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MASS CUSTOMIZATION IN APPAREL INDUSTRY – IMPLICATION OF CONSUMER AS CO-CREATOR

Introduction

Mass customization in production and operations management as a process of integrating standardization principles with customization seems to expand this last years in a great number of developed countries. Major companies like Dell, Motorola, Hewlett-Packard, General Motors, Ford, Nike, Reebok, Levis, and others are experimenting and implementing this process in their production and operations facilities. In this paper, our interest will concern the mass customization process in the apparel industry with the using of 3D body digitizers. The paper explores the concept of mass customization, focuses on methods to achieve mass customization in the apparel industry and discusses the consequences on the supply chain, on employment and on the ecological impact.

1. Mass customization: some elements from the literature

Mass customization is one of the strategies adopted by retailers to better serve their customers. Indeed, in response to an highly standardized offer, even if resulting after a segmentation process, the desire for differentiation with respect to other consumers and the wish to participate in the product design has risen sharply among consumers. So, mass customization is a growing phenomenon since a few years. Numerous examples of customization program in the fashion and clothing fields can illustrate this phenomenon. Most often business models with customization are based on information technologies (online website shop in web 2.0) because of a need of an interface for the interaction between customer / supplier is necessary. So, as pointed out by Lee et al. (2012), Threadless.com is a T-shirts company that displays wide-ranging designs, colors and artworks of T-shirts, and produces and sells them according to its customers' orders. In addition, its customers often provide their artwork to the company so that it can develop a new product out of customers' designs. This is a great example of company-customer co-creation, and bigger companies like Adidas, Nike, Reebok, Land's End, and Levi's also have adopted various systems of customization to provide products and services better fitted to their customers' needs.

The term 'mass customization' was first coined by Davis (1987) in his book *Future Perfect* and popularized by the seminal work of Pine (1993b). Since these early works, numerous studies have investigated this phenomenon of mass customization. Overall, mass customization corresponds to the delivery of a wide range of products and services that meet the specific needs of individual clients. Mass production of individualized goods is, by definition, an hybrid organization system between mass production and customization. More precisely, this organization must make compatible two production methods a priori antagonistic. So, it is recently possible due to the use of information technologies, organizational structures and flexible production processes (Silveria, Borenstein, & Fogliano, 2001; Radder & Louw, 1999). Information technologies increase the interaction between the company and the customer, increase the market knowledge, and assist segmentation, customization and personalization. The software of computer aided design allows consumers to configure and modify the attributes of a product before buying. Thus, the software offers many variant configurations, the visual feedback allows the real time representation of the product that the customer customizes and the analysis tools let to transcribe the orders of the consumer in a list of materials and tasks immediately transferred to production. So, the use of information technologies induces firstly a real decrease in the transaction costs and, secondly, the production of customized products at prices that are more or less comparable to those coming out of mass production.

It is necessary to clarify the purpose to distinguish the mass customization concept from the personalized offer concept. According to Merle (2010), the two concepts are different due to the degree of participation of the consumer to the process. So, in the framework of a personalized offer, the producer advises the consumer by deducing information of preference based on past observations of the customer or solicits preference information directly from the customer on the base of information that he provides. This induces two categories of personalization, one implicit and the other explicit. Advances in information technologies cause the rapid drop of the costs of data computation. This makes the process that starts with data collection and includes storage, analysis, and finally reporting on customer profiles and behavior to become more affordable (Rust & Espinoza, 2006). For example Amazon.com collects information on customers and thereby provides truly-customized services (Lee et al., 2012). So, the offer is more adapted to the consumption habits of the customer.

Conversely, the process of mass customization requires a strong involvement of the consumer. In this second perspective, customers engage in dialogue and interaction with the suppliers during product design, production, delivery and sometimes until the consumption act. It is the customer–supplier dialogue and interaction that is called co-creation or co-production (Payne et al., 2009). Thus, consequently, the customer is considered as ‘always being a co-creator of value’. It is a key foundational proposition of this economic logic (Vargo & Lusch, 2004). In this framework of a co-design experience, Merle (2010) states that this experience can be either:

- by delayed differentiation: Firm produces of standard components and the customer configures the product before the purchase or customizes it after the purchase. So, the company delays to the maximum the ‘time when each product acquires its specific identity’ (Merle, 2010).
- by modular design: Self-customization occurs when the customer self-selects attributes or modules from a given list to create or configure an offering that is best suited to his or her requirements (Ghosh et al., 2006).

