Mass Customization, Business Model for the Future of Fashion Industry

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Abstract

Until the 1950's clothing was predominantly designed and manufactured on a 'made-to-measure' basis, with each garment created for a specific customer. Today fashion industry can be segmented in the following main categories: haute couture, designer wear and street fashion. Most people buy their clothes in the mass market of street fashion. However, fashion companies can offer well-fitting clothing to only 30 to 40% of their target. When addressing new target groups this is often reduced to merely 10%. This stands in stark contrast with the changing demands of the consumers who lose their tolerance for regular products and have become more and more demanding for garments with a personalized style, fit and colour/print. As a result fashion companies miss an enormous potential and there are many obsolete stocks. For coping with this new challenge, fashion industry should shift from a mass production to a mass customization business model. Several new technologies and an optimization of the supply chain organization for diversified products can help mass customization operations.

Today the construction of the basic pattern and the grading to other sizes is based solely on 1D body dimensions. The grading is proportional or rational, but never allometric (taking into account the body proportions). Because the actual morphology of the target is not taken into account the result is a poor fit. 3D body scanning technology allows to acquire precise body measurements and a visual model. These results can be used to customize apparel products. 3D prototyping simulation can be used to provide consumers with a personalized try-on illustration. This technology can also offer an advanced 3D designing environment to designers. This feature will largely decrease the number of real prototypes and reduces significantly the time-to-market. Digital printing offers additional personalization and the possibility to co-design.

1. Introduction

Today fashion industry can be segmented in two main categories: haute couture and ready-to-wear. Ready-to-wear, or prêt-à-porter, covers any collection that consists of garments

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produced in volume – distinct from the one-off garments in haute couture and is divided in designer wear and street fashion. RTW can be traced back to the beginning of the 20th century, following the Industrial Revolution and the introduction of the sewing machine. In the beginning it relied on Paris couture and highly skilled dressmakers would copy designs. Although produced starting from standardized sizes it was up until the 1950's predominantly designed and manufactured on a 'made-to-measure' base, with each garment created for a specific customer. In the 1970's and 1980's the market became saturated with basic products from Marks and Spencer, C&A and other high street chain stores. In recent years globalization and a number of socio-economical and technical trends have greatly changed the demands of the consumers and have created a need for conspicuous and customized design.

Globalization

With globalization, the textile and clothing industry in Europe faces competition from low-wage countries, especially where it comes to the delivery of large volumes and basic garments. These products are above all most often produced in places where environmental regulations are not demanding and often violated without consequences. The environmental costs that have to be paid in Europe are therefore experienced as an additional disability.

Socio-economic and technical trends

For thousands of years, clothing has consisted only of a number of layers providing warmth and protection beyond our natural skin. Today the textile and fashion industry is challenged to respond to the demands of our modern society obsessed with risks, thrilled by experiences, cocooned by well-being, obliged to achieve sustainability, enslaved to low prices, individualistic and self-indulgent.

During the period of the last 50 years a new generation of innovative fibres, textile materials and products was created. Many of these fabrics show high performance and have multi-functional purposes, such as rainwear that can be fashionable and protect against rain, wind and cold or protective garments providing ballistic, chemical, microbial and flame protection. These functions are added to fabrics by using fibres that have inherent functional properties or by coating or laminating a polymer layer that provides the required function(s). Most polymer systems that were built-in in one way or another in textiles during the last century ensure elementary functions such as waterproofness, chemical resistance, breathability, flame retardancy, anti-microbiological or antistatic properties, etc. These systems are all passive systems. At the dawn of the new millennium (September 11, 2001) society experienced a

major change in its way of life and became more or less obsessed with safety and quality of life. Passive polymer systems are often no longer satisfying, they must be intelligent and must sense and adapt to environmental stimuli to ensure an optimisation of the behaviour of the textile they are built-in. For several years the development of active systems was only of importance to the military and space industry. Nowadays fire fighters, sportsmen, business people, elderly people, etc. all want to benefit from this revolution in materials for their individual specific needs (customized products). Personalization of products requires a greater degree of customization than choosing from a range of alternatives, often a personal contribution is required, making an emotional connection with the product (eg. T-shirt printed with a picture of your own child). (Don A. Norman, Emotional design: why we love (or hate) everyday things - Basic Books 2003).

