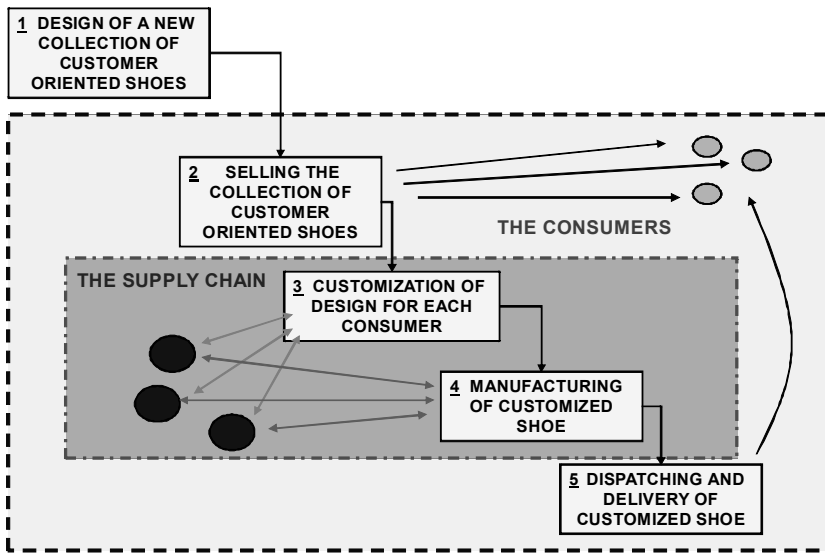
When we move to custom fit in combination with style customization, we have a dramatic impact on all processes: the higher the level of customization the company aims at (fit/comfort, functional/performance) the more complex and high technology demanding the sales outlet becomes; on the design side new functions and operations become necessary, while on the manufacturing side it will be a real challenge and a quest for the utmost flexibility to handle a virtually “infinite” range (at least in terms of dimensional parameters) of products and to keep manufacturing costs of unitary lots at a level appropriate to the amount of money the consumer is ready to pay (more) for the customized shoes.

Eventually, all the variables of the complex equation that leads to the final cost of the product (the customized shoe sale price) must be combined in such a way that the result falls within that range of “mark up” to the normal selling price that consumers are ready to pay (various market surveys indicated that up to 20% more than the price of the same shoe made in the traditional way could be acceptable – see again [1]). It would seem evident and intuitive that producing in unit lots goes against the historical principle of economy of scale and will make the product costs increase; it is much less intuitive that a careful analysis of the entire value chain could highlight enormous and unexpected saving potentials that can compensate for increased costs in manufacturing. An analysis of this kind was conducted in the apparel field and presented at the First Congress on Mass Customization and Product Personalization [5]. Facts and figures presented in such a study, indicate that mass customization could actually bring down the final end user price (for example for a pair of trousers or jeans), by preserving the manufacturer’s margin and even the retail margins. Similar results are to be expected for the footwear sector.

Having explained what mass customization is, how it can be applied to the footwear business and what it implies for the sale, design and manufacturing processes, it is worth understanding, in more precise terms, the way a hypothetical company offering customized shoes works. This is useful to highlight the kind of changes a traditional shoe company should undergo if it wants to adopt the paradigm of mass customization in its business operations. We can describe the operations of the company as one main process, broken down into five separate sub-processes:

1. Designing the customized shoes collection.
2. Selling the customized shoes.
3. Customizing the design for an individual consumer.
4. Manufacturing the customized shoes.
5. Delivering the customized shoes.

The whole process starts with the development of a new shoe collection “customer orientated”; depending on the company-specific parameters (shoe types – male or female, formal or casual, classical or trendy), the shoe models will be designed for the specific season and will take into consideration design and manufacturing requirements dictated by the design and manufacturing infrastructures of the company.



**Figure 2.5.** The five processes of the shoe mass customizing enterprise

To these typical contents of the design process (common to all footwear companies) a new dimension is introduced: customization. This implies additional requirements in terms of:

- *Material/component/colour variants* to be taken into consideration in the design phase and in the product structuring in terms of Bill of Materials; every “configuration” (design + choice of materials + choice of components) could generate a specific product code.
- *Higher granularity in terms of size and fit combinations* if the **best-matched fit** approach is chosen, which implies a careful coding of each individual last and of the specific size–fit instance. Nonetheless, size and fit definitions adhere to the traditional standards used in shoe making. The problem here is whether all necessary lasts should be supplied by the last maker to the manufacturing plant before production is started or if some of them can be ordered and procured only when needed (this could imply also producing the last internally in the shoe factory rather than at its supplier).

A further design dimension could be introduced here: biomechanics. As far as step 1 is concerned, biomechanics is to be intended as a means of improving the design of the shoe for the specific “segment” of population the footwear company intends to serve with its products.<sup>13</sup>

<sup>13</sup> For example if the consumer segment the company addresses to is composed of people who like a good cushioning of the sole and the company produces shoes with plastic soles, it

In relation to this aspect, the great potential mass customization presents for shoe companies stands precisely in the possibility, through the direct and continuous contact with hundreds of consumers, of learning very intimately what their features, desires and demands are and to make use of these findings to improve the design and technical contents of the shoes.

The next step involves the sales points. The “ideal” customer-orientated shoe enterprise bases its business model on three distinct sales outlets: brand or flagship stores, department store sections (a shop within a shop), and the Web. The brand and flagship stores are large and elegant, they exhibit the “image” of the company, they have an adequate staff and the most complete (and expensive) foot scanning equipment, they aim at the most exigent and demanding customers (for which the company will make truly custom made or custom fit shoes); the department store sections are shops within a shop where shoes are exhibited and sold, they are smaller with minimal staff and less expensive equipments and are aimed at capturing the largest possible share of consumers to the idea of customized shoes. The Web is the place for the future; it is already the privileged channel for the second purchase of the company’s loyal customers. This is not a unique sales strategy in itself, but a winning component of a three-tier sales approach. Whatever the approach, the sales process comprises a precise set of actions and responses to a well-defined ritual that will be described later.

The various sale outlets will collect the customer orders daily and transmit them to the factory for their processing. If the company is structured to offer several levels of customization, orders are split into two groups: best-matched fit orders can be immediately processed and are sent to the shop floor, while custom fit orders will follow a separate path. In fact the “consumer specific design” has to be generated in order to start with the manufacturing of the various shoes. This step, that can be called “*design tailoring*” (or design customization for each consumer), and it requires the usage of the “quick adaptation functions” available in CAD systems and produces a unique last + shoe design that merges style requirements, depending on the model selected by the consumer, foot size requirements, depending on the morphology of the consumer’s foot, and (possibly) biomechanical requirements related to the “function” of the shoe when used by the consumer. The output of this phase is a complete “project” of the shoe and of all its components, uniquely tailored on the specifications of the given consumer; CAD file data of the components are at the same time transferred to external suppliers in order to launch the manufacturing of all the various shoe components, although in the case of custom fit shoes the higher the level of process of integration in the factory itself, the easier is to serve the customers.

In the case of custom fit (or fully bespoke) shoes, only when the “customized” design is ready all the information required (in terms of quantities, production lots, machine part programs, material and component allocations) are available, and hence the manufacturing phase can start. The process at this stage will very much depend on the shoe typology and construction(s) adopted by the company; this dictates the configuration of the manufacturing line. Once more, in the most

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will try to use “design rules” that correlate for instance sole geometry with cushioning effects, designing shoes with the appropriate cushioning properties

complex case of companies offering all levels of customization, two separate paths can be identified: *best-matched fit* shoes will go straight to the making and finishing lines, components (including lasts) are likely to be stocked in the company warehouses and production is managed in the usual way. Vice versa, *custom fit* shoes will flow through all shop floor departments (cutting, stitching, last making, shoe making and finishing) receiving those components that cannot be handled internally just in time from the suppliers.

As a last step of the entire process and to close the “consumer loop” (a procedure that starts and that ends with the consumer itself), the produced shoes are sent to the consumers, either to their personal address or to the sale points where they purchased them. This last step, although simpler than the others, implies some specific procedures and a good deal of integration with the information systems and infrastructures of forwarding agents and transporters.

Going one step deeper in the analysis of the operations of the shoe mass customizing enterprise, it is useful to understand more precisely what each step aims to achieve, which resources it necessitates and which are the constraints to be taken into consideration. The schematization we adopt here describes each one of the steps (or better sub-processes) of Fig. 2.5 as a “function box”, whose task is transforming the given input into the desired output, using well-defined resources and under similarly defined controls, as follows:

1. **Design** - the design activity is performed, as previously noted, in a relatively traditional way: average information on the human foot, biomechanical requirements and style/fashion considerations all affect the design of the shoe and its last. These considerations are the *controls* that dictate the design work; the *input* is normally a “draft” (physical) last used as a basis for the work and formalized/non formalized style ideas, the *output* is the complete shoe project (including information for manufacturing), while human operators and CAD systems are the *means* to accomplish the work. This process is repeated for all the new models that form a new collection (although it has to be remembered that different style variants, or even different models, could share the same last). The main process steps are those typically undertaken by all footwear companies using CAD software to support their design activities. It is assumed here that the design cycle is mainly done “digitally” with extensive use of CAD/CAM systems and in particular of a 3D CAD; it is also important that modern and powerful CAD systems are available in order to increase the chances of having a “good fitting” shoe at the first iteration. It is also important that suppliers of “key” components (last, mould and sole makers) are equipped with computer systems that can communicate with those ones of the footwear company. To this extent, the approach of the mass customizing company is not that much different from the one of any modern and digitally equipped shoe company, but in this case the shoe mass customizing enterprise will make full use and take full advantage of its ICT infrastructures.
2. **Sale** - no matter what the sale channel is (brand shops, department stores or the Web), the sales process develops in a few basic steps: its *input* is

represented by the consumer in general terms (feet dimensions, habits and tastes), while the *output* is represented by information generated by the process (in terms of selected shoe design, feet geometric data and biomechanical patterns) and the purchase order. *Controls* are here represented by the available range of styles and style variants and the price brackets the consumer can buy in. The *means* to perform the activity are the sale assistants in the shops (or the consumer itself in the case of the Web sales), foot scanners, the product configurator (software) and consumer profiling questionnaires. Two major differences appear here, in the perspective of the shoe company and with respect to the way traditional ones are organized. The first one deals with the moment this process takes place: before production is started rather than after; normally shoes are produced and then sold to consumers. In the mass customizing case shoes are first sold and then made. The second major difference is that in this phase of selling, we look specifically at the consumer, at each individual consumers rather than to unidentified categories of generic buyers.

3. **Design tailoring** - this design phase is defined to be internal to the already mentioned consumer loop and it appears all the times that custom fit/fully bespoke shoes are offered.<sup>14</sup> It is in fact aimed at procuring the data to manufacture the customized pair of shoes the consumer has selected. The *input* to this activity are the geometric data of the consumer's feet, his or her biomechanical patterns, the product code corresponding to the particular configuration of the shoe selected and the administrative information related to the order. The *output* can be as simple as a "pure" manufacturing order (in the best-matched fit case) or as complex as the manufacturing order accompanied by a "customized" design of the shoe (the custom made last data, the adapted shoe design, the CAM data and so on). *Controls* in this activity could be the available lasts (in the best matched fit case), the required due date for delivery, the availability of materials and components, and so on, while *means* to perform the activity are again human operators (shoe customization technicians) and the appropriate CAD system.
4. **Manufacturing** - this relates to manufacturing the customized shoes, according to their specific sequence of operations. The *input* for this activity is represented by the "classical" set of materials and components (to be noticed that the last can be an input or an output depending on the specific scenario between best matched and custom fit), and the *output* is represented by the customized shoes. *Controls* are here mainly represented by the bill of materials/components, the machine part programs and the manufacturing routing for the various models. The *means* to perform the activity are production planning and management

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<sup>14</sup> As a corollary when only best-matched fit/semi bespoke shoes are offered, this phase is not necessary, since no design tailoring for each individual consumer is needed; this is a very relevant affirmation since it indicates a possible path to customization that represent a workable compromise between consumers' satisfaction and complexity of operations.

software, machines, production systems and human operators. It should be noticed that it is very difficult to “generalize” this process since the more we go into details the more the description becomes specific to a given shoe construction.