Prior research suggests several reasons why a customer purchasing a customized product is likely to derive greater utility from the purchase compared to a customer buying a standardized product. Firstly, the ability to choose from a larger variety of potential module for ‘building the product’ increases sharply the probability that the buyer will receive a configuration matched to their functional and aesthetical preferences (Randall, Terwiesch, & Ulrich, 2007). That is, buyers can design an offering that is best suited to their preferences among the lines of color, functionalities, size, and so on. Secondly, working with the seller to create a personalized offering provides to the buyers an opportunity to distinguish themselves from others by possessing a truly unique product (Franke & Schreier, 2008). Consumers can therefore express their individuality by purchasing a customized offering. This is the reason why many researchers try to explain the additional perceived value by consumers with a mass customization strategy. Several studies have shown that consumers prefer customized products and, for 60-80% of them, consumers are willing to pay a premium for these products (Franke et al., 2009 ; Franke et al. 2010). In this study of 2006, Schreier establishes for three products that the willingness-to-pay increases between the standard version and the self-designed. The difference of willingness to pay can reach between 100% and 200% (the products are cell phone covers, T-shirts and scarfs). Merle et al. (2010) seek to identify the reasons of the potential appreciation of mass customization and how they influence the global perceived value. Two additional sources of value are highlighted. So, additional value is derived by:

- The customized product itself. The product is more in line with the preferences of the customer and there is a stronger match between the product and the customer expectations, besides the customer can stand out compare to other customers. Three sources of value added by customized products are identified: the utilitarian value, the value of interpersonal differentiation and the value of the expression of his personality (self-oriented value).
- The experience of co-creation through the fun, the excitement linked to the co-design time and the fulfillment feeling induced from this creative activity. These two others intrinsic value drivers are qualified as hedonic value and

pride value. The results of Merle (2010) confirm those from Franke et al. (2009). In this latter study, it is shown that the use of non-conventional technologies to elicit personal specifications and co-designing products with customers. They conclude to the importance of hedonic value due to the mass customization processes with interactions. The results of Merle et al. (2010) indicate a situation in which the value of the experience is the higher. This specific value impacts the value of customized product that in turn influences the overall value. This result is consistent with another work that focuses on the relevance of increasing the degree of autonomy of consumer (Addis & Holbrook, 2001).

Ogawa & Piller (2006) suggested that customer involvement in design is a major determinant of the degree of personalization that can be offered by mass customization. Nevertheless, many difficulties exist regarding the effort for the adoption of customized products. Costs associated to such an effort have been developed in the literature. For example, Merle (2010) emphasizes two types of costs. Firstly, the cost linked to the cognitive effort: it will be much stronger than the complexity of the creative process will be big! Let us note also that this effort integrates cognitive effort representation of the product itself when we are in the clothing sector. Directly related to the complexity of the process, there is the cost of the time required to co-design and to the implementation process of customized product and so also the time of delivery. Secondly, Merle (2010) introduces the social cost. This cost is associated with fear of making a bad choice and the impact that this choice can induce the social image of the consumer. The existence of this type of cost is campaigning for the establishment of a process to support the client in the process of co creation.

In this paper, we focus our discussion on mass customization in one sector, the clothing, and the use in the co-creation interactive process between customer and supplier the technology of human body scanner with its 3D representation.

It is therefore to think and to analyze a mass customization business model in which there is a co-design of garments and a production system a posteriori (post-production with downstream/upstream high flexibility and unit production capacity at relatively low costs). Thus, it is a complex organization particularly in terms of information transfer, qualification of human labor and the logistics operators monitoring.