The development and the marketing of these customized products is subject to an enforced market orientation, to textile materials with high levels of quality, beauty and performance characteristics, to more flexible small batch oriented manufacturing processes that allow both a better consumer orientation (mass customization) and high levels of quality and performance of the garment and finally to an intense cooperation within the textile/clothing value chain.

This challenge involves major changes in managerial attitude:

- The introduction of the four key elements of strategic innovation:
    - *Value innovation: offering the customer a product or service that he perceives as valuable and new;*
    - *New market creation: stop focussing on the same market segments as their competitors, but instead attract new types of customers. New markets can be created within existing industries by identifying unserved customer segments, targeting new combinations of existing customer segments, or redefining how the market is segmented (Markides, 1997);*
    - *Go-to-market innovation: finding a novel approach for marketing products or services;*
    - *Competitive disruption: deviating from the structure existing in the fashion industry and adopt an entirely new business model.*
- The availability of capital and the will to take risks in developing products and processes for which the market is still in a developing phase.

- The introduction of quick response strategies that speed up the flow of information and merchandise between retailers and manufacturers of apparel and textiles, all driven by the consumer.

- The receptiveness for an adequate circulation of knowledge across the entire supply chain and along the different layers of organisation (industry, research and education) for each link in the supply chain and layer has its own specific expertise and relevance.

2. Mass customization

Within the Western society consumers underline their personality and status through the purchase of certain consumer goods. Tuned cars are a clear example but eccentric garments are also used to move from the crowd. Although the consumer attaches great importance to personalized items, research has shown that consumers do not want to pay significantly more. Personalized items are mainly the result of traditional crafts, but due to high labour costs, the market for customized products remains a (small) niche market. Companies that are obliged to deliver customized products because of the sector in which they operate, or by a changed market situation are faced with the same challenge: deliver customized products at a price level similar to that of mass production.

For several decades a business model has been developed that tries to offer a solution to the paradigm customization at mass production cost : mass customization.
A mass production environment is organized in a way to efficiently manufacture and sell products, preferably in large numbers.
Within a mass customization oriented company the production is started after the customer has placed his specific order. Here the supply chain must be organized in such a way that the product can be delivered at a mass production price.
Mass customization distinguishes itself from handicraft by production within an industrial setting at maximum efficiency (and low production costs). Mass customization is applicable to both goods and services. It has many facets and one of the biggest misconceptions about mass customization is that the manufacturer grants total freedom to the consumer to create a product entirely according to his specific wishes. This is of course only possible in a very limited number of cases.

Customization may cover one or more aspects of the product or service and this in varying degrees. Between pure standardization and customization is a full range of options:

- Pure standardization: the customer can only choose from a full pre-defined range.

- Segmented standardization: Products are customized for each segment. An example is the automobile industry where cars destined for the U.S. are standard equipped with an automatic transmission and cars destined for the European market with a manual gearbox.

- Customized standardization: the customer can choose from a number of predefined options. For a car, the customer can for example choose the body colour, the colour and composition of the upholstery and the type of the engine.

- Tailored customization: the customer can choose a number of parameters. An example is a men's shirt offering the possibility choose the type of collar and cuff, the number of breast pockets, the length of the sleeves, etc.

- Full customization applied to the above example would allow the customer to also design the style and the print or weave.

Mass customization therefore offers a wide range of possibilities. To successfully implement this business model, companies must make the right trade-off between full standardization and full customization. When a product is highly standardized, it offers no benefit to the customer, if the customization is too far-reaching, production can be too complicated (too expensive, too long delivery time, ...). It is not enough to customize the product, but the production process must also be adapted. This can be reached by paying attention to elements such as setup times, automation, production speed, ...