5. **Delivering** - this takes place at the end of the entire sale, design and manufacturing cycle and closes the loop with the consumer; *input* for this phase are the produced shoes (each pair referred to a well defined consumer) while the *output* is here represented by the delivered shoes. *Controls* for this step are the consumer information (place of delivery, address, due dates and so on), while the *means* are represented by the forwarding and delivery infrastructures. It is a process typical of the customized shoe scenario, in particular when the final step of delivery to the consumer is taken care of directly by the shoe company.

The aim here was to decompose the operations of a hypothetical shoe mass customizing company in order to understand which are the relevant process steps, the order in which they appear, how they are related to one another, and which technologies and resources they imply. As a general comment, it can be concluded that most of the resources that this new business model requires don't seem to be that much different from the ones shoe companies already rely on. What is different is their relative importance, the moment they come into play, and the way they need to be managed. Some other technologies are more specifically connected to the business approach mass customizing brings in and for this reason they will be specifically treated and described in the following chapters.

Hence, a footwear company that is considering starting a venture in the field of mass customization should make a careful checklist of the resources it can count on and of their quality, in order to be sure that it is approaching the problem with an adequate level of understanding and consciousness. A possible checklist of the most important factors to be considered could be as follows:

- **Pervasive IT** - the key and the secret of running a shoe mass customizing company is a pervasive use of information technology (IT) at all levels and in all phases of the process. Mass customizing (MC) deals mostly with processing consumers' information in order to achieve consumer satisfaction; and when consumers are counted in thousands and for each one of them individual information (from specifications to individual orders) is to be gathered, processed and tracked, very efficient and powerful IT infrastructures are needed. Their role and relevance must not be underestimated, as its potential should not be neglected, because the knowledge of the consumer base that IT systems enable the company to achieve is one of the major values related to the adoption of MC. Tackling an MC project with no computer systems, manual process planning and control, fax and telephone is not impossible, but it will very soon limit the whole potential of the project and it will not allow a full exploitation of the paradigm.
- **Flexibility in manufacturing and in the supply chain** - relying on adequate manufacturing facilities with high levels of flexibility, capable

of handling the very unpredictable (in terms of quantities and typology) structure of the daily orders, is a must in order to cope with the two basic parameters that matter here: keeping the manufacturing costs as low as possible and duly respecting the delivery dates; and this of course with no compromises on the side of quality. Selling customized goods, and shoes more than others, is a business based on trust and confidence. If the trust relationship is not established or, worse, is broken, the venture is destined to failure. Where and how manufacturing is done, play here a relevant role, hence this choice deserves a great deal of attention.

- **Focus on the product** - we will further discuss this aspect in one of the following chapters, but it is worth mentioning it here. It should never be forgotten that at the end of the day, what is sold must be a pair of good shoes, or, more precisely, better shoes because the whole deal in shoe mass customization is exactly that one of offering a product with more contents (of material or immaterial nature) than in traditional shoe making. So if the product is not selected properly, accurately designed, well configured in terms of materials and colours, complying with the relevant fashion or style trends, it will simply not sell, no matter how well it is personalized.

As a conclusion of this introduction of the basic concepts of mass customization and of its background mechanisms, it is worth mentioning that there is no unique path to it, but that rather each company will have to identify and study its pattern to adopting the new paradigm. In general terms, what can be noted here is that there are at least two “models” that can be already identified and that indicate alternative ways of implementing the paradigm.

One model puts more emphasis on the customization side of MC and it finds its followers among new or traditional suppliers of bespoke shoes (typically for men) who want to modernize their handmade approach to the consumers, with all the most modern equipments and methodologies that computers and ICT (information technologies) are making available to them. Their products will than be an “affordable luxury”, as the slogan of a very well-known producer of customized women’s shoes states bringing down to a wider segment of consumers the “top class” prices that traditional purchasers of bespoke shoes are ready to pay. This is still not really for the masses though.

The second implementation of mass customization looks more at the masses of consumers, and is more adequate for traditional shoe producers, relying on their classical and available manufacturing facilities and really aiming at capturing a much wider range of consumers, who have never experienced customization, with a personalized product at a price that is only a little more expensive than the one they normally pay. We will further comment on these two models in the central section of the book where case studies of the current pioneers of shoe mass customization will be presented.

## 2.4 Three Good Reasons for Mass Customized Shoes

We have analysed in Section 2.2 how complex and challenging is running a footwear enterprise in these first years of the new millennium. Rules are changing, and the relative relevance of the various manufacturing regions of the world is largely different from what it used to be only ten years ago. Western companies are struggling to compete in the global markets, repositioning their products to more rewarding marketing segments, restructuring their production, trying to change their approach to business.

Mass customization and product personalization can provide an answer to these kinds of challenges, putting Western footwear companies in the position of moving the competition onto grounds that are much more favourable to them than the old ones in which production volumes and low costs seem to matter more than anything else.

In order to make a correct evaluation of the convenience of adopting the mass customization paradigm and to carefully assess the parameters that can determine the success of the project, several aspects must be thoroughly understood, both from the technical and economical standpoint. In Section 2.3 we have given some basic definitions and a description of the technical difficulties that producing and selling customized shoes imply, highlighting the implications of such a move and the impacts that it has on the organization of the company. These issues will be further exploited in other sections of the book, where a detailed presentation of the necessary enabling technologies will be given.

What it is necessary to address now is the very fundamental question: why should a footwear company choose to go for mass customization to better compete in the global markets in the years to come? Perhaps it is first worth clarifying which footwear companies we refer to in delivering the comments that follow. We have already stated that not all the footwear world is the same: there are regions that don't need (at least for now) special recipes to gain or maintain their commercial success, at least as long as there will be a market ready to absorb the enormous volumes of low cost shoes manufactured there; and we don't see in the short to mid term any signals that would indicate that this kind of demand for "mass produced" shoes should change that much. Then we are not thinking (yet) of countries like China, India or Vietnam (the manufacturing champions) when we propose "mass customization" as a path for a regained competitiveness.<sup>15</sup>

We are not also thinking of producing areas such as Latin America (and in particular Brazil), with strong domestic markets and a relatively protected position with respect to the Far East producers. The regions that we believe can benefit the most from the new business models and its market implications are: Europe first,

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<sup>15</sup> Comments on a fast-learning and fast-growing country like China (and India too) are always very delicate; despite the common image of China as a typical mass producer, it must be noted that in the country there is a growing interest for all aspects related to technologies and in particular to mass customization and product personalization. So it has to be expected that it would not take long for the Chinese tiger to convert its production to the new paradigm, should the markets indicate a clear demand for that. So the time factor is once again very crucial.



with all its major footwear producing countries; North America, should it want to reintroduce at least part of the shoe production that it has lost with time; and, last but not least, Japan, a small nation, with highly demanding consumers and still a relatively well-established footwear industry. These are the countries (and regions) that we think could benefit by this paradigm shift and by the adoption of this more modern approach to the old-fashioned footwear business.

Let's return now to the fundamental question we introduced a few paragraphs before: why should a footwear company consider mass customization? There are at least three good reasons: the consumer, the product and the market. Enterprises producing consumer goods do exist exactly for these reasons: to serve consumers, located in a well defined geographical area and in a precise market segment with the most appropriate and adequate products. We will in the following pages explain how mass customization can find its motivation in relation to each one of these "drivers" and how it can help the company enhancing its performance in each one of them.

### **2.4.1 The Consumer**

In traditional economic theories, consumers are "value destroyers"; they annihilate the "added value" that the company has put in the creation of the product by the act of purchasing and using it. When a traditional pair of shoes is sold to anonymous consumers, its life cycle, at least from the perspective of the manufacturing company is over, and there are no more value returns to the company during the "use" phase of the product life.

What mass customization returns to footwear companies is the direct contact with their final consumers; such a contact is now lost in favour of a mediated market approach in which the majority of the companies sell to retail networks which are then in control of the expectations, desires and feedbacks of the consumers. Needs and requirements of them are filtered back to footwear companies with time delays and through the "lenses" of the retailers. There is little use and few possibilities that such valuable information on what consumers want and how to better serve them can be made available to footwear producers when it would be needed. Even those companies which have direct sale channels (their own chains of shoe shops) don't exploit this possibility, since their sales approach is still, in the great majority of the cases, anonymous. Consumers are only known through their credit card numbers.

Mass customization puts the consumers back at the centre of the attention of the footwear producer, as it used to be in the past when the contact "consumer-shoe maker" was a direct, one-to-one contact; as it still is for the small community of manufacturers of bespoke shoes and their lucky and wealthy clients. Consumers are, in these kind of operations, greeted, inquired, scanned, measured, questioned, supported, and assisted in their purchase experience, transforming a simple necessity act (buying a good pushed by the need), into a ritual that makes the consumer feel that what the company is trying to do is not simply selling an item, but learning more about his or her desires and expectations. All these things greatly improve the purchase experience; they educate the consumers too, improving their capability to choose the right shoes for their feet and their tastes.

This is exactly how it should be: by “studying” the consumers the company “learns” something about them; they learn how their feet are alike, what are their fitting preferences, what their tastes and preferences are. There is a lot of value in this learning, as long as it is not dispersed but rather transformed into “knowledge” to be used to improve the design of the last and of the shoes in order to make them more and more comfortable and better value for the consumer, and to make material procurement forecasts more reliable and driven by consumer demands. In this respect mass customization can transform the traditional footwear making business into a “knowledge” business in which the knowledge of the consumers’ biometry, preferences and expectations is the value that is created in the sale of a customized shoe. The consumer is no more a value destroyer but a value creator for the company that rewards him or her (yet at a cost, since customized shoes are more expensive than normal ones) by means of a more comfortable pair of shoes, perfectly fitting both in terms of measures, style, colours and materials that the consumer was able to choose based on his or her own desires.

It’s a relationship of mutual trust that as long as the manufacturer is capable of maintaining its promises in terms of quality of the products, reliability in deliveries and attention in fulfilling expectations, it will create very loyal customers who will have no doubt and no hesitation in coming back many more times to maintain their relationship with the producer.

### **2.4.2 The Product**

The product is certainly the second driver to go for when mass customization is considered. In the previous chapter we have stated that both designing and making customized goods, namely shoes, is more difficult and complicated than making mass produced ones. Although these complications can somehow be controlled and managed with the use of appropriate and well-suited technological tools (as we will describe in the following chapters), the fact remains that a “to be customized” product must be carefully studied, designed for modularity, and planned for production in order to minimize the impact that this completely different way of selling shoes brings with it.

Yet there are very relevant positive factors in relation to the product too that make mass customization attractive; first of all the fact that products are made only if needed. Mass customization of shoes implies that the company switches from a “made to stock” approach to a “made to order” one. Only those models, styles, colours and sizes that customers actually order are produced, as well as the tools and components that are needed for their production.

So the price that is paid in the product design and manufacturing planning phase, when a longer time and a greater attention is needed in order to approach these steps properly, is compensated by the diminished risk of investing money in tools, components, materials and shoes that will not encounter the favour of consumers and that will not sell as well as expected. It must be said that risks in these areas can be controlled and reduced but not eliminated completely. Initial procurements of materials and of the most critical components will have to be done in any case, based on forecasts and estimates of what the consumers will later want to buy.

A highly flexible supply chain (with suppliers capable of delivering components and materials almost in real time) and the availability of appropriate planning and procurement managements software tools can help reducing the risk and augmenting the advantages that can derive from a very reactive and lean supply chain.

Despite these difficulties (and the relative inefficacy of the tools that are currently available to support such operations), relevant advantages are still there: made to order means fewer or no stocks, virtually no low or under cost sales, and a lower risk of high quantities of unsold items that the company has to get rid of. It also means smaller sales surfaces; big inventories of several models in all possible sizes (so that the chances of serving all consumers are higher, no matter what their size or preferences are) are no longer necessary at the shop, with the direct (inventory cost) and indirect (cost for the area of the shop) costs that come with them. A relatively small sales surface where a few samples are physically available (whilst all the others are there only in the form of digital catalogues) is enough with all the positive implications in terms of reduced initial investments and of lower running costs.

### **2.4.3 The Market**

Market motivations are the third area that mass customizing companies need to consider. Shoe companies are used to thinking of their market in terms of the “quality segment” in which their shoes would fit (high quality-high cost, competitive price-quality ratio, and so on), the use their shoes are aimed at (casual, formal, sport, fashion, safety, and so on), the gender of the consumers they are addressing (male or female) and the age category they belong to and, finally, the geographical area their consumers are based in.