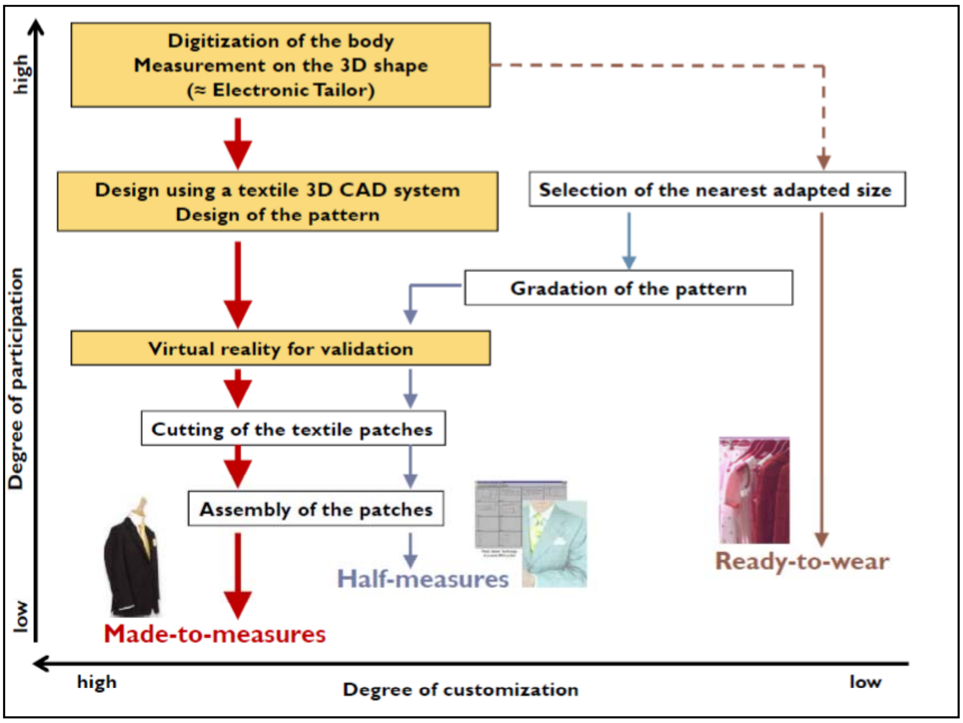
2. Mass customization with body digitizers in the apparel industry

This paper considers a mass customization based business model in the apparel sector as following. The first step of the chain consists of measuring the customer using a 3D body digitizer that can be in a private specific shop or in a booth located in a public area (as railway station, mall,…). As one of the results, the digitizer delivers a virtual 3D body with all the corresponding measurement. The second step is the interactive co creation process between the customer and the designer (supplier) that will start as soon the body data are available using a computer aided design (CAD) system. Co creation is supposed to consist in selecting the style of the model, the fitting, the fabrics, the accessories, the colors and the general design (Liu et al., 2010). For helping the customer to accept his own 3D image, it is preferable to automatically pre-position the virtual cloth patterns on the body (Fuhrmann et al., 2003). The third step is the designs of the patterns that can be simply made by the customer by sketching the garment on the virtual 3D body (Yasseen et al., 2013). But, it is better to have a real co-creation with an expert helping the customer (Hu et al., 2008). The patterns are directly transferred with information technologies to the manufacturer to be cut, assembled and finally send to the customer. Based on this principle, the customer may interact both on the degree of personalization and on the degree of participation in the co creation process. This business model of mass customization already exists. For example, in Paris, the company 'les nouveaux ateliers' applies this model for suits for men. Nevertheless, this implementation is extremely rare for the moment.

To provide access to customized clothing at a low cost to lots of people, it is necessary to automate most of the process of creation from the taking of the measurements until the delivery of the final clothes. Thus, the chain of automated manufacturing can be described by the following diagram in which the elements related to the measurement and co-creation (publicly available) are shown in gray lines:

Under this scheme, we suppose that the more the customer can intervene prior to production, the more the process of co-creation is rewarding for the customer. So the increment value for the customer under the conditions that the co-creation is highly guided (Franke et al. 2009) so to limit the gap between the customer a priori wishes and the final obtained result.

Figure 1. An overview of alternative garment confection chains



To understand the barriers to mass customization in the field of the clothes, it is important to understand the process of their creation.

The dressing up of lots of people can be made through the simple size selection like in the context of the fast assignment of military garments packages (French Navy since the 90s for example). Regarding the previous scheme, this size selection corresponds to an extremely low level of personalization that require nearly no creative co-design from the customer.

