IN-DEPTH ASSESSMENT OF THE SITUATION OF THE T&C SECTOR IN THE EU AND PROSPECTS

TASK 6: ASSESSMENT OF THE EVOLUTION OF RESEARCH AND INNOVATION PRACTICES IN 5 TEXTILE/CLOTHING REGIONS OF THE EUROPEAN UNION. DESCRIBE PROSPECTS FOR RESEARCH AND INNOVATION IN THE SECTOR.

HELDER ROSENDO, CITEVE

MICHIEL R. SCHEFFER, SAXION UNIVERSITIES

FINAL REPORT ENTR/2010/16
PREPARED FOR
EUROPEAN COMMISSION
ENTERPRISE AND INDUSTRY DG

SEPTEMBER 2012

Saxion Universities
M.H. Tromplaan 28
7513 AB Enschede
The Netherlands
www.saxion.nl

CITEVE Technological center for the textile and clothing industries of Portugal
Rua Fernando Mesquita, 2785
4760-034 Vila Nova de Famalicão
Portugal
www.citeve.pt

Danish Technological Institute
Policy and Business Analysis
Teknologiparken
Kongsvang Allé 29
DK-8000 Århus C
Denmark
www.dti.dk

IFM Institut Français de la Mode
36, Quai d'Austerlitz
75013 Paris
France
www.ifm-paris.com

Workshop s.a.s.
Via Triulziana, 40
20097 San Donato
Milanese (MI)
Italy
www.workshopco.eu

With the support of:

EURATEX European Apparel and Textile Confederation
24, rue Montoyer
B- 1000 Bruxelles
Belgium
www.euratex.eu

TABLE OF CONTENTS

LIST OF CHARTS AND TABLES

CHARTS

TABLES

LIST OF ABBREVIATIONS

ADI	Agência de Inovação *Innovation Agency*
ASTM	ASTM International (Former American Society For Testing and Materials)
ATP	Associação Têxtil e Vestuário de Portugal *Portuguese Textile & Clothing Association*
BRITE	Old European funding program fro Technology and Materials
CENTI	Centro de Materiais Técnicos Funcionais e Inteligentes *Centre For Nanotechnology and Smart Materials*
CIEF	Investigación económica de la Fundación Caixa Galicia *Caixa Galicia Foundation Economic Research*
CIRFS	European Man Made Fibres Association
CIS 2008	Community Innovation Survey 2006-2008
CIS4	Community Innovation Survey 2002-2004
CITEVE	Centro Tecnológico das Indústrias Têxteis e do Vestuário de Portugal *Technological Centre of The Textile & Clothing Industries of Portugal*
CMT	Cut, make and trim production model
CNMP	Centrul National de Management Programe *National Centre for Programme Management*
COINTEGA	Confederación de Industrias Textiles de Galicia *Textile Industry Confederation of Galicia*
CTCP	Centro Tecnológico do Calçado de Portugal *Shoe Technological Centre of Portugal*
DTB	Dialog Textil-Bekleidung.
EFTA	European Free Trade Association
EIS 2011	European Innovation Scoreboard 2011
EMPA	Swiss research institute for science and material technology
ETP	European Technology Platform for The Future of Textiles and Clothing
EURATEX	The European Apparel and Textile Confederation *Federal Ministry of Economics and Technology*
FATM	Forschungsstelle für allgemeine und textile Marktwirtschaft *Centre for Research in General and Textile Market Economy*
FEPSA DIGITAL	The largest European event for the digital wide-format print industry

HEIMTEXTIL	International trade fair for home and contract textiles
IGE	Instituto Gallego de Estadística *Statistic Institute of Galicia*
INCDTP	Institutul National de Cercetare-Dezvoltare Pentru Textile Si Pielarie *Research Development National Institute For Textile and Leather*
ISO	International Organization For Standardization
ITMA	International Textile Machinery Exhibition
ITV	Institute of Textile Technology and Process Engineering Denkendorf
IUS	Innovation Union Scoreboard
IVGT	German Industrial association for textiles
NP	Norte de Portug*al North Region Of Portugal*
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organization for Economic Co-operation and Development
PLA	Polylactic Acid
POLYMAT	Polymer Science Network of Slovenia
PTIC	Club Português de Inovação Têxtil *Portuguese Textile Innovation Club*
RIS	Regional Innovation Scoreboard
SKU	Stock-keeping Unit
sqm	Square meters
SME	Small a**n**d Medium Enterprise
TÜV	*Technischer Überwachungs-Verein*; Technical Inspection Association

EXECUTIVE SUMMARY

This task focused on understanding how European textile & clothing companies are engaged into innovation practices. Hence key questions regard what is critical to transform knowledge and Research and Development (R&D) into good selling marketable products and which are the driving forces and relationships towards a better competitive performance through innovation. The analysis was carried out and the trends were then verified in selected regional cases: Lombardia Piemonte, Baden Württemberg, North Portugal and Galicia, Slovenia and Romania.

According to the European Technology Platform Roadmap, European textile and clothing industry is a world leader in technology, process and product innovation, including fashion clothing and other "non technological" activities. The textile sector has been enhanced by innovative products and processes in particular in the growing field of technical textiles. But in general textile and clothing industry spends a relatively low share of their turnover on research compared to other industries.

Product/process innovation. In the European T&C sector product innovation strategies are mainly based on product differentiation through a path of incremental product development. Radical innovation strategies play in fact a minor role in the sector. Product innovation is also relatively more common than process innovation and is considered to be more important towards future development of the sector.

During the years 80s and 90s the major force driving textile process innovation and technology development was productivity; while looking at the 2000s the focus shifted to flexibility and new drivers like sustainability and environment friendly production emerged. Most of the European textiles and clothing companies are more engaged in product development than process development. Non-technological innovation has been very often referred to by companies interviewed as being of great importance for the sector, which produces a significant variety of products, in a relatively short time.

Looking at the major trends in technological innovation, the 2000s have not seen substantial investment in equipment in Europe; in fact the EU accounted only for 5% of the new installed machinery, while China accounted for 50%.

Spinning has become a niche sector in Europe specializing in higher priced, more complex yarns, often involving blends and further processing. In weaving the trend is to balance efficiency with smaller production batches. Finishing is an area with substantial incremental innovation but also with breakthrough technologies. This area also involves interdisciplinary coordination as often mechanical, chemistry and ICT industries are working together. Clear trends are production of low batches and the reduction of the environmental impact of finishing and dyeing.

Knitting has improved machines thanks to ICT. Consequently, companies in Portugal and Italy keep a clear leadership in knitting technology; while sewing was characterized by little incremental innovation.

A highly innovative area for textiles is the production of special fibres and fibres from biopolymers such as high performance polymers/fibres, with new functions or higher aesthetics.

Digital printing is one of the most significant examples of innovation in textiles since the late 90s. The application to the textile sector is a truly European achievement of textile machinery producers (mainly from Lombardia) that were able to understand the needs of textile companies. The improved performance has come from developments in computer technology, engineering, automation and electronics.

Looking at non-technological innovation, the main area is commercial innovation. It covers a wide range of subjects such as design, organization and technologies applied to retail and logistics. The interaction between non-technological and technological innovation is complex and intense. Examples in this area are design, differentiation, fast fashion logic, new ICT retail technologies and mass customization.

Marketing innovation is growing in importance and is more commonly adopted than organizational innovation. Particularly companies in the clothing business and controlling the distribution channel and/or the retail management, consider marketing innovation as strategic for the commercial performance such as the release of new products. Besides, the importance of communication practices within the innovation performance, is present in several cases in North Portugal and in Slovenia. Marketing innovation effectively linked and integrated within product innovation strategies, was also identified as a key factor for the success of launching innovative products into the market in several cases, which are using the internet as an alternative marketing channel (North Portugal cases or Lombardia/Piemonte cases).

Suppliers, clients and companies within the same supply chain are the more relevant cooperation links engaged during the process of bringing a technological concept to industrialization and commercialization (the so called innovation pipeline); this happens in particular for big companies, which are driving and leading their innovation processes. The corporate “customer” or final client itself is an important driver for the innovation strategy; Companies which have direct access to the final consumer tend to profit in a more effective way from such contact, exploring continuous information feed from shop to the innovation process. However often innovations are pushed from the supply side: yarn and fibers suppliers are particularly relevant in the case of textile companies, while fabric suppliers are more relevant for the clothing manufacturers. Technology suppliers, especially machinery are often engaged in the innovation process for both textiles and clothing companies but in a secondary role. They follow the lead of their clients. The role of technology and research institutes varies: large companies tend to keep research work inside using own resources, while in the cases of innovative SMEs the collaboration with institutes is more relevant either through project based activities or with subcontracting services relations. Most of the identified success stories in collaborative projects have in common a leadership role of companies and their involvement from the very beginning of the activities.