This provides a very classical approach to the market, where the “market” the companies aims at serving derives from the intersection of the various specific aspects that we have mentioned above. Whatever its definition and composition might be, one point remains characterizing the common approach of shoe companies to the market: it is an indirect approach mediated by the retail network the company uses to bring its products to the consumers, as we have already mentioned.

The direct connection to consumers that mass customization implies turns into a transformation, for the mass customizing footwear company, from an indirect market approach to a direct one: the knowledge gathered during the sale phase, besides allowing the company to better assess the consumers’ needs and to use such needs as “design drivers” for its new products (feedback on products), provides also an immediate and direct feedback on the responsiveness of each one of the “markets” tackled by the company. What actually happens is a strong identification between the “consumers” and the “market”, being nothing more than the aggregation of many individual consumers, located in a given geographical area served by the company with its shops, who have common tastes for the kind of shoes offered by it and the same attraction for the personalization offer. In the traditional shoe business this identification between market and individual consumers does not, to this extent, exist.

For traditional shoe companies, markets are somehow abstract entities, with defined rules and mechanisms, not always well understood and mastered by the companies; markets, in the approach of the shoe company, have lost any relationship with their intrinsic nature of being eventually composed of individuals with individual tastes and interests.

Is this regaining of a more proper, human centric vision of the market, good or bad in itself? Can it be regarded as a competitive factor in favour of mass customization? On the one hand, even if we focus on markets as “collections of individuals”, they will nevertheless possess their own dynamics and behavioural paths, the same they have when we consider them in the usual abstract way. Latin consumers behave and have tastes which are different from the ones of the northern part of Europe, Americans would be different from Asians, men would approach mass customization in a different way than women; differentiation factors are there anyway and they have to be carefully considered by the mass customizing shoe company.

On the other hand, in the case of mass customization and of a direct communication link of the footwear producer with its consumers, market dynamics, market responses and critical factors are obtained from a direct and daily observation of the sales record and of the individual choices of the consumers, or from punctual and detailed analysis of the reasons for lost sales or for unsatisfied consumers. What this regaining of the individual dimension of the market also brings in is a much shorter time span in determining the reasons for a missed sale or in highlighting the most relevant winning factors when a satisfied consumer walks out of the shop.

To summarize, we believe that mass customization enable shoe companies to regain a level of control on the market that is not easily achievable with a traditional organization, and this for the following reasons:

- **Amplification factor** - this is related to the fact that market responses and dynamics are now obtained as “summation” of the behaviours of a relatively high number of individual consumers, whose purchase decisions, preferences and wishes are collected in an analytical and detailed way; they are not “estimated” on the basis of forecasted average trends based on never consolidated (in a phase of rapid changes and very volatile purchase attitudes) historical data. This generates an “amplification” effect of those aspects that are more relevant to be considered to maximize sales and consumer satisfactions, whilst with the traditional sale approach those factors tend to be smoothed down rather than emphasized.
- **Time factor** – this is related to the almost “real time” feedback that the shoe company can obtain on its performance of footwear service provider (which is the right perspective to look at mass customization of footwear) thanks to the data communication link and ICT infrastructures the mass customization business rely on. Whatever works or does not work in the products, its quality, the way it is offered, its acceptance by consumers, is known and made available to the footwear company in real time, day by

day. This allows an unprecedented potential for quick response and adaptations.

These aspects together should motivate the potential interest of footwear companies for the paradigm of mass customization. So we think the following are good enough reasons to induce modern shoe companies to carefully look at the possibility of adopting mass customization in their business; to once more recall them:

1. **Consumer centricity** - the consumer is put back at the beginning and at the end of the life cycle of the product he or she buys, determining its characteristics at the beginning of the process and closing the loop when the shoes are delivered and used or becomes a value creator for the company, the value being the knowledge the company can gather about his or her tastes and needs. If the company can make good use of this knowledge by producing shoes that fulfil the expectations of the consumer, a long-lasting relationship of trust is built and a high level of customer fidelity is achieved.
2. **Product fertilization** - mass customized and also standard shoes can be greatly improved by the data base of biometric information obtained as a by-product of the sales operations. What is learnt from the consumers is translated into better specifications for the products and these improvements can be transferred also to the common mass produced shoes (should the company maintain both approaches) thus producing a generalized product enhancement, thanks to the fertilization that the knowledge gathered in the sales phase can produce to the entire model range of the company.
3. **Market reactivity** - as a result of the detailed knowledge of the mechanisms and the rules of a market that is known to be composed of a high number of individuals the company aims at serving, analytical knowledge together with real time information availability put the new shoe company in the position of being much more reactive to the changes in the demands of the consumers that constitute its market.

It is worth at this point analyzing the types of companies that can be potentially attracted by the new paradigm. We classify them with two parameters: their origin/history, which dictates their specific implementation path, and the kind of consumers they offer their products to. According to this classification, mass customizing companies can be described as *innovative shoe makers* or *appealed outsiders*, offering their products to masses or elites.

### **Innovative Shoe Makers**

These are traditional/historical footwear companies that believe in the necessity of changing their approach to the market and are convinced that personalization and customization of products can represent an evolution of their traditional business

and a way of gaining a definite competitive position. These kinds of companies can make use of available infrastructures (namely in product development and manufacturing) and often a network of retail points and sales outlets, in order to test new approach. They also have a pre-existing knowledge of the segment of consumers they want to serve and of the kind of shoes they might want to buy; knowledge that will be perfected and enhanced thanks to the direct approach to consumers that mass customization brings. Companies like these will very likely maintain (at least at the beginning) their traditional lines of mass produced products, taking full advantage of the fertilization effect that we mentioned earlier, running the mass customizing business as a distinct brand, a separate unit or even a newly formed venture (still utilizing the available infrastructures).

On the other hand, organizations like these are more difficult to transform and to become mass customization oriented; this requires a change in perspective of the management, some more or less in depth reorganizations of the business processes and, very likely, the updating of some or part of their technical facilities. At best, they have the possibility of exploiting the potential of mass customization, but will encounter many intrinsic difficulties in embracing the new philosophy easily and rapidly.

### **Appealed Outsiders**

These are organizations or entrepreneurs coming from different sectors and different personal experiences who are interested in the paradigm of mass customization and who have, at different levels, an interest in footwear. These outsiders are favoured for the fact that they can shape and tune their organization and the related processes specifically for mass customization, without the constraints and the difficulties that their traditional competitors might find. If these are the positive factors they can count on, what they lack is the experience in the business (at least for some of them), a consolidated knowledge of the product and, more than anything else, they lack the specific design and manufacturing infrastructures they need to start up their ventures.

Typically outsiders of this kind will start from the sale side of the business and from a thorough concentration on the product aspects, which will define the failure and success of their adventures. The crucial decisions in this respect are those ones that will determine and identify the key suppliers they will need to begin with their operations, namely for the product development activities and for the manufacturing operations. In the central section of the book, in which several case studies of footwear mass customizers will be presented, detailed information about their origins, experiences and possible evolution will be given.

A second relevant decision for companies wishing to adopt the mass customization paradigm relates to the nature of consumers (hence the nature of the market) they want to tackle. One option is addressing their services and their products to the wealthy upper edge of the consumer pyramid. Offering their modern and efficient shoe customization services to an *elite* (yet in relative terms) of consumers; this kind of approach maximizes the quality of the offered product, the amount and the extent of customization, the efficiency of the delivery service at a price for the consumers that is not such to attract the masses. The sale/production volumes (in terms of pair produced per day) in this kind of approach will never be

enormous and the size of the market served will remain relatively limited. The aim of this “variant” of mass customization is to modernize the typical artisan approach, by means of IT technologies, of some degree of industrial production, of “making digital” the key processes of the traditional producers of craft made bespoke shoes. Where is in this case the competitive advantage? It is in the possibility of making “luxury” affordable, if not to masses, at least to a wider segment of consumers hence with higher chances of obtaining interesting sale margins and rapid return on investments.<sup>16</sup> As we have already noted, there is much more customization here than mass.

When rather than elites, the company decides to serve *masses*, we have a true and full implementation of the mass customization paradigm; we believe that the greatest potential of the new business approach lies mainly here. The challenge that is taken in this case is the one of serving large segments of consumers, providing them with customized shoes at a price that must not be much more expensive than the one they are normally ready to pay for their regular shoes. It is in the adoption of this approach that adequate technologies, not only on the side of ICT, but also and mainly in the design and manufacturing processes, becomes necessary to allow a fast and efficient production of unit lots of very diversified shoes, taking advantage as much as possible of the economies of scale typical of traditional shoe production.

With the argumentations that have been presented in this chapter we have indicated some very general motivations that, in the opinion of the writers, should induce shoe companies or, in general, attentive entrepreneurs in moving towards the mass customization paradigm. What they have in common is the fact that they move away from the traditional considerations of competitiveness in terms of quality to price ratio and products content and of economical sustainability in terms of break even as a function of volumes produced.

What the new paradigm, more than anything else, introduces is a competition based on different parameters, it moves the battle to conquer the market onto a battlefield much more favourable for Western producers, in which the labour cost nightmare is much less a preoccupation than in the traditional business. The product alone is complemented by the service the producer is capable to offer to its consumers, sales margins are not strictly dictated by manufacturing costs and retail strategies; but they are more determined by the service content perceived by the consumer; the distribution of the added value in the various phases of the product pipeline changes too, allowing the company, also supported by the shift from a made to stock to a made to order production approach, to obtain higher margins on the terminal steps of the pipeline that compensate the higher costs that some others imply.

Besides that, two other major transformations actually take place when a footwear company decides to move to mass customization:

- *A transformation from a labour intensive to a capital intensive activity, where capitals, material (machines, equipment and technologies) and*

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<sup>16</sup> We believe that this approach is more typical for outsiders than for traditional shoe companies.

immaterial (brand and product contents) assets count much more than labour. Capitals are much more easily found (and their cost is lower) in the western countries than cheap labour.

- *A transformation from a resource driven to a knowledge driven business approach*, in which knowledge at all levels (knowledge about consumers needs, tastes and desires, control on all the information exchanged in the various steps of the process, leveraging on such information to enhance the know how of the company) replaces the amount of resource the company can rely on, as the driving factor for competitiveness.

There is a last aspect to be considered in this analysis, which has been, up to now, mainly concentrated on footwear companies (or new start-up ventures) as such, and this is the role of retail. One might gather the opinion, from what was stated in the previous pages, that retail networks and retailers have no room in this scenario; indications were in fact given in the direction of assuming that the maximum advantage for footwear mass customizers would come when a direct control on the retail side of the business is there (so that the relevant margins that are generated in this phase can be fully absorbed by the company); this is certainly true, nevertheless it must be noted that retailers too can get benefits from this approach, both in the case of renewed partnerships with producers, and in the case of independent ventures they might think of starting themselves.

Retailers in this respect can take advantage of their direct contact with the consumers and of their in depth knowledge of the market, which is their daily field of action; it should not be difficult for them to figure out the potential for high quality service together with potentially higher margins, that mass customization brings. If suppliers are available with the adequate capabilities to produce customized shoes, an expansion of their product offer to include this typology of footwear would certainly give them a very valuable added value.

To conclude this analysis, we can state that mass customization, if properly implemented, can produce a winning scenario in which advantages are there for all the parties of the new business: for the consumers that take advantage of much higher levels of service (higher consumer satisfaction), for the retailers that can differentiate their product offer and aim at more interesting sale margins and, eventually, and for the producers, who have the possibility of more easily gaining a competitive edge on their traditional competitors.

## 2.5 Implementing Mass Customization in Footwear Enterprises

The aim of mass customized shoe manufacture is to produce individual units of shoes where each pair of shoes, including the left and right shoe, are different. To obtain the competitive advantages promised by the mass customization paradigm, both the organizational structure and the productive process must be updated [6]. The emerging tendency by a capital goods producer is to become a service provider rather than a product provider – according to the global service philosophy, which helps to make the whole scenario more homogeneous inside the



mass customization context and its related requirements. Manufacturing companies, then, need to be 'customer oriented' rather than 'product oriented', consequently changing their own organizational structure. There is an identifiable trend to ask for manufacturing services (rather than production units) that could be rented only for the time of use; this is true for all SMEs, as they do not have great financial resources at their disposal.