In contrast, a more sophisticated system, that fully automatically designs and draws the customized apparel, does not allow the customer to control precisely the co-creation. Some tests were made since the 90's like for example (Huang et al., 2012; Li & Lu, 2011 ; Li et al., 2010; Kim & Kang, 2002). More precisely, this process of mass customization corresponds to a modular choice that may limit the customer in the design. Only, the size of the clothes is customized and the choice among the different models. It concerns mail order selling typically used by Internet if the customer communicates his own personal measurements.

Finally, the process that allows the customer to be deeply involved in the creation process requires a full automatic measurement system associated to a computer aided design system, so the co-creation is possible along the creation chain.

The automatic measurement system is required due to the low accessibility to the tailors for the greatest number of people for two reasons linked to costs. On the one hand, the cost of the tailors are high because of his high skill level and, on the other hand, the transaction costs regarding the Williamson approach are equally high (costs linked to the research of the tailors, the time spend to welcome, to measure and to advise the customers). Moreover, insofar as each tailor has his own style, it is difficult to imagine the final product before the end of its completion.

We can envisage the automation process since the beginning of the line by using what we might call an ‘electronic tailor’. Its role consists of automatically and quickly provides reliable measurements of the person that has to be dressed up. It is usually a three-dimensional body digitizer (like the digitizers sold by companies like Telmat informatique, Cyberware, Human solutions...) even if the first attempts were made a long time ago with much more rudimentary means. The principle is to digitize the 3D body shape as quick as possible so the customer is not delayed too long.

It is useful about it to distinguish the scanning time and the time of mobilization. Indeed, the scanning time must be very short in the same way that a picture must be taken quickly to avoid blur. This is to avoid respiratory movements and the movements helping to the balancing of the body.

For reasons of convenience, the mobilization time must be short and so the total digitization time for obtaining the final tridimensional body shape can be a few seconds. Although this time is not critical for scanning, it should avoid making the customer waiting too long underweared if it is not useful. Indeed, it must be remembered that the standards used to measure the customers theoretically impose that they wear their best fitting underwear.

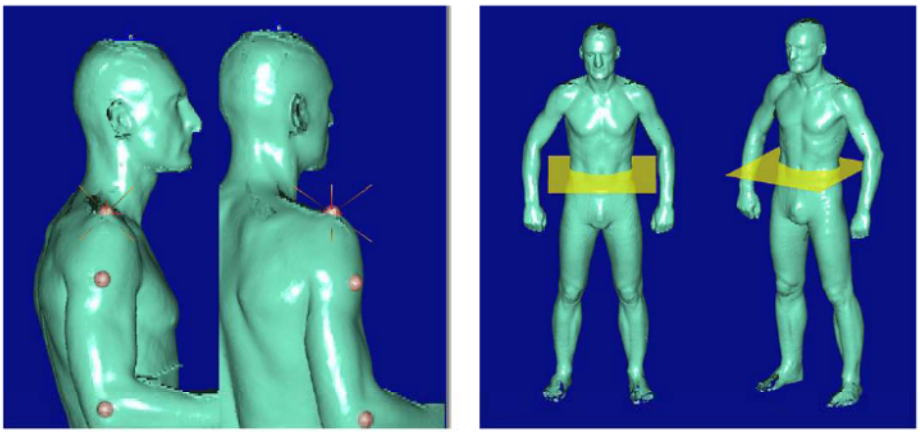
Because several viewing angles are necessary to digitize almost the entire human body, the digitizers are often impressive and the process delivers several pieces of the shape. The surfaces are digitized and filtered and then merged eventually smoothed. Often there are still holes but usually without major consequences for further processing (Guerlain & Durand, 2006).

Figure 2. An example of 3D digitizer booth (Cyberware for this example)

Source: http://www.cyberware.com/products/scanners/wbx.html.

The digital surface of the body allows the placement of the characteristic landmarks used for measurements such as elbows, shoulders, etc.