Public funding is of major relevance for supporting R&D and innovation related activities. Looking at data regarding public funding to companies, it shows that the share of innovators receiving public funding is higher in the countries that perform better in terms of innovation (Austria, Netherlands, Italy and Finland)

Considering fundings for innovation at local, national or European level, the share of innovators receiving any public funding is not significantly different between the textile and clothing sector and the manufacturing sector in general. Several companies mentioned that funding is much more oriented to scientific activities while (innovation) activities closer to the market, including non-technological, lack a project framework in the field of product innovation. Often the incremental innovation activities of companies do not fit into European funding programmes, hence the activities are carried out with internal resources or through national/regional small scale projects.

Regarding the awareness of European funding, the European Framework Program (FP6 and FP7) comes first on the list and only after the Competitiveness and Innovation Framework Programme (CIP) appears, no matter in which regional case this issue was presented.

No spontaneous reference or comment in particular was made in any interview about the Community Framework for State Aid for Research, Development & Innovation in any of the regions addressed by Task 6, Innovation. State aid aspects are covered by the existing funding schemes; in the case of Interreg projects state aid is subject to a specific declaration that the amount of the grant is, cumulatively for the beneficiary, still below *de minimis* criterium, but this is rather considered an administrative procedure. This is a sign for a lack of awareness among the companies regarding state aid, whose debate has probably been kept at a more political level.

Intellectual Property Rights (IPR) is still a complex issue for companies to manage within the innovation pipeline, even for those with a relatively high qualified internal R&D staff; consequently SMEs lack the resources to manage such a process. Patent registering is still considered to be expensive and complex, but there is a lack of knowledge even regarding simple and cheap procedures, that can at least provide some protection in early stages of product development. Germany is by far the most active country regarding patenting. That position is in line with the dominance of this country regarding two kinds of businesses which are more suitable for patenting activity: technical textiles and textile machinery construction. Textile companies are patenting more often than clothing companies, which usually tend to use trademarks and designs.

When looking into specific regions:

In the case of Baden Württemberg, public funded R&D is of marginal relevance. Innovation could be described as a constant iterative process between several actors, either based on formal or informal road-maps or on a project oriented approach. This type of innovation does not combine easily with public funding in terms of project management.

The Lombardia-Piemonte case shows a good dynamic of innovation in the private sector, with limited public involvement. In both subcases the dynamics reveal incremental step by step improvements and further diffusion of innovation. What both subcases also show is that next challenges may need more intensive involvement of public research and public funding.

Innovation in North Portugal and Galicia is following different patterns, mainly due to the stronger presence of textile companies in North Portugal, which makes the sector more diversified in that part of the region than in Galicia. In North Portugal technical textiles and other product oriented innovations, towards specialized applications and markets are more important, as well as process innovation leading to product differentiation (new finishing, new fibre blends and new functionalities). In Galicia, the stronger presence of clothing manufacturing companies is mostly due to the Spanish market (with the exception of INDITEX that represents 90% of the region's exports), under a model which is strongly influenced by the INDITEX phenomenon, which drives innovation through a path which is more focused on organizational innovation.

The Slovenian case supports the idea that innovation is clearly on the agenda of companies as an important competitive factor towards international markets. Within the Slovenian textiles sector most of innovation paths followed by the companies are in line with fibre and textile related fields of development, with similar drivers to the ones found in North Portugal. Eco-innovation and process innovation strategies towards more efficient use of

resources are very often adopted by companies which find a well-developed R&D capacity available in that particular field at university.

The Romanian case can be characterized by a strong focus on production capacity and associated supporting services. The strong presence of foreign companies which have installed their production centres in the country, due to a competitive labour cost offer, is still important for the present sector's profile. Companies see innovation as something important for the future, but it is still far from being on the top of companies' agenda today. Non technological innovation will have an important role for the clothing manufacturing companies, which are starting to develop a shift from a pure Cut-Make-Trim (CMT) model.

Looking through all the success stories and cases that were presented in the different regions it is possible to identify common critical factors which are considered relevant when it comes to innovation performance. The strong link with suppliers (raw materials, chemicals and sometimes technologies) is present in every case and particular for SMEs this is a very relevant input for innovation. The engagement of the client (in both business to business and business to consumer cases) through more or less formal methodologies it is also a common factor which is present in every success story, with particular relevance in the case of business to consumer (B2C) relationships regarding incremental product innovation or non technological innovation strategies. Interaction with users has been mentioned several times as one of the richest information sources for innovation.

The importance given to marketing and communication specificities, when it comes to present an innovative product, within or not the usual markets, has been underlined in almost every case as having a critical influence on the "new product" success. This factor is even more critical when the innovation strategy addresses non-traditional markets. Here specific regulation, such as in medical textiles, or procurement systems, such as in protective equipment, have been pointed out as one of the critical common innovation barriers. The importance of industrial know-how is present with higher or lower intensity in every case, directly or indirectly. The role of innovation centres and R&D centres in the innovation pipeline, beyond the latest stages of the development processes, which is more relevant in the case of SMEs, seems to be connected to a role of information providers acting sometimes as hubs to reach less known application sectors from the companies' point of view.

The future outlook for innovation is rather positive as many companies are focused on it. Most of the innovation will be in incremental product development and process innovation, much less is in non-technological innovation or in radical innovation. The outlook is rather positive for innovation when a leading customer takes the lead (e.g. Inditex or BMW) or when a technology push is manifest (e.g. digital printing). Competition between retailers, clients and suppliers also will foster innovation, especially since a cooperative approach is harder to organize. Innovation requiring the organisation of the supply chain such as ICT standards or adoption of biofibres will remain fragmented. Institutional barriers such as difficulties to cross-border cooperation because of differences, education systems, in innovation funding, or public procurement,still enhance this fragmentation. The lack of regional funding for innovation (e.g. in Romania) or severe cuts in funding for innovation (e.g. in Lombardia) is also a barrier to innovation.

1. INTRODUCTION

1.1. METHODOLOGICAL ASPECTS

This report focus on understanding how deep the European textile & clothing companies are engaged into innovation, what is critical to transform knowledge and R&D into good selling marketable products and which are the driving forces of those processes within. companies. The findings are then analysed and discussed in detail in the cases regarding innovation performance into five selected European regions. This task will also analyse innovation breakthrough into textiles and clothing in the last 10-15 years and from that best practices have been analyzed.

This report presents a general introduction about innovation with an assessment of existing reports that benchmark innovation performances of EU Member States and EU regions and the textile and clothing sector. Then an overview of the state of the art of technological innovation in textile and clothing is presented, highlighting major breakthrough and impact on the industry. Then study cases into five selected EU regions or member states were carried out; they have been performed through field work in direct contact with companies and other relevant organizations within the innovation system, aiming at the identification of the particular situation in those specific regions or member states:

- Lombardia-Piemonte (IT)
- Baden-Württemberg (DE)
- North Portugal – Galicia (PT, ES)
- Slovenia
- Romania

Since Lombardia-Piemonte and Baden-Württemberg have large and diversified industries (in terms of employment ad/or turnover), in these specific cases the analysis has been differentiated between textile and clothing technology and focused on specific innovation subcases.

The cases have been carried out by realising several individual interviews, workshops and round tables in each region. Moreover a focused analysis of relevant strategic documents, studies and roadmaps, has been carried out; the documents where directly provided by local organizations and authorities or publicly available. The participants in the different round tables and individual interviews organized in each region are listed in Annex 1.

EURATEX data regarding market and exports figures was also considered in order to characterize the sector dimension and profile in each of those regions.

The links with other aspects analyzed in the present study, in particular with the tasks looking into training, restructuring or SME's in particular, was mostly done through coordination meetings between the different task leaders in order to identify common issues or relevant findings supporting common conclusions.

Regarding the technological overview and technical information for specific technologies, besides company's and expert's opinion, two major sources were considered: on site evaluation in during ITMA 2011 and bibliographic research on different scientific and technical documents.

1.2. CONCEPTS & DEFINITIONS

The concept and definition of innovation adopted for the realization of this task is based on the Oslo Manual (1997)[1]. Therefore we adopt the following terminology within the present study:

Innovation is a new or significantly improved product (good or service) introduced to the market or a new or significantly improved process introduced within an enterprise. Innovations are based on the results of new technological developments, new combinations of existing technology or the utilization of other knowledge acquired by the enterprise.

Enterprises engaged in innovation activities (propensity to innovate) are those which introduce new or significantly improved products (goods or services) to the market or enterprises that implement new or significantly improved processes. Innovations are based on the results of new technological developments, new combinations of existing technology or the utilization of other knowledge acquired by the enterprise. The term covers all types of innovator, i.e. product innovators, process innovators and enterprises with only on-going and/or abandoned innovation activities.

An organizational innovation is the implementation of new, significant changes in firm structure or management methods that are intended to improve the firm's use of knowledge, the quality of its products and services, or the efficiency of work flows.