Together with the development of systems, which are able to evolve during their own life cycle and adapt to market requirements, renting the desired configuration of such a manufacturing system may be a 'financial' instrument to mass customization. A number of different, new strategies are developing to deal with these market developments that require a market layout redesign. On the system producer side, the manufacturer of the machinery could retain ownership and lease 'production hours' or 'products per month', taking responsibility for operation, programming, service, maintenance, *etc.* Their customer (a material goods vendor), would pay for this service. As an alternative, a 'system integrator' might act as a 'technology broker', working as an interface and arbitrator between a company that needs a given productive capacity, and a group of functionalities and one producer of modular macro-components of the production facility [7].

This actor, probably supported by a finance or leasing company, would be responsible for the selection of the modules, their customization for the required process and their integration. They could rent a customized production capacity to the end user together with the operation and maintenance services. After completion of the rental period, the facility could be disassembled into its basic 'building blocks' and be reused again and re-assembled for a new production capacity that would fit new end-user requirements.

Expensive and time-consuming tasks such as maintenance and reliability become critical aspects in these evolutionary layouts. Maintenance would in fact be part of the service provided, so that the provider is interested in minimizing breakdowns. Thus the equipment must then be designed for maintenance. Modularity and re-configurability in manufacturing systems and system components must also be considered as key enablers for such a new market layout [8]. It must be noticed that in such a scheme the system provider becomes a process provider. This is coherent with the mass customization paradigm, in which, as previously described, the emphasis must be laid on the process and its life cycle rather than on the product. Many products are realized inside one process, and each process lasts longer than the product realized inside it. The type of update in the organizational structure of the enterprise for this market layout change can be considered as a part of the extended enterprise approach [7]. This seems to be a promising paradigm that allows enterprises, and in particular SMEs, to cope with the dynamic nature of the current global market and to compete with larger organisations [8].

## 2.6 The Role of Technology: Where to Find the Appropriate Enablers

Various technologies have been, in time, developed and tested to support shoe mass customization operations; they can all be regarded as “enabling technologies”, *i.e.* aimed at supporting the various processes (design, sale, manufacturing and distribution) through which the mass customization paradigm is realized in footwear. Most of them were born in the EUROShoE project (which will be extensively presented in the chapter 3), and at its conclusion most of them were at a relatively early prototypal stage. Nevertheless the work done in the project had the merit of highlighting the key technological components without which mass customization in footwear cannot work.

The aim of this section of the book is to provide the readers with a short review of the solutions that, in the years that followed the conclusion of the research effort, have appeared in the market and which shoe makers can rely on for the implementation of their mass customization projects. As the experience of the EUROShoE project taught, specifically developed technological elements are needed at all stages, from design to sales, from manufacturing to distribution; but what actually characterizes the mass customization approach is the way the shoes are offered and sold to the consumers (as it will very clearly appear from the case studies in Sections 4.2 and 4.3). Mass customization can exist even with “traditional” manufacturing means and with limited enhancements to the design procedures and the tools used in that phase; but without the set of dedicated equipments, software and procedures adopted at the point of sales, it simply cannot exist. Hence we will concentrate here on this family of technologies.

It is convenient at this stage to split the hardware and software “architecture” of a footwear mass customization system into two sections: the “front office” (or “front end”) part and the “back office” (or, better, “back end”) one. With reference to Fig. 2.6, we can identify four major “technological modules” in the architecture of the front end:

1. **Foot scanner** - this is device that is used to capture the features of the consumer’s foot and to obtain its more relevant measures. There are two classes of devices of this kind that can be used and that have been adopted by one or the other of the MC companies:
  - Manually/automatically operated measuring machines - this kind of system doesn’t actually perform a real scanning of the foot and does not produce a digital model of it, instead it registers the 3D location of selected points on the foot, from which distances, lengths, breadths and widths are calculated. The machines are basically manually operated and require a certain skill of the operator to deliver the desired results
  - Fully fledged foot scanners that, with the use of specific laser, optical or photogrammetric technologies, can generate a 3D digital model of the foot; on such a model several predefined geometric measures can be taken to characterize completely the biometry of the foot.

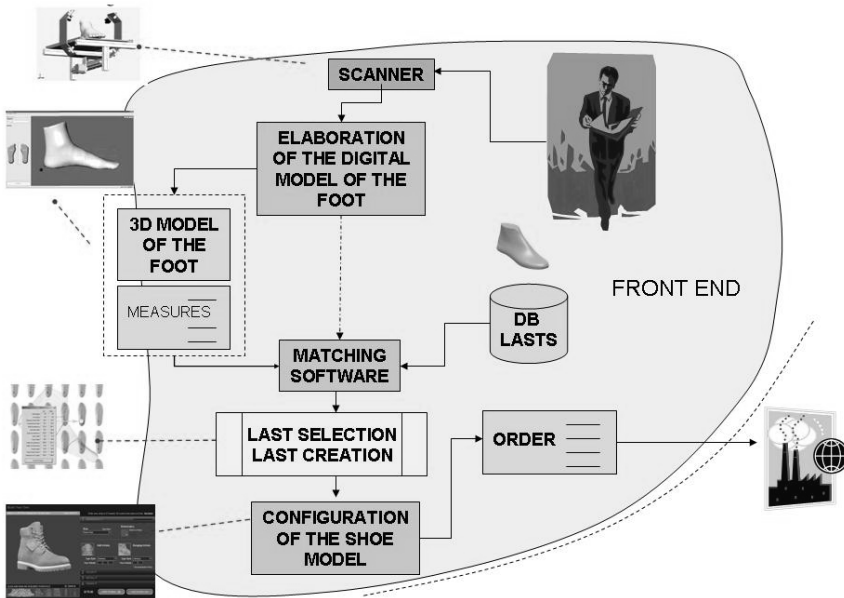


Figure 2.6. The front end architecture

2. **Matching software** - this is the second “core” module that enables the mass customization shoe sale process. It is normally a software module<sup>17</sup> that performs the comparison of the measures of the scanned (or measured foot) with the similar (homologous) measures of the last; the purpose of this operation is to identify the “best-matching” last among all those (for all models and all size/width combinations) stored in the data base of the company. Easy of use, reliability and consistency in the selections and automatic operation (no need of skilled personnel to use it) are the desired features of this software module.<sup>18</sup>

There exist also other software applications that allow a visual and interactive comparison of foot-last. In such a case the matching software is not installed in the shop, but foot data are instead sent to the company’s headquarters and

<sup>17</sup> Normally, but not necessarily, from the presentation of the case studies, it can be seen that in the case of Selve, for instance, the identification of the optimal last size for a given customer is actually done with the aid of no software; this step rather relies on the experience and know-how of the sale personnel.

<sup>18</sup> There are several options possible here: if the consumer knows in advance the shoe model and the style he or she wants to buy, the last “shape” is fixed by the model selected and only the size and the fit are to be searched in the matching phase (a “style-first” kind of search); when the consumer has no precise idea of the shoe model required, then a more general search is done that leads to the identification also of a possible range of shoe models (styles) that match his or her foot measurements (a “measurement-first” kind of search).

where each customer's order is manually processed, by visually (using another family of software applications) comparing the foot with the last in the database until the appropriate one is found.

The matching software is, most of the time, the only one used in the shop at this stage; but for companies offering true custom fit (like Viavor for example) other software programs are used, whenever an acceptable fit is not found among the lasts in the database, to elaborate the geometry of the tailor-made last. This operation is not done in the shop, but instead belongs to the back end processes.

3. **Shoe configurator** - this is the software application used, once the size and fit of the shoe for the consumer has been selected, to "configure" its personal variant of the desired model (selection of the materials to be used, of their colours, of the components and accessories that will be used for their shoes). This family of applications is widely used by all those companies that have started offering aesthetic customization and it is the most relevant enabling technology for such an approach; there are examples of shoe configurators at various levels of sophistication, designed for Web use only or for multiple use, both in the shop and on the Internet. Although we cannot yet speak of "standardized" off the shelf solutions, we already notice the presence of "dominant designs" for this applications that can be easily reviewed by visiting the Websites of the various companies that we present in Section 4.2. In this case too, it is not said that the configuration process can only be done with a software; once more the case of SELVE and also of the Mongolian BBQ show that the creation of the personalized variant of the shoe for the individual consumer can also be done physically with no software, by selecting the desired options from a component catalogue.
4. **Last database** - a database of lasts in digital format is necessary in the case the matching process has to be done automatically using a dedicated software module. This might not be an issue when the mass customization company is already using a 3D CAD software to design its lasts and shoes, but when this is not the case (as with shoe companies only using 2D CAD, or start-up companies which outsource the design process), this tend to become a critical point. In all these cases, lasts must be digitized, stored in a given and appropriate data format, and managed through a carefully designed database tool that can support easy and fast searches among numbers of occurrences that can be relatively large (hundreds or thousands of items depending on the number of different styles offered and on the range of sizes and widths each style is produced in).
5. **Order processing system** - although less relevant than the others, the importance of this last module should not be underestimated. It can take the form of a very simple procedure that, at the end of the scanning-matching-configuration process, summarizes all the relevant elements of the customer order and is then sent to the manufacturing unit (the back end). Or it can be a much more complex set of IT procedures, that integrate a POS (point of sale) system, that interface the company order processing and production management and planning system. Whichever the case is, this module completes the whole procedure, consolidates and stores the customer's data,

and initiates the process that will lead, eventually, to the delivery of the customized shoes to the consumers. Hence its role in the process chain must be adequately planned. It is a good and advisable practice that the procedure (or the software application) used can produce a set of printouts and documents that can be left with the customer to document its purchase and as a remainder of the choices he or she has made.

These five modules are found, with various degrees of sophistication and possibly aggregated in different paths, in all implementations of mass customization that we have monitored so far; they are then to be considered the basic ingredients for all projects of this kind. It is then important to examine what the market is offering, in terms of hardware and software solutions, to fulfill the needs of footwear companies wishing to implement their mass customization project, starting from the front end side of the business. In the next section of this chapter we will then provide a quick reference of the most consolidated available solutions that have appeared in the last few years. We have concentrated our attention in particular on *foot scanners*, on the *matching software* and on what we can call *integrated systems*.

Concerning the scanners, we will only provide information on automatic devices, leaving aside the kind of manual measurement systems that some companies are still using; although the reasons for their adoption are understandable (simplicity and low cost among others), we are convinced that they, on the other hand, require quite a high level of attention and skill in capturing the right points on the foot and only permit the acquisition of a few basic foot measurements. It is for these reasons that we believe that they are not really adequate to provide the matching application with the quality of data which is needed. Therefore we will turn our attention to the more promising and fairly mature automatic scanning systems.

Configurators are a family apart; as already mentioned there are no specific applications that can be bought as such on the market; all the big names presented in Chapter 4 have invested relevant budgets into the development of their own configurators (although the similitude of some of them leads to thinking of a common software engine underneath the different, customized user interfaces). And this is possibly the situation for all other companies which will have to consider investing, as far as this module is concerned, into the development of a tailor made software application to fit their needs.

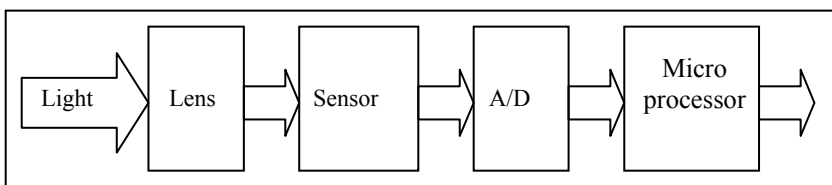
There are different modes of mass customization as we have seen in the previous chapters and as it will be shown particularly in Chapters 3 and 4. However, we may say that when we talk in particular of footwear, we are confronted with the following technical challenges:

- the object to customize is extremely variable both in term of the foot as well as of the style designed and selected by the customer
- the foot itself may change slightly of shape during the day and during the seasons
- the type of shoe may vary greatly in terms of materials, components and form.