The concrete implementation of the paradigm "mass customization at mass production price" can therefore be very diverse. On the one hand, the nature of the product will limit the number of options. On the other hand, the possibilities for customization are determined by the company itself.

Many companies wish to apply the mass customization business model to keep their market shares. Some do this on their own initiative but most will generally rely on external consultants. The interpretation of the mass customization model is not only sector-specific, but even company-specific (and even within one company a different interpretation can be given to the multiple product lines). When introducing mass customization, companies need support from an organization that is both familiar with mass customization and has a good

understanding of the industry, its raw materials, its semi-finished products and its production processes.

In the clothing industry, collections are developed almost exclusively on the basis of forecast data. The large uncertainty in estimating the demand means that certain collections never find their way to the customer, while for other collections the demand is greater than supply. When many collections are offered, the consequence is that the production is distributed over many small runs that just meet or are below the EOQ (economic order quantity), that many switch-overs in production are needed and that the number of SKUs (stock keeping units) and total inventories increase. The turnover that one gets with a limited number of successful articles is often largely consumed by the losses of less successful articles.

Within a mass customization based business model this problem is avoided by manufacturing only those garments that are effectively ordered/desired.

Apparel is the perfect product to address the three dimensions of personalization: fit (style, dimensions, sizes), functionality and design (taste, shape). Products that require adjusting to various physical sizes and functionalities, can be sold at higher prices than products that are personalized by merely adjusting the colour or print.

A mass-based clothing company does not have the structure to supply an individual order within an acceptable delivery time and at a mass production price. The needs of the apparel industry are mainly in the context of specific challenges regarding flexibility, results, cost control, process control, customer value, speed of change and innovation, translating the product message through a customized client interface.

A SWOT analysis, conducted at the University College Ghent in the fall of 2006, with 53 experts from the textile and clothing sector brought some bottlenecks to the front including a lack of communication and vision within the value chain of textiles and clothing, the excessive focus on mass production and the lack of knowledge of the possibilities offered by ICT. Mass customization relies strongly on new 'enabling technologies', in which ICT and other digital technologies are important.

Fig. 1: Example of unique prints made-to-order by colaboration between a fashion brand and an artist: The Tissue collection, created with C.E.B. Reas (www.reas.com)

3. Ready-to-wear sizing systems for mass customization

By definition ready-to-wear clothing is developed and offered for sale before potential customers select and try on styles of interest. Ready-to-wear is offered in a limited number of sizes. Most sizing systems in Europe are derived from the EN 13402 standard. However, individual firms have always interpreted the standards differently and have over time created their own size charts to distinguish their garments from their competitors' garments. In other words a size 38 from one company is not the same as a size 38 at another company so both will have a different resulting fit. Some brands even practice vanity sizing (labeling their garments with increasingly lower size numbers) as a sales tool.