Innovation co-operation measures the active partnership of the observed enterprise with other enterprises or non-commercial institutions such as universities or public research institutes, at national or international level. Co-operation can take place with more than one partner. Concerns enterprises with product and process innovations (regardless of their organizational or marketing innovations).

In brief:

- Product Innovation – New products
- Process Innovation – New process in production
- Organizational Innovation – New organizational methods
- Marketing Innovations – New marketing strategies

[1] Organisation for Economic Co-operation and Development, *The measurement of scientific and technological activities - Proposed guidelines for collecting and interpreting technological innovation data - Oslo Manual*, ,3rd edition, OECD publishing , 2005.

1.3. INNOVATION IN THE TEXTILE & CLOTHING SECTOR

The Innovation Union Scoreboard (IUS2011) is the tool that provides a comparative assessment of the innovation performance of the EU27 Member States and the relative strengths and weaknesses of their research and innovation systems.

The study aggregates 25 indicators that are grouped into three type and eight innovation dimensions. In specific enablers type: human resources; open excellent and attractive research systems; finance and support. Firm activities type: firm investments; linkages & entrepreneurship; intellectual assets. Outputs type: Innovators; Economic Effects.

Based on their average innovation performance the member states fall into four performance groups:

The performance of Denmark, Finland, Germany and Sweden is well above that of EU27 average. These countries are “Innovation Leaders”.

Austria, Belgium, Cyprus, Estonia, France, Ireland Luxembourg, Netherlands, Slovenia and the UK all show a performance close to that of the EU27 average. These countries are the “Innovation Followers”.

The performance of Czech Republic, Greece, Hungary, Italy, Malta, Poland, Portugal, Slovakia and Spain is below that of the EU27 average. These countries are “Moderate Innovators”.

The performance of Bulgaria, Latvia, Lithuania and Romania is well below that of EU27 average. These countries are “Modest Innovators”

The Regional Innovation Scoreboard (RIS) provides a comparative assessment of innovation performance across NUTS 2 level regions of the European Union, although data for some regions are at NUTS1 level or aggregated. Last edition available is 2009, and it can benefit from a more comprehensive and detailed regional Community Innovation Survey (CIS) indicator that can replicate the methodology used at national level in the European Innovation Scoreboard. Despite this progress, the data available at regional level remains considerably poorer than at national level, and in particular four member states - Germany, Sweden, Ireland and the Netherlands – were not able to provide regional CIS data. Due to these limitations, the 2009 RIS does not provide an absolute ranking of individual regions, but ranks groups of regions at broadly similar levels of performance.

The study reveals that there is considerable diversity in regional innovation performances also in the same country: all the countries have regions that performs differently in terms of innovation; the most heterogeneous countries are Spain, Italy and Czech Republic where innovation performance varies from low to medium-high.

However nearly all the "high innovators" regions are in the group of "Innovation Leaders" identified in the European Innovation Scoreboard (EIS2009). Similarly all of the "low innovators” regions are located in countries that have below average performance in the EIS. However, the results also show regions that outperform their country level: with reference with the regions and states analyzed in this task, Lombardia and Zahodna Slovenija are listed into the medium high innovating group of regions while Italy and Slovenia are listed into the group of moderate innovators and catching up countries.

The European Textiles & Clothing industry is often regarded as a 'low tech' sector: various studies pointed out how companies on average spend a relatively small percentage of their turnover on research as compared to other manufacturing industries, and they score low performances in terms of output of new products and skill level of employees.

Regarding textile & clothing innovation, Europe Innova published the "Sectoral Innovation Performance in the Textiles and Clothing Sector" in 2010[2]. This report examines the innovation activities in the textiles and clothing industry processing data from the fourth round of the CIS, referring to years 2002-2004. The results showed a differentiated picture of innovation in the T&C industry. It confirms that innovation performance is below manufacturing level; innovation relies to higher degree on the acquisition of external technologies and is based to a lesser degree in in-house R&D. Innovation cooperation is less frequent in T&C and patents or other means to protect intellectual property are rarely used; this finding was also confirmed in , research, 2 of this study.

The report also presents a disaggregate analysis for textiles and clothing. At this level various indicators show significant differences between the two subsectors as well as differences between these industries in terms of innovative behaviour. Textiles enterprises have more in-house innovation activities and invest a higher share of their turnover in innovation activity compared to clothing enterprises. Formal innovation cooperation is more frequent in the textiles sector then in the clothing sector, were informal linkages are more important.

In the specific field of product innovation, European companies are recognized in several areas as leaders, both within the technical products market, as in the fashion or home-textiles market. Product oriented innovation is in most cases resulting from a creative combination of fibres, finishing, materials or chemicals, powered by an experienced combination of processing options and amplified by the introduction of new designs or new product functionalities. Frequently all these kind of innovations will not be considered as research but falls more into the concept of non-technological innovation.

Many innovations in clothing (and partly in textiles) mainly alter the aesthetic characteristics, but not the functionality of the products. Innovation of aesthetic features is connected with the ability to build and sustain brand identity and brand recognition over time is essential for this industry.

Non-technological innovation has been very often referred as of great importance for this sector, which produces a significant variety of products, in relatively short periods of time, through the above described combination of factors that normally represents most of the innovative activity in companies, both from the textile value chain side and from clothing manufacturing business. However, as it is stated in the Europe Innova report, non-technological innovation remains invisible in the official statistics which contributes to the underestimation of the sector's innovative capacity and performance and especially in the clothing industry. However it must be noticed that indicator about SMEs that perform non-technological and organizational innovation has been introduced in the survey

It is interesting to verify some of the indicators used in the Europe Innova report, that builds on the results of the CIS4 (coverin period 2002-2004) and compare it with the more recent set of data from the Community Innovation Survey available from Eurostat the one from 2008. CIS 2008 dataset includes also figures from non EU Member States such as Norway, Iceland, Croatia and Switzerland; they are included in the figures but non commented.

[2] http://www.europe-innova.eu/c/document_library/get_file?folderId=148690&name=DLFE-13428.pdf

Looking at innovation expenditures as percentage of turnover chart in CIS 2008 data Figure 1 we see that Belgium is the top scoring country while in CIS 4 was the second, with 2.3%,below Poland which now scores significantly worth than the second position obtained in 2004.

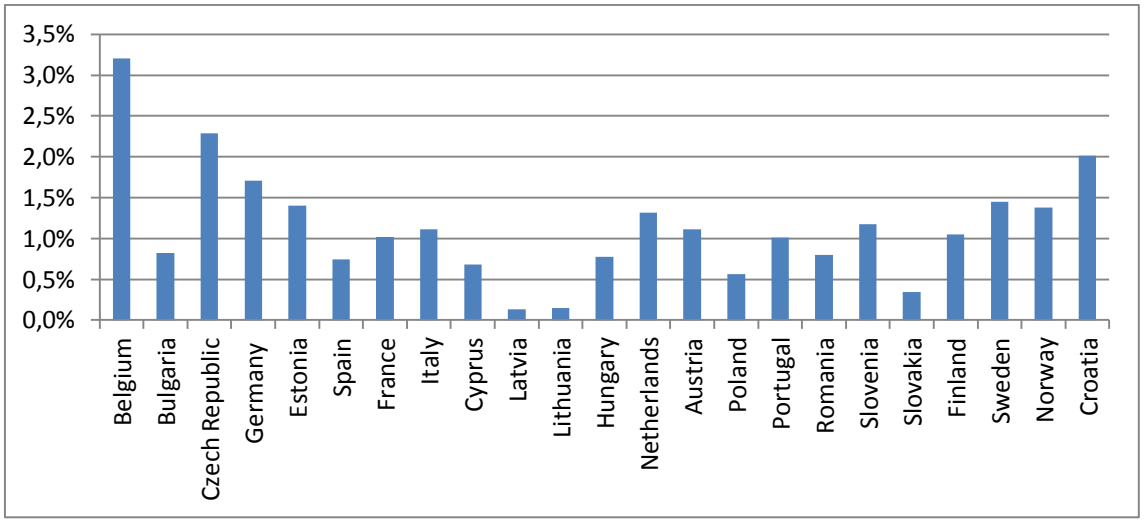

Figure 1: Innovation expenditures as percentage of turnover in the T&C sector [SOURCE: CIS 2008]

Regarding this indicator and the situation described in the Europe Innova report, one of the most significant differences is the decrease of Italy from almost 2.5% of innovation expenditure to nearly 1% in 2008 and Portugal that increases its expenditure in innovation from 0,5% to 1%.

Cooperation towards innovation was also one of the major concerns during the field work developed in targeted regions for task 6 innovation and which results and conclusions are shown further on. This indicator is measured in the CIS 2008. The Figure 2 shows the relevance of each kind of different cooperation links regarding innovation activities within innovators. It shows that almost in every country, the global trend points out that particularly suppliers and also clients are more often engaged in cooperation towards innovation than other kind of organizations. The relevance of suppliers is even clearer in good performing countries regarding innovation such as Belgium, Netherlands, Austria or Germany.