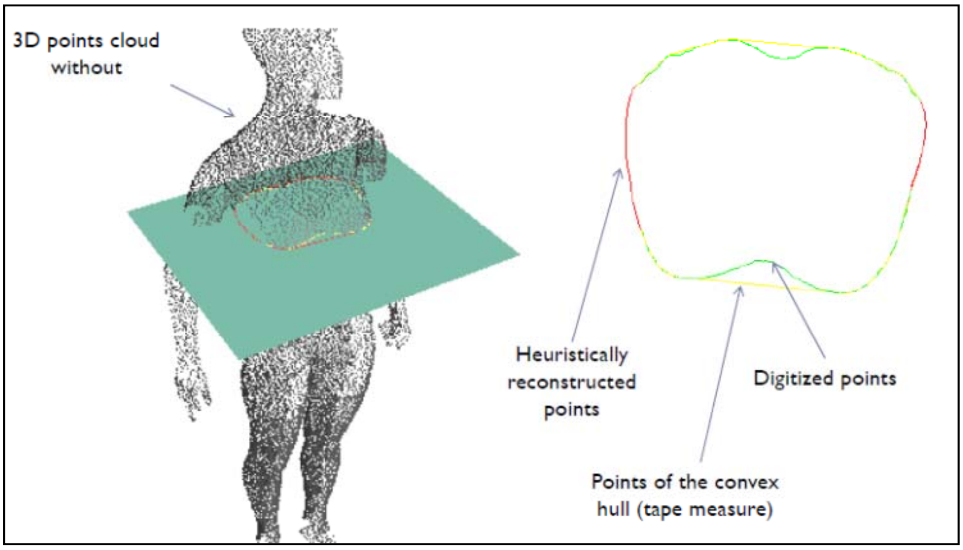
Figure 3. An example of 3D digitized surface with landmarks for measurement



Source: www.human-solution.com/apparel/products_anthroscan_en.php.

Measures can be taken from point to point (crotch height for example) or along the surface (such as a portion of the length of the back) or along the convex hull of cross sections (as chest circumference for example). So that the obtained measurements are fully useable, they must be taken according the relevant norms of the garment industry. These norms are very often country dependent like NF EN 13402 – 1, 2, 3 for France for example.

Figure 4. An example of one measurement along cross section (chest circumference)



Compared to the manual measurements, even if the localization of the landmarks is sometimes inaccurate (theoretically some points like the acromions require a palpation that the machine is not able to do) automation provides a gain in the reproducibility of the measurements. Moreover a considerable gain in terms of hygiene (no more body manipulation) and measurement time (approximately 45 minutes per person if made by hand during an anthropometric survey compared to less than one minute with a digitizer) at a cost of acquisition and use that is finally acceptable.

A few thousand points wisely chosen on the body already allow good measurements useful for the allocation of ready to wear clothing or even half measures clothing. Yet for designing made-to-measure clothing it is necessary to cover the maximal surface of the body. This supposes to digitize much more points homogenously distributed and to limit the hidden areas.

Indeed, during the made-to-measures process it is important to allow the customer to visualize the final result. The best way for this consists to submit him his avatar virtually wearing the clothes corresponding to the client wishes.

One actual challenge consists of obtaining realistic movements of the mannequin in association to a realistic mechanical behavior of the dressed garments.

Concerning the mannequin one first and historical solution consists of selecting a ready to use model among several morphotypes and then to slightly deform it so that its measurements correspond to the customer. A more difficult, but more realistic research is to create the avatar directly from the points but in this case, treating the areas masked during digitizing is a complex problem based on heuristics (Guerlain & Durand, 2006).

An intermediate solution is the deformation of a generic model to fit it to the scanned points cloud (Luginbühl et al., 2009). This solution requires a lot of calculation time but these avatars can be static or animated (Volino et al. 2005) with the great advantage of having the landmarks for measurements already identified on the model and matched to the 3D digitized real shape.

Of course, the realism of the textile behavior is required to achieve the presentation in front of the customer. These very complex tools, based on mechanical models depending on the tissues and the assemblies (Boubaker et al., 2007) are expensive in terms of computing power. Compromises must then be found for the final rendering (Mongus et al., 2012) that finally leave some doubts in the mind of the customer.