For the individual customer it would be easier if all size 38's would fit in the same way. Unfortunately, it does not seem feasible for the apparel industry to shift to a standard sizing system as this would decrease the consumer's fit choices. Fit is a very effective marketing strategy and interesting tool for mass customization. Besides a trendy design, the feeling of wellbeing and comfort in a particular garment are the key triggers for consumers to proceed to purchase. A garment can only be comfortable and flattering to the wearer if the fit is good. Persons having the same size may have a very different body shapes so this is not evident. This is shown in figures 2 and 3.
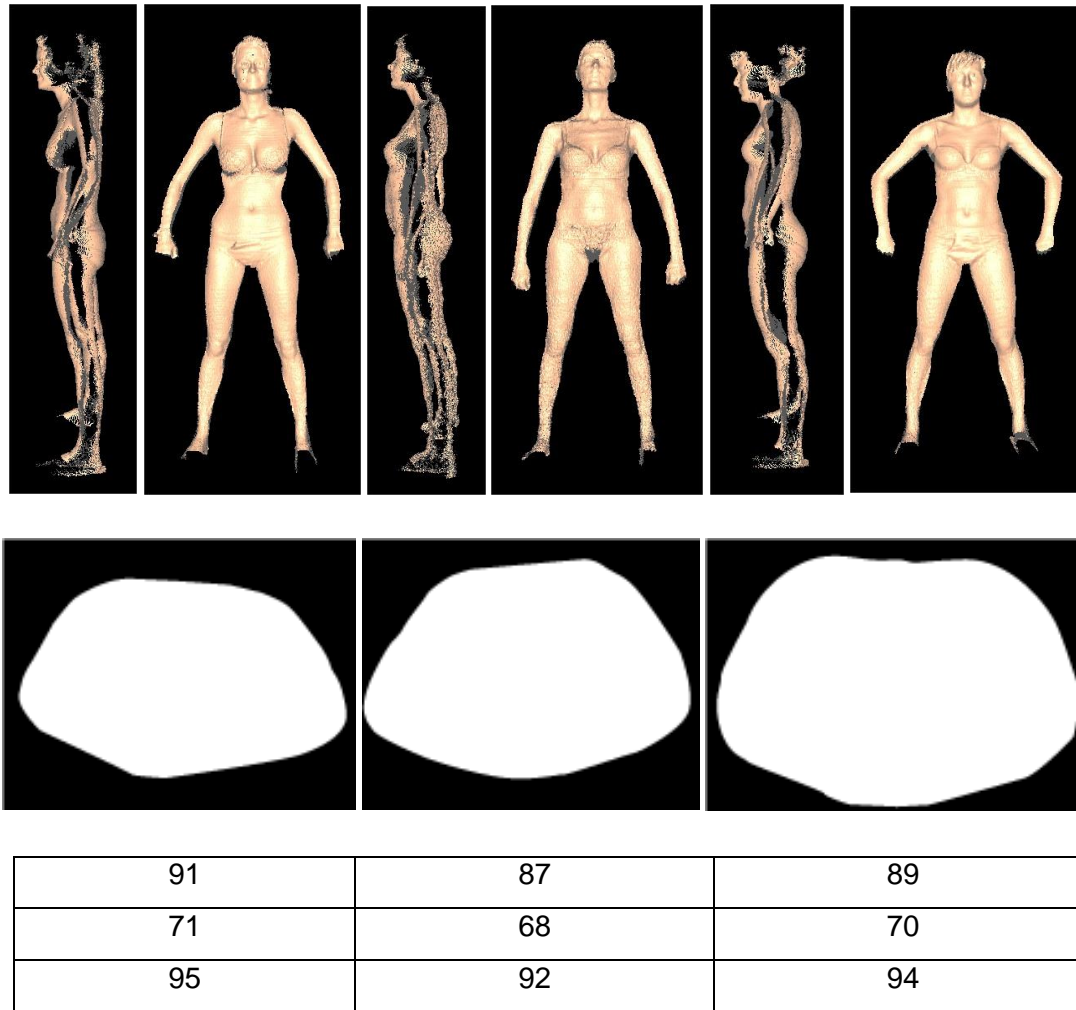
91	87	89	breast
71	68	70	waist
95	92	94	hip

Fig. 2 One size, three body shapes

Fig. 3 Right size, wrong fit (source SHARP Dummies)

A good fit is also one of the main parameters to obtain adequate thermophysiological comfort and protection. In the development phase of clothing manufacturers used to focus on the

physical (strength, elasticity, insulation, air permeability, …) and sensory properties (hand, colour, smell) of the textile materials in order to obtain the required comfort level. The two-year research project 'Comfortex' which was conducted by the authors has proven that technical components such as clothing design, assembly techniques and especially fit and sizing are for over 50 % responsible for wear comfort and ergonomics of the finished garment.