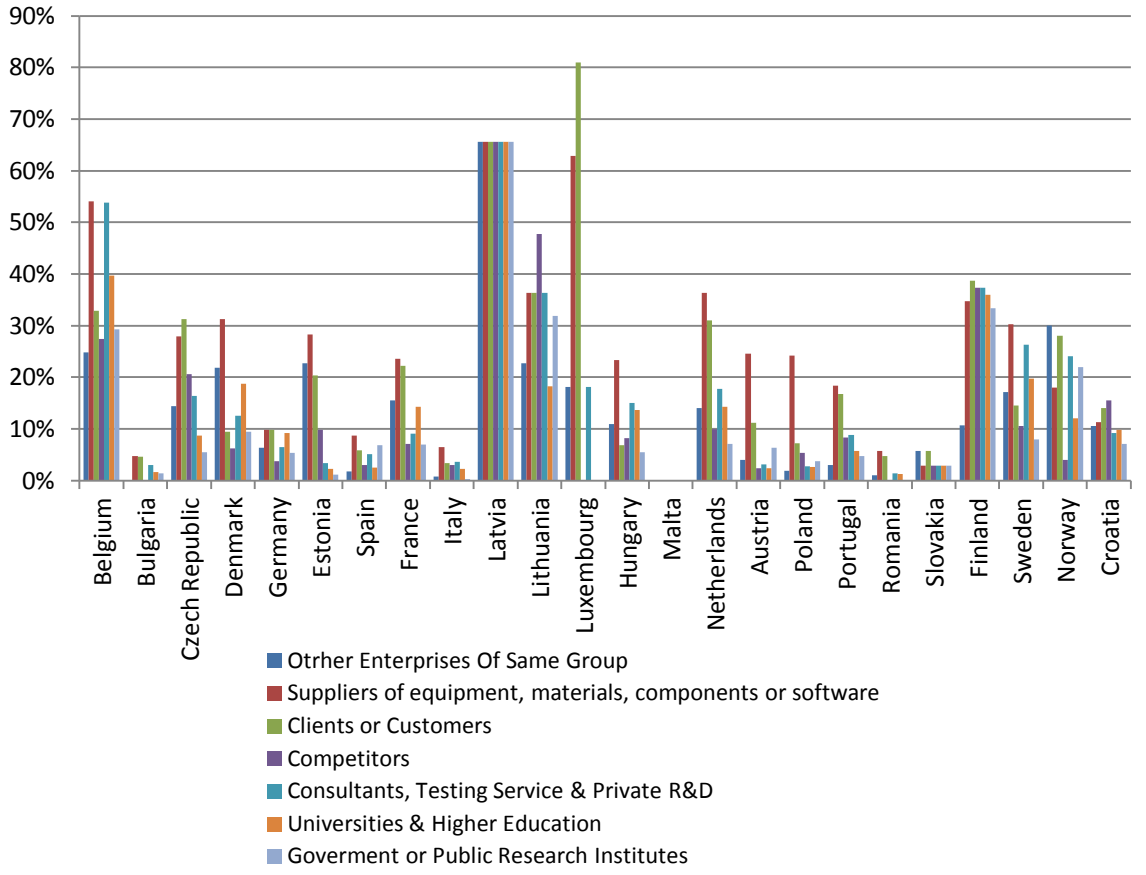

Figure 2: Innovation cooperation links in innovators in the T&C sector [SOURCE: CIS 2008]

Looking at the European average in terms of the survey population from each country, presented in Figure 3, the trend regarding innovation cooperation is even more clear and confirms the general trend where suppliers and clients/costumers being more relevant for the innovation process than other kind of organizations.

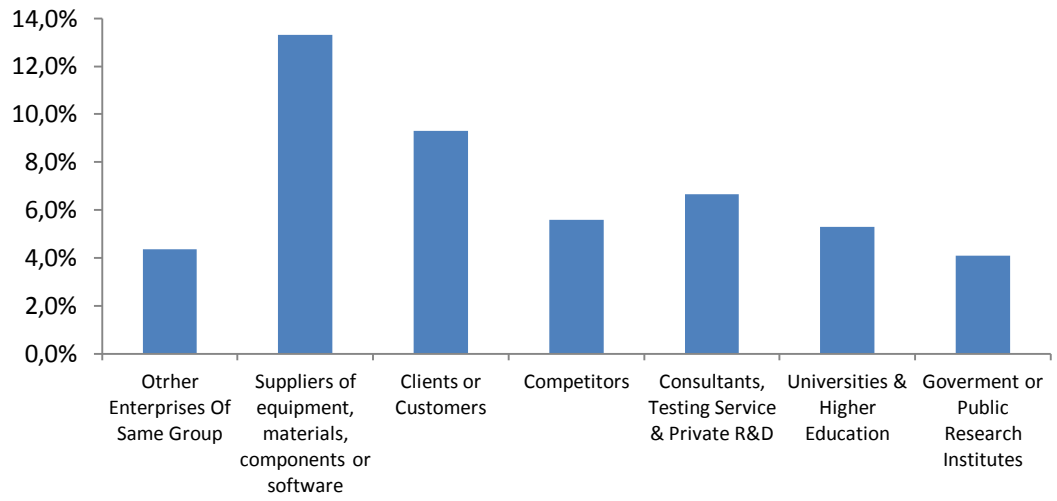

Figure 3: Average weighed by survey population regarding innovation cooperation partners in the T&C sector [Source CIS 2008]

The innovation dynamic within a company can lead to different results. The implementation of innovative processes within the T&C industry normally aims at cost reduction, higher productivity or better environmental performance. Product innovation will normally lead to new products that will affect the company's sales. Those new products could be grouped in two major categories; 1) New to market or 2) New to the firm. New to market products are clearly novelties in the market that were not available before the company developed it. New to firm products falls more into the imitation concept and those are products developed by the company, but that already exists in the market, in a very similar way. This indicator is showed in Figure 4.

.

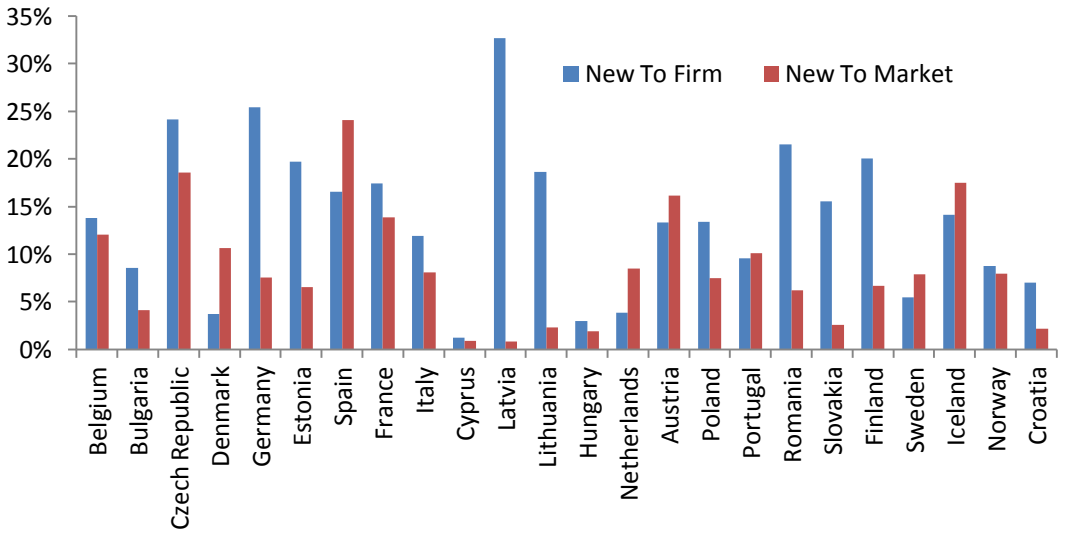

Figure 4: Sales share of new to firm and new to market product for innovators in the T&C sector. [Source CIS 2008]

As expected, in the T&C, the new to firm products are normally more representative than new to market ones. Regarding new to firm products, Germany, Latvia, Estonia, Lithuania and Czech Republic, Romania and Finland show the best rates scoring above 15%. Regarding the new to market products, the higher turnover share can be found in Spain, Czech Republic, Austria and Iceland. Looking at the figures of CIS 4 and comparing only the most performing countries, it is possible to observe an interesting improvement regarding the share of turnover resulting from new products in the T&C sector.

Public funding is of major relevance for supporting risk associated to R&D and innovation related activities. Looking at CIS 2008 data regarding public funding to companies, we see that on average, the share of innovators receiving public funding is lower in textiles and clothing then in the general manufacturing sector. Exceptions are in Italy, Germany and Spain. See Figure 5.