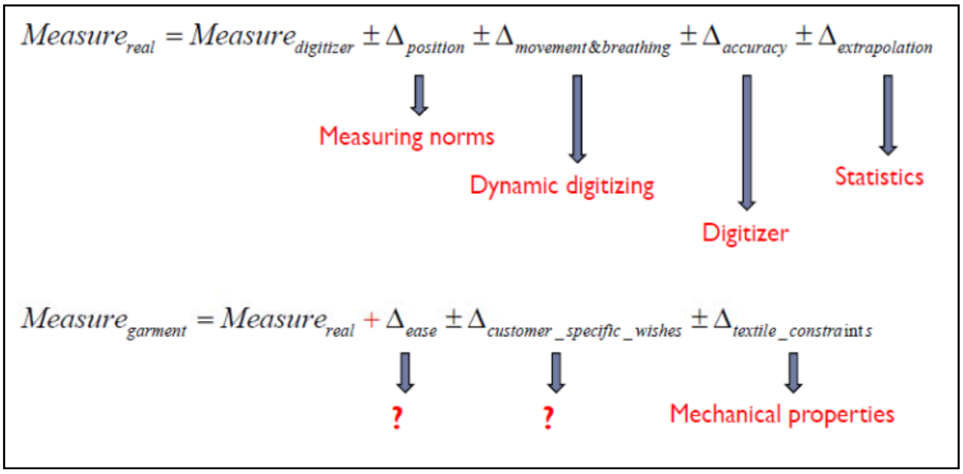
The automation of the transfer of information between the devices and the possible heterogeneity of the equipments of the production chain impose the respect of the same precise rules of measurement and communication and also, as a consequence, the emergence of norms.

Even if the expertise of the tailor is incomparable, the degree of automation of the production line allows him to focus on the essentials of his craft by delegating mundane tasks to machines. In simple cases, the presence of a tailor is no longer required and the control of the design process can be done over the Internet with measurements provided by the user and adapted to a user selected morphotype.

Anyway, one should be aware that errors exists at the different stages of creation of clothes and that these errors cannot always be avoided or quantified. Moreover, these errors are cumulative and a mistake at the beginning of the chain of design will only grow over the process.

Furthermore some errors are simply unquantifiable and dependent on the customer when he fails to express his expectations in terms of comfort and style.

Figure 5. Propagation of the errors from the body to the garment



The absence of an expert eye on the process of creation forbids the experience based correction of errors. This is not too annoying when the ease and the style of the garment can absorb the error, but if the material is no soft enough or if the style is too close-fitting, it becomes possible to obtain the extreme stage of an unwearable clothing.

3. Discussion and conclusion

We will now examine rapidly some potential consequences of mass customization process using a body digitizer on structural organization and the supply chain, employment and environmental impacts

The first important change is linked to the supply chain. How to deal with the contradictions between scale production effect and the satisfaction level of customized demand is the key problem? The classical answer to this question is the postponement, whereby some of the supply chain activities are not performed until customer orders are received, can provide a practical solution for realizing the benefits of mass customization by combining push and pull forces in an operating system (Mikkola & Skjøtt-Larsen, 2004). Both mass customization strategy and postponement are closely linked to the so-called modularization approach, aimed at organizing complex products efficiently by decomposing complex assemblies into simpler portions. But in our system described above, it is not really the good answer due to the fact the co-creation process is more pronounced. Thus, the supply chain in a system of mass customization in which the client is involved since the outset of the creation of clothing is based on the control of the information. The information transfer process is the essential vector for piloting the activity.

At the stage of creation and the provisions of materials (fabrics, accessories...) there is a need for designers to propose a large choice to the co-designer customer. So, suppliers should have a permanent stock of fabrics, accessories and components immediately available to manufacturers. This can be treated in a network wholesaler provided that the reactivity is high.

Following this first stage, the manufacturing process is necessarily at a high level of flexibility. This induces a lot of agreements between the co-designers of clothes and all manufacturers and assemblers based on specific choices realized by the customer co-designers. The more the opportunities for co-design are high, the more the freedom is given to the customer in the creative process, and the greater the number of providers under contract will be. This is especially necessary due to the fact that the activity of each supplier will be weak in the sense that each garment is unique and the supplier cannot therefore benefit from economies of scale. So, in the center of this business model, we find the offer that co-designs with the client and then give orders to his various suppliers able to respond in a very short time. In general, studies show that the clients grant a period of two to three weeks for delivery of customized clothing, but that beyond this period disutility appears and can cancel the additional utility that is born to the co-design process. In this supply chain, there is a decrease of the quantities due to a low level of each garment type produced but the variety of the stock (i.e. the extent) is very important. Note that at the end of the chain, there is a very strict reduction of the security stock for the various outlets.