To customize the shoe it is necessary therefore to perform at least some measurements of the feet of the customer and then adapt these measurements to the type and style of the shoe chosen by the customer. The foot is a three-dimensional shape and therefore until few years ago only some more or less standard measurements were taken with some sort of simple ruler in term of length, width, girth, *etc.* If more of such measurements are taken, more information is gathered and therefore more precision on the real foot is possible. Of course the larger the number of measurements the more difficult it becomes to interpret and correlate the data. With the advent of cheaper computer power, it became feasible to scan the feet in three dimensions. Several technologies are available for 3D scanning: laser beam, 3D photogrammetry, *etc.*; each requires a 3D reconstruction of the scanned data in terms of point clouds and/or plane patches, or 3D splines, NURBS, *etc.* Research in the past concentrated on the use of digital cameras as a scanner of 3D shapes.

There are several different techniques to make digital cameras. These techniques result in cameras with different quality and applicability to a variety of uses. The idea behind using cameras in a foot scanning system is to use low cost consumer digital cameras for the photogrammetrical 3D measurement of the human foot. An understanding of the methods used in the camera's design is required to judge the suitability of a given digital camera technology for this specific application.

Fig. 2.7 shows the general schematic for transforming an optical image into a digital one. The image sensor is a grid of photo diodes which convert the photons that strike them into electrons. The electrons are stored in small buckets (capacitors) which are read out as a series of varying voltage amplitudes which are proportional to the image brightness at the particular picture elements (the pixels). The analogue voltage amplitudes are converted into binary numbers by an analogue-to-digital (A/D) converter and the numbers are stored and processed by a processor within the camera.



**Figure 2.7.** Transformation of an optical into a digital image

There are several definitions that are typical of digital camers:

- geometrical resolution
- dynamic range
- sensitivity
- blooming
- colour aliasing

We will not enter into the details because they are explained in several textbooks on the subject but the correct selection of the above parameters are essential for the definition of low-cost and easy-to-use foot scanners. The development of a very low-cost and mobile foot scanning system for capturing the relevant dimensions of the consumer's foot both in a shop and at home was one of the purposes of the EUROShoE project. The system was based on photogrammetry. The foot is covered with an elastic sock which is marked with special photogrammetric patterns. It is then photographed from a certain number of overlapping, but otherwise unknown, handheld camera positions. The photogrammetrical marks will be detected automatically using a combination of colour and black and white image processing. Once the corresponding marks in the different overlapping image pairs or triplets have been detected and the lists of homologue marks has been computed, the 3D coordinates of each mark are computed using close-range photogrammetry techniques.



The foot must be static during the imaging; more exactly, the foot can move in space as the camera does during the shooting of the different overlapping images, but it must not change its shape in between ("frozen foot" condition). This nevertheless means that the image acquisition time is limited to maybe 30 seconds.

On ground of the low-cost requirement the only candidates for the scanner were one-chip color cameras with mosaic filter. These cameras have adequate resolution but suffer from so-called "artifacts" (defects in the acquired pictures), especially blooming and colour aliasing. Although these cameras are not designed as geometrically accurate measuring cameras, they can be used for the foot digitizer having an accuracy requirement much below that of an industrial photogrammetry system. The more professional three-chip and high-resolution scanning cameras are much too expensive and not suitable for a consumer approach.



With, for example, a foot scanner like the light beam® 3D you are able to digitize the 3D shape of a foot and take - fully automatic - corresponding measurements like length, width and ball girth. Based on a patented MagicalSkin® technology, this scanner is also easy to transport and affordable.



The customer can access his or her 3D foot and measures immediately after a scan over a Webpage which can be integrated and customized into a Website. The client software controls the scanner connected to a PC via a USB 2.0 interface, it sends the data for 3D processing to the servers and receives the foot scan in about 20 seconds. The 3D copy of the foot can then be seen on the screen, measured and stored in standard 3D formats. Once processed, the data is available in a local database in the client software.

There are many scanners now available in the market and the most important ones are summarized below. Since technology in this area develops rapidly, we don't claim this to be a complete or up-to-date list of all the available systems of the this kind. It nevertheless gives a good idea of the range of solutions available at the time of preparing this book, their main specifications and possible field of application.


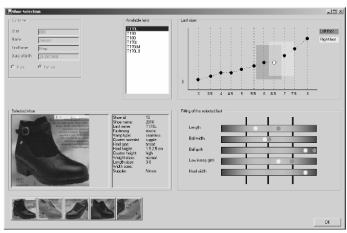
Scanners	
	<p><b>Corpus.e</b></p> <p>The German-based company Corpus.e offers the Lightbeam<sup>®</sup> Photogrammetric scanner. It is a low weight, easy-to-use foot scanner that can be connected via USB to any desktop or portable PC. The consumer wears a special sock (the Magical Skin<sup>®</sup>) with a special pattern that is used by the software to generate a 3D model of the foot. No local processing of the scanned data is done; the frame captured by a digital video camera are sent to a remote server for the elaboration of the foot model. The company sells the scanner and charges an elaboration fee for each foot to be calculated. The software that controls the scanner is programmed to compute the most important measurements of the foot</p>
	<p><b>Infot</b></p> <p>Infot is a Japanese company that has developed the technology for the scanner that is commercially known with the same name; the system has been further integrated and developed by the UK company CSM3D (now part of the Torielli Group) which distributes it around the world. The scanning of the foot is done using a laser beam that is moved along its length. The foot to be scanned should (preferably) wear a white sock for the process. The reconstruction of the foot is done locally in the PC that is integrated in the system. The scanner has no built functionalities to calculate the measurements of the foot; additional software modules are needed for that.</p>



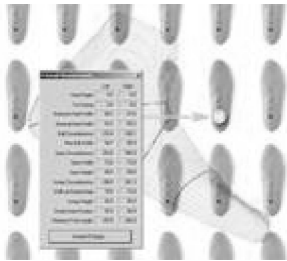

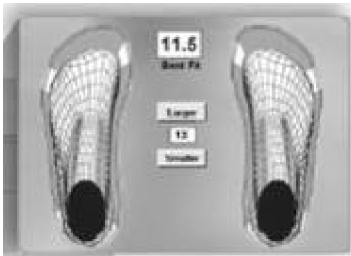
	<p><b>Vorum</b></p> <p>Vorum is a Canadian company with a long experience in the development of hardware and software solutions for the orthopaedi sector. The scanner the company offers for MC applications uses the same approach o the Infoot system (a laser beam that scans the foot); the elaboration of the foot model is also done locally in the PC that controls the scanner and that is part of the scanning station. The scanning software is very complete and can provide a full range of measurements on the foot.</p>
	<p><b>FotoScan</b></p> <p>The UK-based company Precision 3D offers a fixed base scanner (no moving elements) that uses a set of digital cameras to take images of the foot from various directions; these pictures are then combined to generate the 3D model of the foot using a photogrammetric reconstructing technique. The company also produces another device, a plantar scanner aimed at digitizing the plantar surface of the foot for the production of custom orthotics and customized foot beds. Although the equipment produced by Precision 3D systems seem very much orientated to the orthopaedic sector, they might also be successfully employed for mass customized shoes.</p>

	<p><b>UCS</b></p> <p>UCS is a young software and hardware company based in Slovenia, it is a spin-off of the mass customization experience of Alpina with whom UCS worked in close cooperation. The scanning system they offer is a very simple, entry-level equipment that can take, with a simplified scanning /measurement process a few relevant measures of the foot. Rather than a stand-alone solution, the UCS scanner is to be seen as a component of the integrated system USC has developed and that we will present in the next pages.</p>
	<p><b>Formalogix</b></p> <p>The company is based in the United States and has developed an integrated solution that has many commonalities with the UCS system. The scanner, which can also be offered as a separate unit, uses a set of fixed digital cameras to take pictures of the feet from various angles (notice that it is the only unit that scans both feet at the same time; all the others process one foot at a time). A 3D digital model of the foot is then generated; the basic length and width measurements can be extracted from the model of the foot, as well as many others of its relevant features. The model of the foot is stored locally in the kiosk and sent overnight to a remote server for the computation of the measurements.</p>

A summary of the matching software available on the market is given next. If, for the scanners, we can already see a relative diversification in the product offering and a good level of “stability” in their technical solutions, for the last-foot matching software modules we are still in a much less developed situation.

Matching software	
	<p><b>FotoFit</b></p> <p>FotoFit<sup>®</sup> is an interactive software application developed by the UK company CSM3D (developer of the well-known Shoemaster<sup>®</sup> shoe design CAD and now part of the Torielli group). The software is used for a manual matching of the foot against the last; the foot and the last are automatically aligned and then compared visually to verify the correct matching of the last. The software allows the user to perform a wide range of controls on the foot data and to make use of a set of predefined measurements.</p>
	<p><b>Shoe Selector</b></p> <p>Although this is not (at the time of writing these notes) a commercial product, but instead a prototype developed in a research project, it might soon become the first “off the shelf” matching software available in the market. It allows a “semi automatic” comparison of the foot data (measurements) with those ones of the lasts in the database and suggests, within a certain range of tolerance, the ideal (best-matching) last separately for the left and right shoe. A “control deck” gives the user a visual clue of the goodness of the matching. This application stems from the consolidated background in footwear technology of INESCOP, a well-known shoe research establishment based in Spain.</p>

A list of integrated solutions is given next. These combine a scanner and matching software in one package.

Integrated solutions	
	<p><b>Vorum</b></p> <p>Vorum offers a complete and integrated solution to cover all the most relevant phases of the MC process and in particular a complete and powerful matching software that is sold together with the scanner. The software receives the foot data from the scanners and compares them with the previously stored last database. The best-matching last is suggested; when a best-matching last cannot be found, the system suggests to produce a custom fit. A different software module of the same suite of programs does the calculation of the tailor-made last.</p>
	<p><b>UCS</b></p> <p>The integrated solution proposed by UCS uses the foot data acquired by the scanner to perform an accurate search of the best-matching last; a ticket is printed at the end of the process. A list of candidate best-matching lasts (in terms of lengths and widths) is proposed; a try on test in the shop is supposed to confirm the selection made by the software and to help identifying the correct solution for the customer.</p>
	<p><b>Formalogix</b></p> <p>The integrated solution proposed by Formalogix can hardly be classified in this group of solutions for shoe MC. In fact the company seems to promote its system more for shoe retailers (in general terms) than for shoe mass customizers. Its general validity as a system to scan feet and to select a best matching last from a library of digital ones to then produce a pair of shoes made on order, is certainly confirmed. But this does not seem to be a prime target in the view of its developers.</p>

The particular application proposed by Formalogix (and also by UCS) can be regarded as a possible additional and promising “fallout” of mass customization technologies: instead of scanning feet and matching lasts to produce shoes on

order, the idea is to use the same approach to help consumers and retailers in choosing the right size of shoe.

These companies offer their solutions as “virtual fitting systems”: the client is supposed to indicate the specific model of shoe he or she wants to buy, then goes to the scanner to get his or her feet scanned and the system will specify the correct shoe size. Perhaps we are not dealing here with mass customization (shoes are already there, they are not done on order, there is no involvement of production), but it cannot be denied that this approach offers clear advantages to consumers - it educates them to choose shoes in a more “professional” way and it gives the retailer the chance of offering its customers a valued added service. No mass customization but certainly consumer centricity as a fertilization from the pure mass customization approach.

## **2.7 Mass Customization, Footwear and Economics: A “Win all” Game**

The implementation of mass customization (MC) principles in a mass sector like footwear requires that shoe producers change their vision on production and organization. This is already taking place at the level of large companies, which are offering the possibility to their customers to personalize the product (Nike and Adidas are applying the principles of MC). In the case of small and medium size producers this is much more difficult due to problems in adapting processes and production, which are designed to produce large amount of items.

The organizational re-engineering is one of the most important issues for the development of a mass customizing company, because different actors (shoe manufacturer, external designers, suppliers, component manufacturers, subcontractors and customers) are all involved in the shoe life cycle and their relationships need to be reengineered. So MC is not only a matter of new production lines or new machines but it is also a matter of redefining [9]:

- the internal processes of the footwear company
- the processes with external partners, suppliers, subcontractors, *etc.*
- the processes with market/customers (sales and distribution)
- the implementation of ICT tools to appropriately support processes.