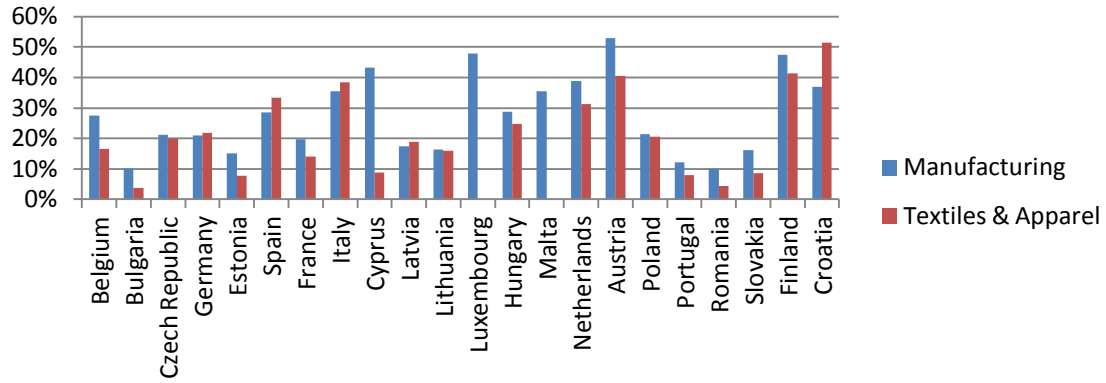

Figure 5: Shares of innovators receiving any public funding (Manufacturing vs. T&C) [Source CIS 2008]

This indicator measures the degree of government support to innovation; it gives the percentage of all firms that received any public financial support for innovation from at least one of three sources: local, national and the European. The situation regarding the T&C firms is not very different from the general situation of manufacturing in most countries. Romania and Bulgaria are the countries where companies are benefitting less form public funding. Austria, Italy and Spain the one with the most.

Analysis of the output of intellectual property rights protection is one of the most common indicators for innovation, namely regarding protection of results towards it valorisation in the future and towards a better return on investments from innovation activities. The T&C sector is not a relevant technology generator and therefore patenting is rarely used, where trademarks and designs and models are more common instruments.

According to a database research done through Thomson Innovation, limited to patent applications filled in by European countries and based on relevant key words and concepts for the T&C sector[3], the patenting activity of the T&C over the last 4 years has slightly improved. This research has been presented in task 2, research of this study.

[3] textile, clothing, fabric, wool, cotton, silk, fibre / thread / knitting e technical textiles

CIS 2008 data confirms that textiles companies are more often using patents to protect its innovations than clothing companies, where designs and models are frequently referred as better adapted to the kind of novelty that can be protected or registered in a clothing article development.

Innovation Strategies and Roadmap

The performance of the European textiles and clothing sector, in a knowledge-based economy will increasingly depend on the ability of the industry to constantly innovate its products, to use the most advanced, flexible and resource-efficient processes and to focus its organizational structure and business operations towards surprising the client with top quality services. In this context, innovation practices and the ability to bring R&D results to the market, both play a strategic role. In an industry composed mainly by SMEs, fragmentation and general lack of (financial) resources is certainly at the top of the priorities agenda.

To this extent the European Technology Platform for the Future of Textiles and Clothing roadmap is a way to repair the lack of long-term strategies for the companies. The good use of the industry roadmap will contribute to prevent shortcomings such a as; fragmentation, duplication and discontinuity of research efforts; shortcomings in the ability to translate research results into product- and process-innovation; shortage of highly qualified "knowledge workers"; difficulties in effectively protecting innovation-related IPR.

European T&C is a world leader in technology usage, process and product innovation, including fashion creation and other "non-technological" innovation activities. In this context it is beneficial that European textile machinery manufacturers themselves are world leaders and that the technical textiles subsector is equally recognized for its pioneering role.. Nonetheless, in comparison to the spinning and weaving of textiles, clothing manufacturing is highly labour-intensive, and steps are urgently needed to overcome this competitive disadvantage when compared to lower wage countries. In this sense, the textile industry is considered by several sources and official documents like a medium technological sector, while the clothing manufacturing sector is considered to be a low technological sector.

The most recent roadmap document published in terms of innovation strategies for the Textile & Clothing sector is the Strategic Research Agenda, developed within European Technology Platform and published by EURATEX in 2006. Besides identifying specific research priorities, this document identifies the more relevant thematic fields of innovation which are considered to be fruitful land for the European T&C companies to invest their innovation efforts towards higher added value products and services.

Despite the document lacks an operational action plan, it shall be noticed that in several cases this strategic paper has been adopted in the policy of specific countries or regions; in this cases an action plan has been proposed upon original strategy, in order to adapt the proposed agenda to the specificity of the sector in each area. This is the case of Baden-Württemberg (DE), Nord Pas de Calais (FR), Saxony (DE), West Sweden (SE), Nordrrhein Westfalen (DE), Netherlands, Portugal, Slovenia and England's North West (UK), where strategic documents regarding innovation in the T&C sector have been identified.

The key innovation themes, leading the research priorities that have been identified in the strategic research agenda of the European Technology Platform are:

- A safe and comfortable environment around us;
- Effective protection and health care for Europe's citizens;

- Innovative mobility and energy solutions;
- Efficient use of natural resources and protection of the environment;
- Extending Europe's creative and innovative leadership;

The strategic document addresses also links to other relevant issues within the innovation system such as education and training or standardization. In many cases national specific clustering initiatives in the sector have adopted the ETP roadmap as a basis for the development of national strategies, taking into account the specificity and the reality of the local industry and environment.

The ETP for the Future of Textile & Clothing, has assumed the role of an hub, gathering together organizations, companies and individual experts from different European countries with the scope of a cooperation platform towards the dissemination of on-going projects, initiatives, building of new European projects consortia (matchmaking). A relatively recent initiative is the European Textile Technology marketplace (ETTMa), a European wide technology transfer service for pre-commercial research results. The ETP is indeed a success story in ensuring transparency and broad stakeholder engagement in European research and innovation policy making and programming.

The development of a Strategic Research Agenda and a technology road-map enhanced funding opportunities, improved coordination and more transparency in the process leading to proposals, especially in the European Framework Program (FP6 and FP7 and now HORiZON 2020), it created bridges to other platforms such as the bio-industry and manufacturing technologies; It offered a platform for regional cooperation, now shaped in the ERANET Crosstexnet.

However there is still work to be done; in fact debates on giving the ETP a firmer institutional legal and financial basis are ongoing. While support from the R&D community is strong, the industrial involvement in the ETP concerns less than 100 companies. As it has been highlighted in task 2, research, national associations are often a lukewarm relay to the industry, often for lack of competence in technology matters. The presence of textiles and clothing in the Horizon 2020 programme with an important role in terms of innovation challenges and large instruments as joint programming is challenging; in fact coordination of national efforts is difficult and a firm and consistent agenda setting on human capital for research and innovation has not proven to take off.

2. TECHNOLOGY OVERVIEW

2.1. GLOBAL OVERVIEW ABOUT RECENT TECHNOLOGICAL EVOLUTION

2.1.1. PROCESS INTENSIFICATION AND INNOVATION

Between the years 1980s and 1990s the major objectives in the textile technology development were productivity and flexibility. In every segment of the textile technology, from fibre processing to fabric finishing, the evolution in processing speed was progressively being replaced in the early 1990 decade by quickest machines set ups, more sophisticated automation towards less working force and fastest material transportation within the process. Productivity in the textile industry, measured in turnover per employee increased from EUR 30 000 to EUR 100 000 between 1982 and 2002[4].

In the year's 2000 major focus of technological development was still on flexibility, in order to allow the processing of multiple material combinations within the same technological park, while at the same time innovative finishing operations were developed, allowing different aesthetic effects in the textile product. Processing speed was suffering incremental improvements, mostly in weaving machines technology. New fibre extrusion systems allowing reduced and specialized batch production, supplied even with a small number of spinning positions were also consolidating within the fibre production scenery. Electronic set up and remote machine assistance through the web became a commodity in most of the processing technologies as well as on site automatic quality monitoring and control. Finishing operations allowing fabric coating or the combination of multiple layers, like laminating or bonding technologies, also started to became important technologies, mostly for technical products production. Also within the technical products segment, nonwoven web forming technologies, but mainly the web consolidating technologies, like hydro entanglement (spunlace) for example, have evolved considerably, allowing nonwovens to enter product domains typically dominated by other textile structures.