With the introduction of mass production and ready-to-wear garments, there was no longer attention for a personal fit. Different manufacturers standardized sizes each in their own manner. A study of Just Style[2] indicates that due to the diversity of people and in many cases the poor quality of body measurement tables most brands can offer well-fitting clothing to only 30 – 40 % of their target group. When these companies explore new markets, this number is in some cases reduced to a mere 10 %. The first years some brands survive with the help of their innovativeness and/or design, but in the subsequent years a proper size range and fit take the upper hand in the decision to purchase. The clothing industry in Belgium and other countries is convinced that size range and fit are a real advantage to compete with cheap imported products[3]. This applies to both companies who distribute their own brands as to contractors. In the case of protective clothing and sportswear a good fit is a must to guarantee the safety and performance ability of the person.

Clothing sizes and fit are difficult concepts to explore and analyze as the relationship between the human body and the garment is complex and often two-fold. The current methods to create sizes and to assess the fit are

> $\Rightarrow$ based on the dimensions of the 'ideal' customer being represented by a single fit model
>
> $\Rightarrow$ adapted to other sizes by applying grading rules to the basic pattern for the proportional increases and decreases and
>
> $\Rightarrow$ visual and two-dimensional (in length and width) evaluation comparing linear clothing measurements and body measurements.

Although these methods are useful to evaluate simple fitting outcomes, they are not suited to assess the complexity of the versatile relationship between the body and clothing of a large number of customers with an extended variety of body shapes within one size.

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[2] Just-style.com briefings service (July 2010), Sizing a headache for glogalizing apparel industry
[3] Karryn Miller (2010), Studying body size is key to market fit, Just-style.com briefings service

It is therefore not surprising that a study conducted by Kurt Salmon Associates indicates that 50 percent of women claim not to find clothes that fit. For jeans this may be up to 64 %. Moreover, poorly fitting protective clothing and sportswear involve serious risks for the wearer. The functioning and performance ability of the wearer is as well adversely affected. Other studies showed that 50 percent of purchases through catalogs are sent back because of problems with the fit.

Companies today are using outdated one-dimensional mean values and percentiles. These data are so deceptive that even with the best intentions errors are included from the start in the product specifications. Moreover, 1D measurement data are blind. They are meaningless regarding the constitution of the measured individuals. When basic patterns are graded to larger and smaller sizes and 3D data of the body are not available, this is mostly an 'educated guess' and even more faults are built in. An alternative approach would be to improve each company's unique sizing system to fit more people within their target market or in other words to mass customize their size charts. An existing sizing system could be improved in the following ways:

a) change the base size specifications to correspond more closely to the proportions of the majority of the people in the target market;

b) develop a new sizing system that may have six or eight sizes that are based on target market body shape measurements rather than on proportional fit assumptions.

This is logistically and financially feasible using the 3D body scanner and computer-aided design (CAD) grading systems.

4. Methodology

4.1 Determining the body dimensions of the Belgian population and development of database, standard size charts and frequency tables

First 0.05 % of the Belgian population, except for pregnant women and children under three, will be measured. This number is the same as the previous measurement campaign from 1990, but higher than in other countries that conducted a sizing survey (France, 11.562 measurements made in 2006 (0,02 % of the population); Germany, 13.362 measurements in 2008 (0,016 %); Netherlands, 2000 measurements of 18-65 year olds in 2008 (0,04 %) and Great-Britain, 11.000 measurements in 2004 (0,02 %). The scanning devices will be a Telmat SYMCAD 3D body scanner and a TC² body scanner using structured white light.

We started defining the measurement procedure and a socio-demographic survey.

All measurements and information about the subjects will be stored in a database.

The statistical analysis of anthropometric data: mean, percentiles, standard deviation, correlation, graphic charts, should allow us to make up the standard body size charts and frequency tables. We will consider 5 age groups in the standard charts: 3-13 years, 14-25 years, 26-45 years, 46-64 years and 65 +, both men and women. These charts can then be further divided into clothing that completely covers the body, covering above the waist and below the waist. This will be in harmony with EN 13402 (CEN/TC 248/WG 10: size designation system for clothing). Existing size tables are of the 1D type. A primary dimension is chosen based on the type of clothing (eg. waist circumference). Adjacent intervals are provided (70-74, 74-78, 78-82, …). The margins are chosen in a way that clothing is comfortable enough without being too broad. The expected values of certain secondary parameters (hip circumference, chest circumference, …) are also given in intervals. The choice of primary and secondary dimensions is decisive to determine the percentage of the target group that can be dressed appropriate. In current size tables intervals do not overlap. In reality this is only possible if all body types within the population are identical except a scaling factor. This is obviously not the case. For each class of waist circumference we must allow a variation of the secondary dimension that partially covers variations of the waist circumference of neighboring classes. Proposals will be made which will form a more specific classification and allow improved patterns.