Companies that are adaptive to the changing environment to specifically meet the customer demands/expectations are more likely to be affected by the benefits of MC. Taking as a model the Dell strategy, a company should eliminate some intermediaries in its production chain and interact directly with its customers especially via the Internet [10] to provide tailored solutions supporting a physical product with value added services. It may be a high tech or a manufacturing product but it has to be customized. Improvements in the relationship between production and marketing within the firm is another way to get benefits, while internal and external flexibility of processes should be enhanced also by the introduction of new machines and new ICT solutions.

The aim of this chapter is to study different strategies for traditional shoe producers that are willing to implement different degrees of mass customization. The work is based on a strategic and economic evaluation of the different possibilities offered to a shoe producer willing to apply such an innovative paradigm. The evaluation is based on the data collected from the outcomes of research carried on in this field and on data from real traditional companies producing shoes. Simulations have been done to define costs and new working time for new strategies implementation and they have been tested to verify which were the differential costs that a traditional company has to sustain in order to produce MC shoes using innovative machines and using ICT platforms to integrate the production process with all the other processes of the shoe life cycle such as sales, design and distribution [11].

Until now in literature many theoretical references explained changes in the cost structure for implementing an MC strategy [1] but few economical estimations are based on real data. The data can be considered a preliminary analysis of the most important costs and benefits of such an implementation.

### **2.7.1 Most Important Changes in Terms of Costs and Benefits**

As has been emphasized in the previous sections, the MC approach implies organizational and technological changes at company and supply chain level. Summarizing some points already described above, it is possible to assess how they can affect the typical production cost structure [12, 13, 14]:

- The costs increase for lower economies of scale as product variety increases and lot size is reduced;
- MC influences order management, moving from ‘make to stock’ (MTS) to ‘assembly to order’ (ATO). This guarantees a decrease in stocking costs since warehouses are no longer packed with shoes waiting to be sold. This implies an increase in the cost of quickly coordinating shoe assembly.
- There is an increase in set up costs due to the diversification of products (many changes of tool, *etc.*); in the case a company decides to produce MC shoes with a new dedicated production line this category of costs is counterbalanced by the higher flexibility of the new production system.
- An increase in diversification costs can be counterbalanced by the postponement of the phases more affected by customization along the production process.
- There will be changes in the distribution costs, because the direct effect of an ATO policy is an increase in lot number which means an increase in transportation costs due to more frequent and more spread delivery.
- There will be relevant investments in automating the production and assembling process by buying innovative and adaptive systems.
- New competences will be required to make use of new automated machines in addition to the consolidated skills at production level, which means investments in training and upgrading.

- Finally investments in software for production management and customer relationship management will be required.

In general, additional costs need to be counterbalanced by appropriate capability of design for variety, developed thanks to training and hiring new designers, use of a modular product architecture, increase in the capability of production planning and control with the support of appropriate tools and postponement strategies [1]. Most important is to increase the capability to integrate customers during the value creation process starting from re-engineering of the sales process and the relationship of this process with production, as already emphasized.

Another important factor to consider is the cost of materials (raw materials and components) and in particular the cost of the shoe last (the last is the block of wood or plastic shaped like a foot, used for the shoe assembly). For standard shoes the request of new lasts is mainly linked to the seasonal new fashion and they can be reused many times as long as models are the same and the last is not ruined by multiple steps of processing on the lasting machines. In the case of customized shoes the last can be personal for each customer<sup>19</sup> and even if it can be possible to reuse it for more than one pair of shoes (if the shape is the same), it is necessary to consider the higher amount of sizes and fits which are to be available to satisfy all customer needs. The last is already a relevant cost for the shoe producer and the production of customized shoes is linked to the customization of the last which increases a lot the costs for materials both in the case the company decides to make it internally or to outsource its manufacturing. In the former case it is necessary to buy innovative machines for last production which have still a limited capacity and can be the bottleneck of the whole production, while in the former case it is necessary to outsource a higher amount of lasts.

As we have listed above, the approach to MC has also a significant influence on lot sizes, reducing the average size of shoe lots from 500 - 1000 pairs to about 10 - 20 pairs per lot (where each pair of the lot can be different from the other), or even to strictly one pair lots. This can have an impact on many other costs like production and distribution costs, increasing the complexity of planning, scheduling and tracking orders [15]. These expenditures can be counterbalanced introducing the usage of efficient ICT tools to provide the required autonomy in decision making and flexibility in job sequencing and to increase efficiency of the distribution network.

The costs of stock management (raw material, [WIP] and final product) for customized shoes decreases compared to standard shoes only if a lean management of materials is applied to eliminate unsold finished product. In fact it is possible to consider that the amount of stock of raw material and WIP (uppers and components) decreases when a strong investment is undertaken also on the ICT systems supporting the capability of the company to manage production and sales in an integrated way, reducing the amount of stocks at the end of the period compared to the amount stored for standard shoes.

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<sup>19</sup> This is true for custom fit or bespoke shoes; it is not the case for the bestmatched ones.

### 2.7.2 Steps to Mass Customization Implementation

Given these changes on the cost and benefit structure, it is now possible to evaluate the impact of MC on a traditional shoe factory. Typically shoe producers completely outsource the preliminary phases of production, like cutting and stitching and the manufacturing of main components as heels and soles.

The investments in MC can be implemented at different levels according to the degree of technological and organizational changes the company wants to apply to its own production system and organization. It is assumed to deal with a traditional scenario where a shoe producer purchases from subcontractors raw materials and components to obtain the final products. The most important investments which should be undertaken by a shoe producer in order to implement a MC strategy, have been grouped into five *macro cost categories* (progressive tiers of cost allocation on the way to the full achievement of the MC project) according also to previous studies [16]:

#### **Macro 1: Purchasing a consulting service for MC from a specialized centre**

When a traditional shoe producer decides to start with MC, it may need support of external consultants on how to transform its business to MC. This service supports the company in defining, for each phase of the new shoe production, most convenient times and methods for reengineering processes through feasibility studies. The service may consist for example in the realization of a simulation analysis based on the current production configuration of the shoe producer itself considering both standard and customized shoes. In fact the company does not have to necessarily change its manufacturing processes but it can simply modify the production organization and the industrialization of the customised shoes. The quantification of the cost of the service provision are related to the time required to the technical staff of the service provider to collect all the data about the production system, to implement the simulation model, to run the simulation and to brief the footwear company on the results of its study. This first source of costs related to the implementation of a MC project, can be regarded as the initial step – minimum investment for the exploratory phase of the project itself.

#### **Macro 2: Changes in the sale process**

This investment category represents the first concrete step towards MC; it supports the direct relationship between the shoe producer and the customer. It implies the purchase of a foot scanning system which will be installed in shops to directly gather information on customers' foot size and style preferences. The company can decide to purchase the foot scanning systems for all or some shops selling its shoes (they can be both private and multiple label shops according to the strength of the shoe producer in the final market). The investment includes also the software (databases and data gathering) to acquire and store data from the shops on the customer's requirements, the training of personnel and marketing activities.

#### **Macro 3: Software purchasing**

MC requires short response time for very small production lots (there may be also lots with only one pair of shoes). This means a very high degree of integration in



the supply chain. The “shoe pipeline” includes many different actors which should integrate their processes using software specifically customized for the shoe sector: an integrated environment where CAD, CAM, ERP, SCM and a scheduler are necessary at this stage to communicate and transfer information also to subcontractors to shorten their response time.<sup>20</sup> This will imply also investments and costs on training personnel. Moreover it implies assuring a proper time to market for products. This can be obtained mainly managing production in order to avoid delays and maintaining production time similar to standard shoes and organizing distribution in order to deliver the product to the customer.

#### **Macro 4: Purchasing of new production machinery**

The company can, at this stage, decide to introduce innovation at production process level by adding new machines for the customized shoe manufacturing. This change can involve the whole process (from cutting to assembly) or just some steps of it. An example is represented by last making which is particularly important in the MC approach. The last of the shoe needs, in the case of custom fit, to be personalized for each customer and outsourcing its production can be very expensive. Usually during one season a shoe producer can reuse the lasts for 300 - 400 times but for a MC production it is necessary to increase the number of lasts according to the level of personalization adopted.

#### **Macro 5: Purchasing of a new internal logistic system**

The company can, eventually, decide to invest also in a logistic system which can be devoted not only to the storage of shoe components, both processed internally at the plant and externally by suppliers, but also to dispatch such components to different locations both in the stitching and in the making departments according to the planned schedule [16]. This investment can increase the flexibility of the overall production system and the capability to handle urgent orders.

### **2.7.3 How to Integrate the Macros Towards Mass Customization**

As it was explained in the previous sections, there can be different kinds of MC depending on the degree of customization: “Best-matched fit” (BF) are shoes with a wider range of fit and size compared to standard (STD) shoes, so to meet the needs of many different customers matching between available lasts and foot measurements; “custom fit” (CM) shoes are more advanced because the last of the shoe is personalized for each customer: CM shoes are also considered for particular categories of customers with problems on foot shape. Also in the case of CM shoes, once the foot is measured by a scanner the software first tries to create a match between the available lasts for BF shoes and the customer’s foot. Usually as long as the foot is not peculiarly shaped, the demand can be satisfied with the available lasts without the need to produce a specific one, which would add additional costs to the whole process.

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<sup>20</sup> A complete suite of programs of this kind has been developed in the EUROShoE project; for further reference see [5].

Responding to the market demand of customized shoes (either BF or CM or both) implies combining the five macro investments described above in relation to the different degrees of MC to be implemented. According to the demand level and to the company investment capabilities, this work investigates the impact of each investment scenario on a medium size, traditional shoe producer to understand how a shoe producer already in the market can combine traditional and mass customized production using outstanding enabling technologies under company's constraints on production, organization and resources.

In the case of macros 3 and 4 it was necessary to consider different sublevels of investment. They are in fact the most challenging ones because they include the implementation of the most relevant new technologies. This means that the company can step towards MC without introducing the whole changes required by the macro but just some of the steps. In particular:

- Macro 3 is structured into three levels:  
*Level 1* - introduction of a database for customers' data management to use all the data gathered from the shops during the sale process for the design and production process.  
*Level 2* - introduction of CAD and CAM systems for the last and the shoe design and production phase.  
*Level 3* - introduction of ERP, MES, PDM, and SCM<sup>21</sup> systems for integrating the different company departments and the external partners.

**Table 2.5.** Macro combinations

		<b>Macro 1: service</b>	<b>Macro 2: sales process</b>	<b>Macro 3: ICT</b>	<b>Macro 4: production</b>	<b>Macro 5: logistics</b>
<b>Higher degree of innovation from strategy A to strategy D</b>	<b>Strategy A</b>	Feasibility study from service provider	Scanning tools	Level 1: database for managing customers' data		
	<b>Strategy B</b>	Feasibility study from service provider	Scanning tools	Level 2: CAD and CAM systems	Level 1: machinery for lasts production	
	<b>Strategy C</b>	Feasibility study from service provider	Scanning tools	Level 3: ERP, MES, PDM, SCM systems.	Level 2; new production line	
	<b>Strategy D</b>	Feasibility study from service provider	Scanning tools	All software	All new production machinery	New internal logistic system

<sup>21</sup> ERP stands for enterprise resource planning; MES is manufacturing execution system. PDM is a product data management database and SCM a supply chain management system

- Macro 4 is structured into two levels:

*Level 1* - introduction of machinery for last production to produce internally mass customized lasts and shoes.

*Level 2* - introduction of a new flexible production line fully automated to change completely the production process.

Table 2.5 represents the way the different macros are combined in four strategies towards innovation to respond to MC requirements. These strategies are somehow incremental; starting from the minimal investment required for MC to the most complete level of investment. For each strategy additional costs and benefits for a traditional company are evaluated and estimated as shows Table 2.5.

### **Strategy A**

This scenario represents the very first step that a company can take towards MC. It can be considered the minimum investment in order to produce best fit (BF) shoes. In order to apply this strategy, the company outsources a feasibility study to a specialized service provider not only for the process but also for the product re-design. The other relevant aspect is to assure MC application is the re-design of the sales process: each shop, licensed to sell the brand, must be equipped with the scanning tool (a foot scanner of some kind) and the software for the customer's information management. The investments for this scenario are the purchasing of the scanning tool which includes the matching software and the configurator (macro 2). Moreover in this context it is necessary to introduce a Database for the management of customer information (which corresponds to a first level of innovation related to the macro 3). Costs are related to the feasibility study outsourced and to the equipment for the shop (including maintenance, training, and so on). Marketing costs are also relevant and very important for this and all the other scenarios and they have been taken into consideration in the analysis.