The last international textile machinery exhibition, ITMA 2011, that took place in Barcelona in October 2011 presented the latest available trends in textile technology. An important area of innovation relates to technologies enabling to realize higher productivity. This is valid in the entire production chain from extrusion till assembly. Assessed in detail, higher productivity can be attained by technical improvements, through process integration and through management and work practices. However process intensification can be examined in terms of

[4] [1]FiantiFianti Noor, [2]ProfProf. Paul Smith, [2]NatalieNatalie Stingelin-Stutzmann & [1]StuartStuart Peters - [1]SchoolSchool of Engineering & Materials Science Queen Mary-University of London (UK) [2]DepartmentDepartment of Materials, Eidgenössische Technische Hochschule Zürich (Switzerland)

productivity increases at constant or higher volumes or in combination with technical change in order to combine higher productivity with product differentiation, higher quality and higher flexibility. The latter change may also mean that less advanced concepts have been taken up as they allow for better quality at the expense of productivity.

In general between 2000 and 2010 there were no substantial investment in equipment in Europe. In terms of new spindles, looms and finishing equipment, Europe represents less than 5% of new installed machines, while China accounted for 50% of new plant installed. In addition with restructuring of all stages of manufacturing, Europe is the largest source of second hand machines. It can be said that in general textile and clothing firms have favoured to modernize, upgrade and extend the lifetime of machines rather than invest in new ones.

The objective of firms is to work with written off machines and to keep investments low. This also enables to preserve overcapacity at low cost to be eventually used in times of high demand. This strategy is often needed since many textile firms in Europe operate in niches that are protected because of specific equipment but are also cyclical. This also helped many companies to survive the recession since depreciation was low in combination with declining working capital.

All incremental innovation in production technologies is primarily a dialogue between textile firm and machine supplier. Most machine suppliers interviewed mention European clients as small clients but also the most innovative and demanding. Italian (dyeing and printing), German (non-wovens) and Belgian (carpets) firms are mentioned to be among the most demanding, often demanding customized solutions to their production, whereas Asian clients go for tested and tried solutions. Both machine suppliers and textile manufacturers report that the adaptation and tooling of the machine is often a key to develop specific product features; hence the adjustments made to the machine are often kept secret to suppliers and competitors. This also leads to a partnership between textile firms and technical consultants and research centres to adjust machines and processes, to protect “recipes”.

It is hard to document but research centres are becoming less prominent than consultants (often retired engineers and technicians) since the latter have more hands-on experience in the installed base. RTO’s are more relevant in upcoming techniques and in complex challenges of aligning different processes.

2.1.2. SPINNING TECHNOLOGY

The spinning sector has become a niche sector in Europe. Most spinning capacity is now within integrated firms combining spinning and weaving. Whatever the position, spinning has oriented to more specialized products. This means in general a shift from open end spinning towards the more traditional ring spinning, namely compact yarns. This has mainly occurred through a stronger restructuring in open-end spinning than in ring spinning.

The spinning subsector is composed of short fibre spinners (cotton) and long fibre spinners (wool). The share of European short fibre spinning industry is declining rapidly, in fact, despite their higher productivity, they compete in lower price ranges. Long fibre spinners have a lower productivity but command higher prices; this is a sign of specialization in higher priced yarns typically with prices above EUR 4 per kg. Finally spinners have focused on making more complex yarns, often involving blends, further processing (e.g. twinning or “adding” filaments for special purposes).

However spinners have been working at upgrading the logistics of spinning in order to reduce labour intensity in handling, improving quality monitoring by applying advanced optics and improved capacity utilization by advanced planning methods supported by online data collection at the machine, hence ICT has been the driver to better

quality and differentiation in spinning, but the improvement of productivity was often not a sufficient condition to survive.

For the larger spinning companies integration with weaving was essential, and for standalone spinners specialization in complex blended yarns and fast change.

An important evolution has occurred in yarn winding and default cleaning, with significant improved processing speeds and more accurate yarn fault inspection and elimination. Technologies that have been used for long in the field of fancy yarns to produce different fashion effects, either for weaving and for knitting are now being oriented to technical applications, mainly as an interesting alternative to braiding in the sense of combining different types of yarns within a single final product.

2.1.3. WEAVING

Weaving has also to accommodate efficiency with smaller batch production. The focus is on faster and automated systems for preparation of the warp, since most adjustment costs in weaving are in the preparation stage. Weaving looms themselves can also be more versatile, and especially when the fabric structure offers differentiation, machines offering a wider range of bindings and colours are of interest. Hence dobby looms and jacquard looms have been much in demand, as well as looms in a larger width, to be used for example in home textiles; besides being more expensive than standard looms, these looms require more space in the mill as well as more qualified staff.

A specific trend is the emergence of 3D weaving or tri-axial weaving. The first trend is rather pervasive and enables the development of complex technical weaves especially for technical textiles. Especially the silk and velour industries have been at the forefront of developing complex technical fabrics using 3D weaving technology. In some instances the 3D weaving aims at replacing tufting. The Belgian carpet industry has been active in exploring weaving carpets (instead of tufting) while TenCate in the Netherlands has presented 3D woven synthetic turf mats. These technologies demand an intensive collaboration between textile manufacturer and machine supplier. For the Belgian carpet industry the local presence of Picanol and Vanderwiele is of relevance. However the German manufacturer of weaving equipment Dornier plays an important role with German, Dutch and Italian weavers. Tri-Axial weaving is an emerging technique. Here relations are more often between textile firms and research centres.

2.1.4. DYEING AND FINISHING

In terms of dyeing technology, besides improving liquor ratio (lower bath/material relations) and introducing sophisticated systems for chemicals dosing, with very accurate precision that allows dyers to achieve unprecedented levels of “right first time” processing standards, CO_2 dyeing was showcased but still too much as a concept. On the other hand, finishing is an area with substantial incremental changes but also upcoming technologies. Finishing covers dyeing, finishing, printing, coating and laminating. Innovation relates to machines, chemistry and monitoring of processes.

Some stages of textile processing are energy and water intensive. Operations such as scouring, rinsing, washing, dyeing, de-sizing or bleaching normally demand large amounts of water and energy and long processing times. In most wet textile processes, diffusion and convection in the inter-yarn and intra-yarn pores of the fabric are the dominant mass transfer mechanisms. Intensification of mass transfer is of paramount importance in improving the efficiency of wet textile processes. Conventional methods for intensifying mass transfer in textiles, such as

operation at higher temperatures or increasing flow through the fabric, are not always feasible, due to undesirable collateral effects on fabric quality standards[5].

One of the key development lines regarding process innovation in this field is the process intensification approach, towards the reduction of water, energy, chemicals and auxiliaries that are needed to process one Kg of textile material. Plasma technology and ultra sound technology have been the most exploited technologies towards process intensification, within the textile processing value chain.

Regarding plasma technology three major technological paths have been followed: low temperature plasma, vacuum pressure plasma and atmospheric pressure plasma. Since plasma cannot be generated in a complete vacuum the name vacuum pressure is somehow misleading and only refers to the low working pressures of such systems. Many authors, however, choose to classify vacuum pressure plasmas into sub categories of low and medium pressures. Vacuum pressure plasmas and atmospheric pressure plasmas are suitable for application on textiles and progress continues to determine their effect on textiles.

In finishing methods, an important trend for Europe is productivity in low batches. Finishing derives its competitive position by being the most downstream sector in textiles; by being close to the market in the supply chain, finishing is a critical factor for differentiation, fast lead times and flexibility in volumes. The shortening of lead times has led to a management of finishing processes whereby economies of scale is being sought after in preparatory stages such as scouring, and bleaching, often shifting towards continuous processes. In activities offering product differentiation, discontinuous processes have been favoured. Productivity is obtained by better monitoring of processes by using advanced optics and sensors in machines. This has also made the processes more predictable.

A clear trend, confirmed at ITMA 2011, is to reduce the environmental impact of finishing processes. This is often justified by the fact that water, chemicals and energy represent more than 50% of finishing costs. Reduction of footprint involves a better design of machines e.g. with better water management and increasing mechanical activation. It also involves innovation in chemistry enabling lower temperature processing, e.g. by developing enzymatic techniques. Lower temperature has a strong impact on energy use. These innovation developments often involve cooperation of all players (textile manufacturers , machinery producers and chemistry suppliers); in case of biotechnology the role of applied research centres is also important.

Less water and energy consumption per material weight unit as a source of lower production costs and better environmental performance, are key driving forces. Process integration between different phases of the production chain was always a hot topic regarding technology development but not very successfully addressed by most of the machinery constructors.

2.1.5. CLOTHING TECHNOLOGY

Clothing technology concerns both knitting and sewing activities.

Knitting technology has been a very active sector in developing improved machines. The focus is on higher productivity at lower batches, expanding creative possibilities and shifting towards technical textiles. Knitting technology has also evolved towards realizing downstream cost savings in making up. Europe keeps a clear

[5] Sergiu-Valentin PARVAN Statistics in Focus – Science and Technology 116/2007

leadership in developing knitting machines (especially Germany and Italy) with Italy and Portugal as leading customers. Of interest is also integration of processes with knitting integrated to spinning (seen at ITMA 2011). Another trend is to improve knitting to shape which causes substantial savings in the further assembly process.