Comparing the results of the socio-demographic survey with the size data will allow us to determine whether there is correlation between the two. We will also be able to set up size charts for specific target groups. This will bring the possibilities and potential of mass customization closer to the manufacturers.

4.2 Study of morphotypes

Second, the body shapes will be studied. We will do this by Principle Component Analysis.

The population will be divided into five or more body types for men and women that will cover 80 % of the population. This should give us also a good view on the most common abnormalities in a body.

4.3 Development of an allometric grading technique

Next an allometric grading technique will be developed.

Grading is a process used to produce clothing in a certain size range. For this, at certain points called cardinal points, dimensional increases or decreases are applied to the pattern to obtain larger or smaller sizes. To establish a relationship between body size and grading technique, the cardinal points must correspond to a landmark on the body which is a horizontal or vertical measurement (grading is done according an XY coordinate system). Landmarks are the endpoints of a measurement. In proportional grading techniques we note that the cardinal points do not always correspond to landmarks, the breastpoint remains in the same position for all sizes, the increases and decreases are conducted with constant rate and all pattern pieces become larger as the size increases. Even when using a rational grading system that takes the proportions in the basic pattern construction into account, the body shape is not considered. When the actual size differs more from the basic size in which the pattern was made up, it inevitably leads to a poor fit. Body measurements do not increase or decrease proportionally as a person gains or loses weight.

At each cardinal point of a pattern a landmark will be assigned. This measurement will either be horizontal or vertical. A landmark may be connected to only one cardinal point. These points will be graded to the actual body proportions and not proportional.

4.4 Processing scan results into usable avatars

Finally the 3D volumes will be processed into a usable avatar for virtual prototyping to assess the fit. This will be an improvement to the parametric avatars available in 3D prototyping software which only permit to adapt the size, but not the shape. Basic patterns can thus be automatically adjusted to customized patterns which will strongly reduce lead time for product development.

This will also create new opportunities for virtual fit of apparel. Today the growth of online retailing of apparel is limited by lack of information on clothing fit. The development of fit visualization, size selection and design style selection technologies can help provide this information.

My Virtual Model (MVM) provides a website which allows the user to create a digital model or avatar of themselves. A range of aesthetic features such as hairstyle and skin colour are available to create a resembling avatar. The parametric avatar is created by means of a

computer algorithm using simple body measurements and the user's perception of their body shape. This avatar can be 'dressed' with digital garments representing the retailer's collection to give the consumer a virtual presentation of how he or she might look in the outfit.

Another aid to select well-fitting clothing is automated size selection based on self-measured body measurements. However, many people have difficulty manipulating a tape measure. Comparing measurements of one person taken by different persons can expose differences as much as 7.5 centimeters. Also, both systems take no account of the exact morphology of the customer so the actual fit on the real customer is very often only mediocre.

Avatars from 3D scans are extremely detailed and personal compared to a parametric avatar and can capture exact body proportions and posture.

These models can also be used in an intelligent fashion design support system for suggesting the most appropriate decision about a new design style and its accordance with specific body shapes towards a specific fashion theme. Moreover, in the same system, the differences between various body shapes and between various garment styles can be quantitatively computed and analyzed. For designers, this treatment is significant for understanding relations between body shapes and styles and identifying the most relevant garment design for a specific consumer.

5. Objectives

5.1 Technological objectives

The primary technological objectives of this project are:

1. Providing companies with the necessary knowledge to develop styles and patterns which take the body shape into account. This will require a study of the morphotypes. Several body types will be defined.