### **Strategy B**

In the case that a company wants to start the production of custom fit (CM) shoes, it needs to add to the previous scenario the cost of machinery for last production. For standard and BF shoes, lasts production is outsourced as in the traditional shoe process. The fact that the company produces lasts internally implies that it purchases also the CAD and CAM systems (macro 3) to integrate the shoe design process and the part program definition with the production of the lasts. Other relevant costs to consider in this scenario are for training of employees on the new software.

### **Strategy C**

In this case the company is more innovative, so it decides to further improve both the production process and the IT infrastructure. The company installs the new automated production line, dedicated to the customized shoes (BF and CM) and it hires new workers for the cutting, stitching (which becomes an internal activity) and for the assembling process. The assumption is that the company sets up a new manufacturing line and that the production of standard and customized shoes is run in parallel on different lines. The IT level is improved adding the ERP, MES, PDM

and SCM systems in order to manage and optimize the information flow concerning products, customers and suppliers. Other costs that will be necessary to implement this scenario are related to licences for software updating, maintenance costs for new machinery and labour cost.

### **Strategy D**

In this scenario the company makes the whole investment for MC adding to the new automated production line, an innovative logistic system to manage the distribution of materials and components along the different machines and along the phases of the new production line. The costs related to this decision are related to the acquisition of the logistic system, pallets, maintenance and operators' training.

Implementing any one of these strategies means that it is necessary to consider also the costs for external logistics for delivering customized shoes. This cost is higher compared to the standard production, because the company uses carrier services to ship everyday shoes to shops or to final customers.

### **2.7.4 Hypothesis on Shoe Demand and Selling Price**

Once the scenarios are defined some hypotheses for the test cases and some basic characteristics and values of the variables used in the evaluation need to be fixed. Demand for customized shoes is very difficult to assess. Some preliminary market analyses have been conducted at European level forecasting data and trends concerning both male and female expectations on customized shoes [1].

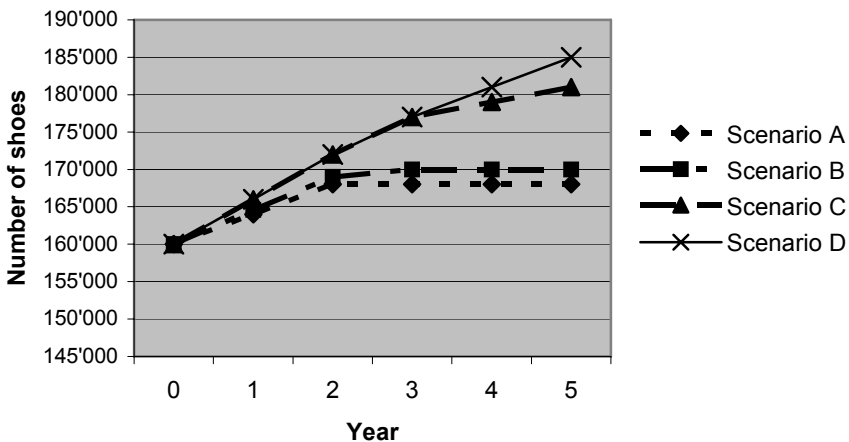
A first hypothesis done in this work is that the demand for customized shoes equals the production capacity of a shoe producer and no costs of unsatisfied demand are considered. In this study we do not take into consideration problems related to capacity limits in satisfying demand for customized shoes. It is assumed that the traditional shoe producer has one traditional production line with a capacity that is not fully used for the yearly average production. This is the most of the time true since in this sector there are seasonal peak demands to be satisfied and the shoe producer always needs to have some spare capacity. This capacity can be used to produce customized shoes in the case the strategy is very conservative and the management decides not to buy the new production line for MC. In the case of customized production this capacity can be used for BF shoes; the peak of demand for standard shoes can be outsourced if necessary.

As far as figures are concerned, the hypothesis made in this work is to consider a shoe producer with a plant with one production line that can handle a demand of around 100 pairs of customized shoes per day. This is also linked to bottleneck problems given by some machines and some phases of the process. In fact, in considering the first step of a customized shoe production, represented by the milling of the lasts, it is necessary to keep in mind the throughput limit of such machines which still represents a constraint for the process. If the company decides to outsource the production of lasts for CM shoes, the cost will increase proportionally with no clear advantage with respect to the purchasing of the

machine and for this reason it is advisable to the management to keep the last making process internal.

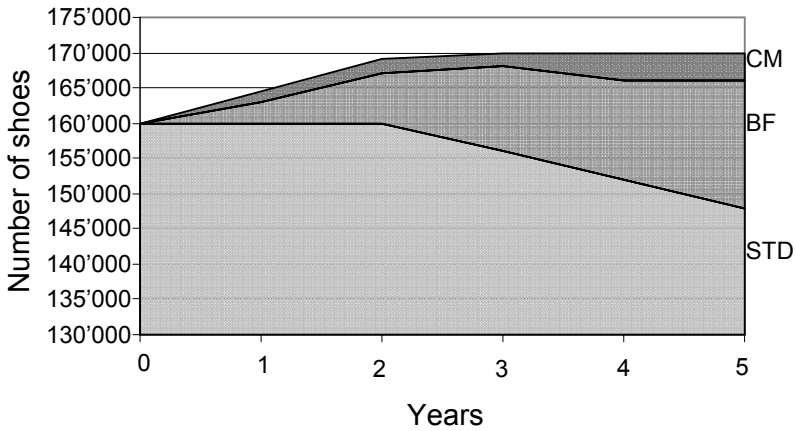
Usually standard shoes, even if sold in big numbers, do not completely satisfy the whole population of customers but just the mean. In fact, supposing that the tastes of the customers have a normal distribution, MC permits an increase in the number of people fully satisfied by the product and an increase in the consumer loyalty ensuring a long - term fidelity to the brand. Mass manufacturing fails in responding to individual needs regarding the desired ideal product of individual customers [17].

From the graph in Fig. 2.8 we assume that the different degrees of innovation also imply different capabilities to answering market demands. If the level of innovation is low (scenario A and B) the producer manufactures customized shoes (BF) using the traditional production line. Over the years the number of standard shoes manufactured could be reduced in order to produce more and more customized shoes; however in scenario A the company doesn't only produce CM shoes; so it is assumed that in the first years the company can take advantage of its spare production capacity, but that this capacity is very rapidly saturated so that, from year 2, there is no increase in the quantities of MC shoes produced.

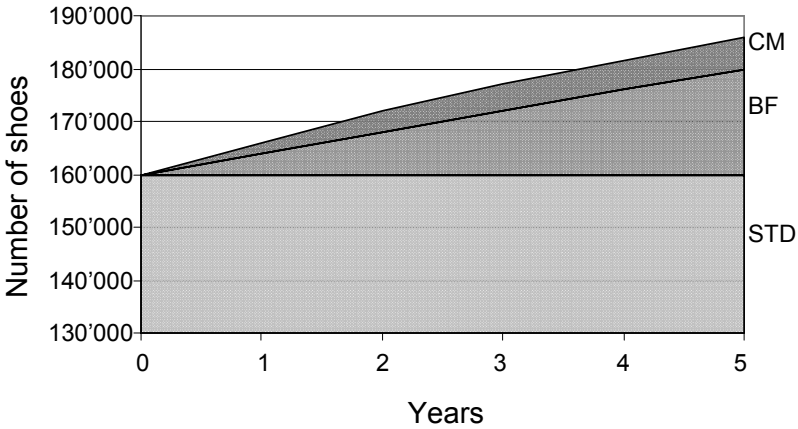


**Figure 2.8.** Total demand (production volumes in pairs per year) for each scenario

In scenario B (Fig. 2.9) it is assumed that the volumes of CM and BF shoes constantly increase with time, initially relying on the spare production capacity; as the market for MC shoes takes off, the production of standard shoes is progressively decreased to accommodate more and more customized footwear. If the level of innovation is higher (scenario C, D, see Fig. 2.10) there is no reason to reduce the production of standard shoes, because the customized (BF and CM) ones are produced on the new production line with an overall increase in the total amount of produced shoes.



**Figure 2.9.** Example of demand level for scenario B



**Figure 2.10.** Example of demand level of scenario C and D

The business model includes the possibility to also tune the price of the MC shoes according to the product level chosen by the customer. In fact the shoe price is based on the combination of different components (colours, heel, outsoles and kind of leather) that can be changed/added according to the customer preferences. It is assumed that the price is a normal variable, with a mean value and variance which is different for BF and for CM (in the case of CM we consider higher variance).

Empirical research has shown that customers are willing to pay up to 20 - 30% above normal price for the increase of service they get from shoes that fit better to their needs than the standard shoes available on the market [18]. It is to be considered that with MC there is a shift in the purchasing decision which is less

influenced by the level of price and more by the value of the product. The customer accepts to pay an average price higher than for standard shoes both for the intrinsic value of having a personalized shoe and for the experience of choosing his or her own features at the sale point.

### 2.7.5 Assessment of the Strategies

All scenarios are evaluated by forecasting the cash flows related to the adoption of new business models based on MC strategies. Investments are assessed first using the net present value (NPV) then applying risk analysis to evaluate the consistency of each scenario.

Some previous studies evaluated the economic relevance of MC in different sectors. A study based on the NPV calculation for the introduction of a laser sintering tool which offers the possibility to adapt any car design to specific customer requests was carried out in the automotive sector [19]. Kotha [20] examines the dynamics of implementing MC in a firm that pursues both mass production and MC in two different factories, making use of a detailed study of the National Industrial Bicycle Company of Japan. Reichwald etc. [21] evaluates MC from an economic perspective applying a general framework on a special setting of decentralized, customer centric production units (so-called mini-plants) located in close proximity to a particular local market in order to reduce distribution costs.

The analyses presented in this book calculate the best conditions in which to apply the MC paradigm in a footwear company according to its investment capabilities. It is assumed that the investment is monitored over a period of five years. In the computation model, cash flows are discounted using investment and inflation rates congruent with the cost of financing typical of the entire sector. Costs of production and similar assumed in this study are to be considered as incremental since we evaluated only extra costs and revenues linked to the application of MC strategies which are compared to standard production. The model was created considering data and information collected from:

- a traditional shoe producer for what concerns costs for production of standard shoes and the typical operational costs in traditional shoe factories
- simulations carried on forecasting the behaviour of traditional and innovative production systems with MC production in order to extrapolate data on production time, production capacity, etc. for the innovative production line.

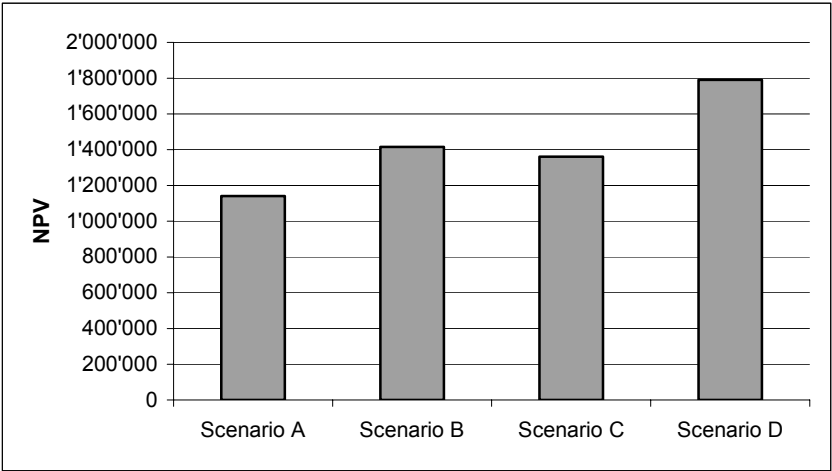
The variability of the NPV of an investment project is an indicator of the project risk level. As well known in literature, considering only the payback period is too limiting because it considers only the short term view on the investments; considering only NPV means choosing between investments according to their monetary value; considering also the variability of NPV permits to choose according to an analysis of many different stochastic variables that influence the whole scenario. The evaluation of the variability of the NPV in this analysis is based on Monte Carlo simulation which generates a (pseudo)-random sample

according to statistical behaviour of the most important variables , such as quantity, price and discount rate.