Cutting and sewing has been an area with very little incremental improvements over the last 15 years. In the 1990s efficiency in cutting was vastly improved through automated cutting machines; while over the last ten years the focus has been on productivity improvement in small batch production. In sewing the focus in the 1980s has been on automated machines, but at the expense of flexibility in the shop floor. The delocalization of production to countries with low cost of labour and reduction of batch size has led the clothing industry to regress to general machines. Europe is clearly no longer a lead market in sewing technology; large German sewing machine firms have downsized and the biennale trade fair in Cologne has been cancelled for 2012.

New welding technologies and techniques aiming to process innovative materials (coated and laminated fabrics) applied in more technical articles within the sport business or the PPE market, are definitively the more significant evolutions in “sewing”. In fact is more correct to talk about welding technologies (HF, ultra sound, taping, etc.) than on sewing. In fact the “sewability” of innovative materials in this more specialized products is often a driver to change or update in the clothing manufacturing process.

Generic to clothing technology is CAD – Computer Aided Design- systems. In knitting CAD systems have improved dramatically over the years 2000s,

enabling a wider choice and rapid development of patterns. In clothing/sewing CAD is a well established discipline with over the last ten years mainly developments in rendering of materials (e.g. for buyers), enabling collaborative work and adapting to made to measure. In general CAD systems have improved in performance and reduced in costs.

2.2. STRATEGIC TECHNOLOGIES AND INNOVATION FIELDS FOR INNOVATION PERFOMANCE

2.2.1. SPECIAL FIBRES AND BIOPOLYMERS

High performance fibres

The chemical fibres International magazine, based on 2011 figures, refers that the global production of textile fibres in 2010 increased by 12% to 80.1 million tons. Of these, 26.3 (an increase of 11%) were natural fibres, 50.2 million tons (an increase of 12%) were synthetic fibres (including Polypropylene film fibres/tapes and spunbonds), 3.6 million tons (an increase of 14%) were cellulosic fibres (excluding acetate cigarette filter tow and lyocell staple fibres)[6].

According to European Man-Made Fibres Association (CIRFS), the European man-made fibres industry is the second largest man-made fibres producer in the world, with 3.8 million tonnes and EUR 10.9 billion sales in 2010. This industry is the world´s largest producer of polypropylene fibres, single-site production units for acrylic and viscose fibres and global leader in polymer-modified fibres (flame-retardant, bioactive, etc.). European man-made fibres industry is also leader in clean production techniques[7]. In accordance with publications of Melliand International, a well-known magazine about the textile industry, the chemical fibres imports in the European Union (EU-27), in 2010, increased by 26%, mainly in polyester staple fibres, polyester textured yarns and polyester industrial yarn[8].

Lenzing group, Austrian leader in fibre production, assesses that the demand of cellulose high quality fibres already exceeds the available supply. It is expected that the global megatrends of population growth, rising prosperity, climate protection and supply shortage of cotton (cellulose gap) will lead to a global increase in fibre consumption, as well as a structural change in fibre demand. In this context, whereas the global fibre market is expected to increase by about 3.3% p.a. until the year 2020, growth in the man-made cellulose fibre market is predicted to be about three times as high, or 9.1% p.a.. It is also expected that in year 2020, more than 10% of market share of man-made cellulosic fibres are due to new special applications[9].

Special fibres try to answer to constant innovative demands of researchers and manufacturers looking to combine textile processing capacity with special properties like being stronger, lighter, safer, biodegradable, resistant to extreme temperatures, with conductive capacity, isolating, etc. These demands are constantly being pushed upon today's industry and market application needs, mostly for those addressing technical products such as the technical

[6] Chemical Fibres International, Nº3 September 2011

[7] http://www.cirfs.org/

[8] Melliand International, Nº 3 August 2011

[9] LENZING "A vision to the world of Cellulosic Fibres in 2020", 50th Man-made fibres congress, Austria 14 September 2011

textiles business namely within the PPE (Personal protective Equipment) market. According to common definitions fibres are said to be either commodity or high performance. Commodity fibres are typically used in a highly competitive price environment which translates into large scale high volume production programs. Conversely, high performance fibres are driven by special technical functions that require specific physical properties unique to these fibres. Some of the most prominent of these properties are: tensile strength, operating temperature, flame retardancy and chemical resistance. Each special fibre has a unique combination of the above properties which allows it to fill a niche in the high performance fibre spectrum.

Today's technologies within the field of multi-component fibre extrusion combined with the extended possibilities to apply additives during the extrusion process, opens a complete new range of opportunities towards the development of small production batches, with very special and customized properties. Bicomponent and tricomponent fibres can combine different polymers and addressing different functional properties along the same fibre structure. According to Hill Inc.[10]., while multi-component fibres can not be considered new *per se*, polymer distribution technology allowing the economical production of micro and nano-sized fibres is new.

Spinning components have historically been manufactured by conventional methods such as milling, drilling, etc. Alternatively, the most modern system uses techniques similar to printed circuit board technology to manufacture the extrusion dies that can very accurately distribute polymers. This has led to many innovations which are economical and practical for production of micro and nano-sized fibres.

There is a wide range of functional fibres according to the product application target. For instance, in sports area, light-weight, moisture management, anti-bacterial, UV protection, etc., are very important properties; hence the development of new fibres tries to take these properties in account, through the development of new polymers, cross-section modifications, combination of polymers in same cross-section, adding additives before or during extrusion process and chemical treatments on fibres after extrusion.

A range of fibres competes for very high performances in terms of tensile strength and heat resistance. These are in high demand for a range of protective and constructive applications. Carbon fibre is one of the most important high-performance fibres for military and aerospace applications. Carbon fibres can be placed into different categories according to modulus, tensile strength, and final heat treatment temperature. The main carbon fibres are made from polyacrylonitrile (PAN,), and are well known for their composite reinforcement and heat resistant end uses. However very few manufacturers supply carbon fibre and demand outpaces the expansion of production capacities.

Meta-aramids and para-aramids are within the most popular and widely used high performance fibres in the technical textiles sector, namely where resistance and protection are key issues. Dupont (US) and Teijin (JP) are the most known players in this business, through very well-known fibres trade marks in the market: both have

[10] HILLS Inc. is an American technology and machinery supplier that has been devoted to the design, development and manufacture of machinery and technology for the synthetic fibre industry since 10971109711971.

significant production in Europe (in Northern Ireland and the Netherlands) with products such as Nomex© and Kevlar© or Teijin Conex© and Twaron©.

High Density Polyethylene (HDPE) fibres offer strength similar to that of para-aramids. Light in weight and with high tenacity, HDPE fibres have very good abrasion resistance and excellent chemical and electrical resistance. Spectra® (Honeywell) in France and Dyneema® (DSM) in the Netherlands are commercial brands of such fibres.

High performance fibres are definitely an excellent asset to allow textiles materials to substitute other materials without compromising technical performance and bringing to the equation interesting textile properties such as flexibility and lightness. According to the World Textile Fibres 2012 - Market Research, global demand for manufactured fibres will rise 4.7 % annually through 2020. Polyester will continue to dominate output while specialty products such as spandex, aramid and carbon fibres grow the fastest.

Bulk fibre industry will remain concentrated in Asia, where the fastest growth is also expected. However an interesting phenomenon that seems to grow is the supply of small batches of very special fibres by small pilot plants, normally installed in research institutes. This kind of business seems to combine the R&D service with the supply of small quantities itself, towards the production of very small lots of niche products.

Research centres in several countries such as in Aachen (DE), Boras (SE) and Roubaix (FR) have developed pilot lines servicing companies with custom made fibres. Clients are either chemical companies developing specialty polymers (e.g. BASF) or end users e.g. in the medical sector. More recent is the interest of textile firms that are seeking specialty materials with tailored properties. In some instances this interest has led to envisage setting up cooperatives for specialty fibre production. In other instances larger groups (e.g. TenCate) have set up centres of competences to develop special fibres. Since there is a relation between fibre properties and textile finishing, controlling both stages enables to create new materials with tailored and proprietary characteristics. In the plastic industry “mini-mills” have emerged creating special compounds and granulates. In textiles such a sector has not yet developed.

Biopolymers

The potential of polymers obtained from agro-resources such as the polysaccharides (e.g. starch) have long been recognized.

Sectors where applications for biopolymers have introduced include (but are not limited to) medicine, packaging, agriculture, textiles and the automotive industry. Many materials that have been developed and commercialized are applied in more than one of these categories although packaging and medical are still leading markets.

Advanced medical applications research uses of biopolymers in combination with advanced spinning techniques to be used in artificial blood vessels (knitted or braided), for scaffolding in bone implants but also in wound dressings.