2. The companies will be taught how to grade their basic patterns allometric so the fit is optimized.

3. Companies will be offered greater insight into the far unused potential of 2D CAD programs and they will discover the potential of 3D virtual prototyping.

4. Database consisting the raw anthropometric data

5. Improved size charts

5.2 Economic value

The use of 3D body scanners has proven its importance in identifying body size and body form of the population in different countries like The Netherlands, Germany, Spain, Britain and France. The project results will allow the clothing sector to better adjust its sizes and fits to the respective target groups. This will allow them to significantly increase the share of the target group that can be dressed appropriate from 30-40 % to 50-80 %. The brand loyalty of the consumers will undoubtedly be increased. The results of the sizing campaign can be used to impart the updated standard body size tables as well as size tables for specific target groups. These tables can be compared with data from other 3D sizing campaigns in Europe, America or Asia. Allometric grading rules will allow manufacturers to adapt all sizes better to the body shape of the target. Now, we see that when sizes differ more from the size of the fit model, the fit gets worse. The time and cost to achieve a good prototype will be halved.

The project results will also be supportive for companies seeking new markets or business models and the retail business.

⇒ The results can be very helpful in preparing a configurator for a mass customization business model.

⇒ The fashion retailer will be given a better understanding of the different body shapes. This will enable him to better support the end user in choosing clothes that suit his or her body shape. Customer satisfaction will increase.

⇒ Within the clothing industry workwear, protective wear and sportswear are growth markets.

Between 2004 and 2008 the production of sports clothing increased by 19.4%. It is expected to increase with another 18.75 % by 2014. The annual growth for workwear is estimated between 2.5% and 5%. For these products a good fit can be of vital importance and / or mean the difference between gold or silver.

⇒ At the end of the season 10 to 15% of the collection remains on the shelves. A considerable part of this is simply due to a bad fit.

⇒ In 2008 21 % of SME's offered products through the Internet. In 2009 this was already 25 %. 80 percent of these SME's foresee an increase in internet sales in the coming years. For clothing, the increase is smaller than for other products. The cause lies in the lack of adequate size data. The latter are the key to the growth of e-Commerce for clothing. 50 percent of returned purchases by mail order or over the

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Internet has its origin in problems with the size and fit. Better measurements and fit will at least halve this figure.

Digital printing offers additional personalization and the possibility to co-design, thus creating additional customer value.

5.3 Social value

The project results will ensure that the performance, safety and wellbeing of users is promoted.

Studies already showed that the fit, together with the materials used in sportswear can greatly affect performance of athletes (Swift Skin for cyclists and skaters and Swift Suit from Nike or Fastskin ® from Speedo for athletes). The project results will support manufacturers of sportswear in the development of high-performance sportswear.

A common complaint among workers is that the personal protective equipment does not fit well. The project results will contribute in adjusting the protective garments to the needs and desires of the individual wearer meaning work and protective clothing will be worn much more consistent so there will be less injuries in case of an accident.

Workstations can also be designed more ergonomic so that the number of workers with back pain will diminish and there will be less absenteeism.

In most Western countries, the population is ageing. Between 2010 and 2020 an increase in the number of people over 65 with 200,000 and with 300,000 between 2020 and 2030 is expected (46%). Old age is not what it used to be. Not only do we all age, we age differently. The New Elderly Person is healthier, wealthier, better educated and more assertive than its predecessor. At an age when their parents were thinking of phasing out quietly, the new 55-plus step in their second adolescence, and they prepare themselves to put the crown on their lives. Seniors today have a busy life, they travel and sport. They also want to dress differently from their predecessors. They want fashionable, colourful and well-fitting clothes for all their activities. Many seniors are faced with a physique that deviates from the standard. This may be merely due to overweight, but also to eg. kyphosis, lordosis or scoliosis. This implies that the fashionable ready-to wear garments offered in the stores do not have the right fit and do not feel comfortable. The project results will ensure that for this specific target group more appropriate garments can be developed.

Acknowledgements

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