The mass customization process with body digitizers induces an increase of specific costs.

- At the first place, a cost connected to the detention of a permanent and immediately mobilizable stock of fabrics, accessories and so on for a delivery deadline of the garment very short.
- Secondly, besides the investment in a cabin of 3D measure for the human body, supplementary costs appear linked to the implementation of new machines for the production adapted to small series (the tables of cutting usually used for padding do not have here anymore).
- Thirdly, the labor costs increase. Indeed, the activities of co-creation, the planning and the realization of the production of personalized products require a staff with high skills than the average of the clothing sector, with autonomous people making numerous small tasks. Considering the increase of the qualifications and the work force productivity, wages have to weigh more in the production total cost.

- Fourthly, the costs connected to the delivery can increase by unit produced considering the fact that every garment is unique. But especially, the system of mass customization with body digitizers requires investing in centers of customer relationships which manage as much the upstream as the downstream customer relationship.
- Finally, the system generates high transaction costs. It requires numerous manufacturers in connection with the retailers as co-designer of clothes. This increase is to be put in touch with the difficulty obtaining economies of scale. Thus, all the relationships must be contractualized and, due to the specificities of assets in game, the costs of this contractualization raise (in particular because of the data protection against duplication of the garment and the general questions of quality assurances). Because of the specificity of assets (in particular immaterial branding specificity, temporal specificity and specificity of the human resources), and strong transaction costs, the question of vertical integration arises to the contractors that is to the distributors co-designers who could develop specific entities of production.

But, other costs may fall. They result:

- of the adjournment of the production activities until the confirmation of the order and, thus, the elimination of the overcapacities of production which are at the moment a classical phenomenon in the apparel industry;
- of the co-design process due to the extrinsic and intrinsic increment values for the customer. Considering the information obtained on customers' needs and preferences, there is a possibility for the providers to elaborate a dashboard for the demand forecast. There is *a priori* neither acceleration nor rough slowing down of the production chain connected to changes of trends;
- of the development strategies for customer loyalty. There is a decrease of the marketing costs of the customer's acquisition and the costs for anticipating the market trends. Besides, the customer has to support costs of suppliers' changes if the data about the measure of its body are only usable by the 3D body digitizer owner. It is a classical type of exit barrier for the customer;
- of the elimination of stocks at the distribution chain because of its almost deletion of unsold articles. The number of returns in store is strongly limited.

According to the French Institute of the Fashion (Chaballier & Vandier, 2011), the mass customization in the apparel industry in France is a market estimated at medium-term to 60 million euros and which will represent before 3 years 10% of the male market and 5% of the female market. Within the framework of the mass customized products, the production process made near outlets finds partly its relevance due to the necessary reactivity of the producers, the flexible organization and the fast and reliable delivery deadlines that appears as a key variable of the consumer satisfaction. However, mass customization activities are not opposed at all to the geographical distance between production sites and outlets because they are based essentially on the transmission of data flows. But, the mass customization process generates an increase of transaction costs, an increase of the wage costs for all the operators on the conception and production chain and an increase of unit costs for the garment transportation. This incites to a localization of the production at closer places of consumption. But this cannot imply a relocation process as well. It will be rather new companies which will emerge because the businesses and the technologies are at least partially new. So, small and medium sized companies, innovative, flexible, sometimes pure players, coordinating a network geographically closed to manufacturers and to producers of materials are the future for the development of jobs in the textile and clothing industry.

The last potential consequence which we wish to evoke in this conclusion is relative to the ecological impacts of the mass customized production of clothes. We can reasonably expect a reduction of waste and emissions in the stages of the design and the production clothing. The main reason is that the system is piloted by the demand. At the extreme limit, it is about a manufacturing unit by unit! Nevertheless, this kind of manufacturing increases the quantity of necessary textile because there is a smaller optimization of the placement of the patterns on the fabric during the phase of cutting. The clearest effect of the ecological reduction of the impacts is expected at the level of the distribution. It is understandable because there is a strong decrease of the disposal of unsold articles and because of the closer geographical location of production and consumptions places. Our next study will try to compare and to quantify in term of life cycle analysis the ecological impacts of the garment mass production and the garment customized production.

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