**2.7.6 Presentation and Comment on Results**

According to the collected data and their relationships (variable costs are linked to demand level and other direct and indirect costs driven by quantity and/or price), the above strategies for MC introduction give the possibility to increase the NPV with different impact according to the variability of the demand and correlated variables (costs, price, *etc.*).

The evaluation shows that the NPV of such investments for a traditional shoe producer is always above zero. If we compare the four strategies it is possible to see that its value grows since the increase of costs and investments is counterbalanced by the increase in the demand level which can be satisfied thanks to the introduction of new technologies (see Fig. 2.11).



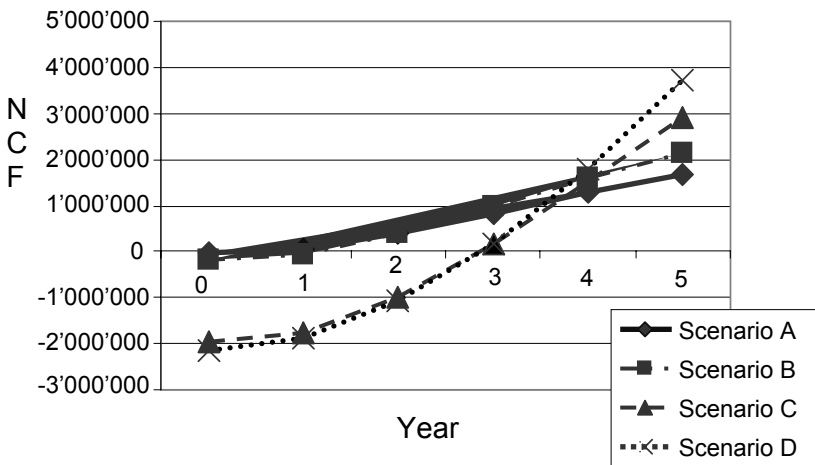
**Figure 2.11.** NPV for each scenario

In particular in scenario A the introduction of the scanning system for collecting information on the customer foot and the support received from a service provider for the feasibility study permits the company to sell a larger amount of shoes, even though some part of standard shoe sales is overtaken by the BF ones. With strategy B, the cost of machine for last production is compensated by cost saving on outsourcing of last production and by the increase in the level of satisfied demand with CM shoes. In strategy C the big investment in ICT and production technologies permits the company to increase the number of sold BF and CM shoes but the increase of NPV is limited due to large investments. Cost savings can be registered also in the percentage of initial stocks and in the amount of raw materials and components which the company manages to reduce thanks to a better organizational system.



Even though strategy D requires larger investments at the same time the total demand level that a shoe producer can satisfy is higher thanks to the greater flexibility of the system (achieved with the introduction of the logistics system) and the capability also of answering urgent orders. The NPV also benefits from an indirect impact on some other variables such as raw materials management or shoe delivery time which allow the realization of higher revenues.

In Fig. 2.12 it is possible to see that the payback period is very dependent on the type of investment undertaken: the first two strategies (A and B) requiring little investment can be quickly recovered while C and D require longer payback period (between two and three years). The investments in strategies C and D are more risky in the first year but in the following years they overtake the results of the other scenarios A and B.



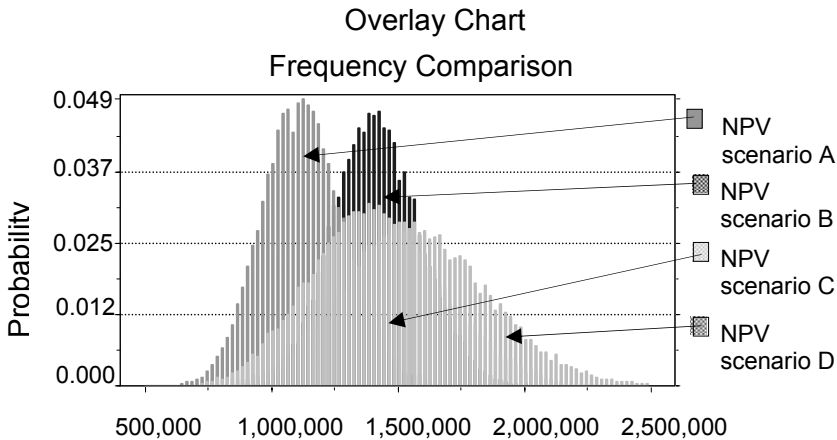
**Figure 2.12.** Cumulative net cash flow for each scenario

The goal of this work was not to define the best scenario for a shoe producer, but it is important to show how a company can decide to apply MC according to different strategies taking different degrees of risk.

### 2.7.7 Risk Analysis

After a static analysis, a Monte Carlo risk evaluation was carried out. Risk analysis assesses the same effects as a sensitivity analysis does, but also takes into account the probability distribution of the input variables. The four investment scenarios can be analyzed using this method because they are independent from each other, and a company can apply only one among the four without problems of stochastic dependency which can sometimes arise with Monte Carlo simulation. The most important variables, such as quantity, price and discount rates, have been given a probability distribution according to some hypotheses on their statistical behaviour based on historical data evaluation. For a matter of simplicity it was assumed that

quantity of sold shoes has a triangular distribution while the price has a normal distribution with the hypothesis that over the years the price is either the same or does not decrease. Moreover it is assumed that the variability of MC shoe price is higher with respect to standard and BF shoes and it is justified by the fact that (as already mentioned) the company can apply a different price to almost each customer according to the level and the type of customization required. Variable direct and indirect costs, change according to the relationships existing with the quantity and prices. Results of the four scenarios are shown in Fig. 2.13 where it is possible to see the distribution of the NPV.



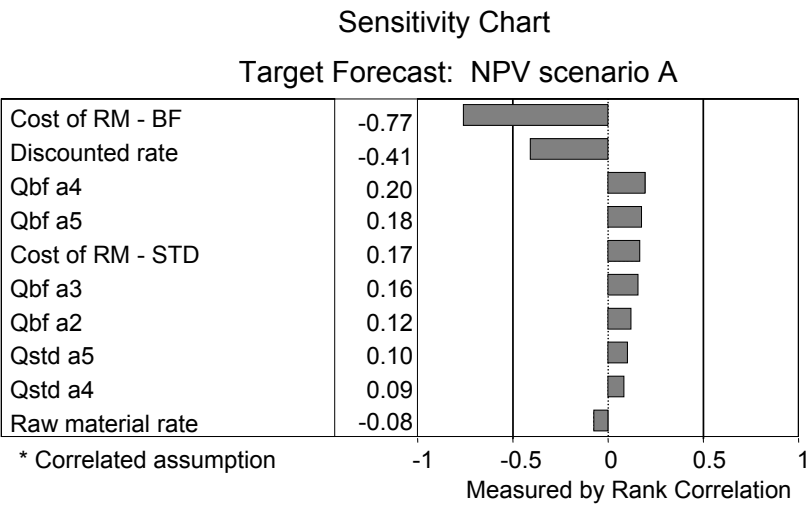
**Figure 2.13.** Comparison of the NPV distribution of the four scenarios

All the scenarios have a low risk level since the probability of having a negative NPV is zero. The strategies A and B have lower but more stable mean NPV values since their standard deviation is much lower than in the other two scenarios C and D. Higher variability in scenarios C and D is linked to the higher level of initial investment required, but they guarantee higher level returns.

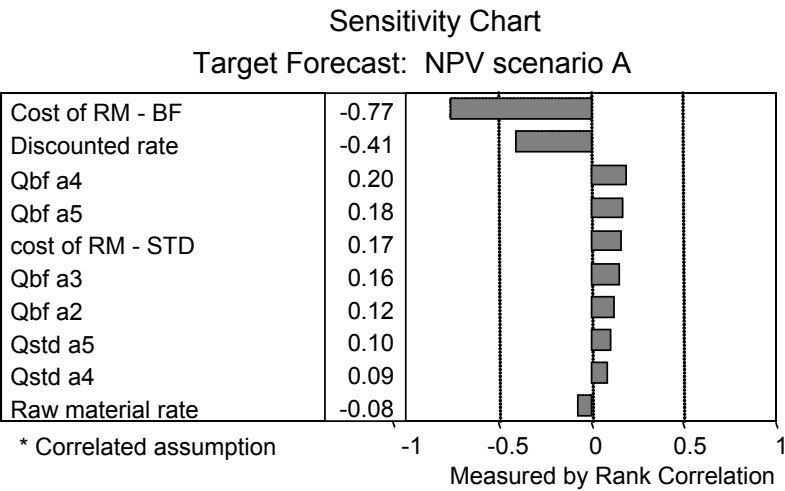
The risk analysis permits to evaluate also which are the most important input variables influencing the NPV in each scenario, according to their behaviour and their correlation with the NPV distribution. As an example we show the case of the scenario A (see Fig. 2.14) where it is evident that unit costs of raw materials for BF shoes largely influence the behaviour of the NPV as well as the discount rate. The variability of quantity level of BF shoes has a positive influence and it is more or less the same along all the years.

From scenario B the unit cost for raw materials and components for CM and standard shoes assume more relevance on the variability of the NPV while in scenarios C and D the variability of the discount rate influences the overall NPV due to the larger variability of the cash flows (see Fig. 2.15 for scenario D). Costs of raw materials are generally a very influencing variable and in the case of customized goods they are even more strategic than in the case of standard shoes, given the higher variability that is to be managed. The just-in-time approach

becomes even more a winning strategy thanks to the ICT software that can support integration between different providers and different departments.



**Figure 2.14.** Tornado chart for scenario A



**Figure 2.15.** Tornado chart for scenario D

### 2.7.8 Further Qualitative Evaluation of MC

The model that was applied is based on data collected from the case of a modern strategy for implementing innovative services and production processes in a traditional shoe plant. The risk analysis analyzes how stable they are in order to understand whether it is a convenient approach or not. The limit of this analysis is in the fact that not all the incremental costs and benefits have been considered. From a late qualitative analysis what is still missing is a detailed assessment of some implicit benefits.

When applying an MC strategy for example, initial costs for marketing are certainly very high but the possibility given by the new tools to gather information on customer requirements directly from the final consumer permits a reduction in the “communication chain”; in fact most of the time a shoe producer has problems in establishing direct contacts with the final consumers because of many intermediaries (sales managers, dealers, shops and so on) and the only way to collect information on new fashion trends is to go to fairs, do market analysis, do brainstorming with designers and sales managers all of which take a great amount of time [18]. Having a database collecting all the data directly from customers makes it possible to ease statistical and market analysis, which reduces the time taken in the preparation of new shoe models (see also the considerations presented earlier).

The integration of the supply chain is another important benefit that is not fully quantified and forecasted in this analysis in terms of time saved and more efficient communication, and this factor is more relevant in scenarios C and D where ICT software is also implemented. Generally speaking, modifications of the organizational structure to facilitate mass customization, transforms the relationship structure and brings long-term benefits. Yet this is not to be seen as a great limit of the analysis, because this means that the NPV can be even higher for each scenario according to other potential benefits not considered here.

Given the impact of different degrees of innovativeness for a company willing to apply MC, it has once more proven the relevance of implementing innovative enabling technologies in manufacturing. The evaluation of the impact of new integrated ICT tools and new manufacturing technologies is extremely important in order to avoid under- or overestimating their impact on the company capability to produce and innovate.

MC represents a way to complete a product range adding new services for the customer in the view of the “extended product” provision. The applied model considers not only product related costs but also all the costs related to the implementation of the new services both for the customer (e.g. sales support) and for the producer (e.g. planning support). In such a context more than the mere economic data, it is important for a shoe producer to understand what steps to undertake as explained in the scenario description in order not to make mistakes and to avoid risky actions. As shown in this part of the work, this can only be achieved through the detailed definition of constraints and assumptions for each new scenario and evaluating all the variables concerned. In the model applied, investments are evaluated as adequate according to the degree of change a company is willing to apply. Most of the time the organizational aspects are the

most difficult to consider and to re-engineer especially when we are talking about an SME. Further improvements to the model adopted should consider the whole life cycle of the shoe in order to evaluate the impact of technological changes not only for the shoe producer but also for all the other stakeholders of the pipeline (from designers, to suppliers, to customers, to dismantlers) and all the life-cycle phases of the product and process.

Mass Customization and Footwear: Myth, Salvation or Reality?

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