In recent years the textile industry has sought new natural and biodegradable materials to meet certain policies for sustainability, environmental conservation and development of new business models in countries with strong primary sector. In this context, the biopolymers are starting to be used. The main applications that are registered in the textile industry are in geotextiles, composites, packaging textiles but also in carpets used for events.

The automotive sector is responding to societal and governmental demands for environmental responsibility. Biobased materials for cars are lighter, making them a more economical choice for consumers, as fuel costs are reduced. Natural fibres are substitutes for glass fibres as reinforcement materials in automotive parts. An additional advantage of using biodegradable polymer materials is that waste products may be composted. Natural fibres (from flax or hemp) are usually applied in formed interior parts. The components do not need load bearing capacities, but dimensional stability is important. Research and development in this area continues to be enthusiastic, especially in European countries.

There is since 2005 rapid increase in the build up of biopolymer production. The driver is mainly bioplastics, but biofibres is following. Several installations have been opened in last ten years. In Belgium Arkema and Total make biopolymers, in the Netherlands Hycail, Purac and Teijin. In Germany BASF and Evonik have developed bio-based precursors for fibres. In France Roquette is active on the topic too. Europe plays an important role in the expansion of biopolymers because of the quality and policy of agricultural production, and the knowledge basis. However textile industry in Europe lacks scale to assure a breakthrough; despite consumption in the European market for biopolymers is growing at an annual rate of roughly 20%, this happens mainly in non-wovens, hygiene and medical products and geotextiles. The growth pattern is more irregular in clothing and home textiles.

The factors driving market development are both internal (advanced technical - properties & functionality; Potential for cost reduction - through economy of scale; Cost-efficient - new recycling option) and external. External factors make biopolymers the attractive choice, as can be derived from the high consumer acceptance, the extensively publicised effects of climate change, drastic price increases of fossil materials, and the increasing dependence on fossil resources; however, biopolymers are less attractive as yet when it comes to colour fastness, washability, or touch and feel. Most biopolymers lose integrity at a temperature close to 100 °C, they are excluded from a wide range of applications were heat resistance is required. In addition to the market drivers mentioned here, political support will play a decisive role in the coming years; a strong regulatory framework that does not constrict industry is a precondition for a thriving bio-economy in Europe and dynamic and successful development of the biopolymers sector[11].

2.2.2. DIGITAL PRINTING

Another important technological breakthrough is digital printing. With increased pressure from developing textile producers in the Far East, the textile printers in Europe, must respond with both increased quality and shorter time of response. This means supplying new design concepts, samples and production printed fabrics in a wide range of colour ways in a time frame unheard a few years ago. The new strategy had to be developed based on speed of response, short production lots, short delivery times, increased innovation and new fashion ideas, and the formation of “partnerships” with the major retail groups. To achieve this strategy the printer must take an integrated approach to the whole textile printing process, mainly design, proofing and production[12].

[11] European Bioplastics – a vision for bioplastics for nearly two decades.

[12] John Provost, “Dynamic Response in Textile Printing”, Textile Chemist & Colorist, Vol. 27, No. 6, pg.11, June 1995.

The use of ink jet printing technology to reduce the overall sampling cost became well established in the textile printing industry in the developed printing markets[13]. But only with the introduction of reliable print heads in the late 1990's was the real starting date in the expansion of the digital textile printing industry[14].

The digital-textile printing market has come a long way from the introduction of first inkjet printer, at the 1991 ITMA in Hannover, from the Netherlands based Stork Trucolor Ink Jet Printer, which had a production speed of perhaps 2 square meters an hour, to the MS LaRIO, installed in 2011 in Como, with a claimed production speed of over 300 sqm an hour[15].

The evolution of digital printing has first been oriented towards faster production in order to be competitive compared to rotary printing. The other trend is to give quality (depth of colour and precision) compared to traditional printing. This has led to chemical companies entering this sector.

DuPont, one of the largest chemical companies in the world, entered the inkjet machine market in 2001. ITMA 2003 in Birmingham, UK, marked the introduction of a number of breakthrough developments for digital printing on textiles and the beginning of production digital textile printing of yard goods. The key developments involved companies with considerable experience in building conventional textile printing equipment, including Ichinose, Reggiani, Robustelli and Zimmer. Their model is to build up alliances with ink suppliers; in addition the alliances with printhead manufacturers proved to be essential. While an open model of cooperation seems attractive, the good alignment of machine, print-head and ink is essential in providing robust and reliable production processes. By 2006, DuPont had placed about 160 Artistri 2020 printers in locations around the world. Sign and banner manufacturers in addition to other product samples and small to medium production fabric printers have acquired this device. Reggiani, in cooperation with Scitex Vision and Ciba, introduced its DReAM textile printer that could print at 600 dpi resolution at a rate of 150 sqm/hour. Reggiani had installed over a dozen of these devices by May 2005, most of which are located in Italy. Robustelli launched its MonnaLisa textile printer, using Epson print heads. Robustelli has placed about a dozen of these printers in Italy. Zimmer exhibited its Chromotex that has focused mainly on printing carpets.

in 2011 at ITMA fair in Barcelona, the production performance per hour, at acceptable textile-print quality, is now in a similar area to flat-screen printing (or for that matter, European rotary-screen production speeds). Hence Digital printing is becoming a structured sector. The vast improvement in performance over the last twenty years has come from developments in such areas as computer technology, engineering, automation and electronics, but the most significant area that has driven the improved production performance is the huge advance in industrial

[13] John Provost, Mike Freche, Elrike Hees, Michael Klug, Juergen Weiser, "Ink-Textile Interactions in ink Jet Printing" – "The Role of Pretreatments", BASF Aktiengesellschaft, Ludwigshafen, Germany.

[14] John Provost, "Print Heads for Digital Textile Printing – Current Market Situation", Provost Ink Jet Consulting Ltd. (www.provost-inkjet.com), 2010.

[15] John Provost, "The Name of The Game is Speed", Digital Textile, Issue 5 2011, pg.21-35, 2011.

piezo-printhead technology[16]. The "key" driver in digital textile printing is the performance of the printhead. It determines the speed of production, performance, reliability and the overall print quality.

For the textile printer considering digital for the first time, or considering moving up from "small-scale" digital textile printers to higher digital-production levels, the increased number of machinery players now in the market can only be seen as a positive development, as it will put more pressure on the machinery manufacturers to maintain technical development and, with all probability, over time reduce overall print-processing costs. The digital-textile machinery market is very much a "consumables" business model, so the increased competition means a probable decrease in the price of digital-textile inks and, hence, lower costs per square meter for the end-user. However, the actual machine prices will probably still stay relatively high, as the machine manufacturers' costs are dictated to a very considerable extent by the overall cost of the print heads from the major Japanese suppliers. The cost of print heads in a digital-textile machine accounts for a significant proportion of the final cost of any machine – an area where the digital-textile machinery manufacturer has very little influence on market prices.

Digital printing is beginning to account for an increasing share of textile print production. As the length of textile print runs decreases, and the demand for short-run production and just-in-time delivery increases, digital printing is providing the cost-effective solution. As digital print technologies improve, offering faster production, good resolution, the inks prices decrease, and larger cost-effective print runs, digital printing will grow to become the technology that provides the majority of the world's printed textiles[17].

However the distance between traditional and digital printing is still enormous. Two-thirds of the world's printed textiles were produced in Asia and 30% in China alone. It is estimated the total printed as 28 billion square meters, a volume that was growing at 3% a year. Of the total volume, 60% was printed by rotary screen, 28% by automatic flat screen and only around 1% digitally (with the Italian digital-textile printing industry accounting for a significant proportion of current production).

Digital textile output in 2008 was around 250 million sqm and growing at about 20% a year[18]. Italy represents 70% of the digital printed fabrics. India comes second, Turkey third. France is an important region for design but has limited volume printing.

There exist a dynamic relationship between the trinomial print heads, inks suppliers and digital textile printer's constructors. Although in most of the digital printing technologies the printing head systems are open, meaning that the machine can work with different ink's suppliers, there is normally a preferential ink supplier suggested by the constructor, which supposedly allows better printing results.

For the development of a specific digital textile printer, the machine constructor cooperates with a printing heads supplier and with an ink supplier. However in some cases, the digital printers manufacturers are developing their

[16] John Provost, "The Name of The Game is Speed", Digital Textile, Issue 5 2011, pg.21-35, 2011.

[17] H. Ujiie, "Digital Printing of Textiles", Woodhead Publishing Limited in Association with The Textile Institute Woodhead, Cambridge England, 2006.

[18] John Scrimshaw, "Digital Textile Has a Long Way to Grow", FESPA Digital Conference, Conference Report, Digital Textile, Issue 3 2011, pg.30-32, Hamburg, May 2011.

own inks, according to the printing heads installed in their machines, as a way of extending business beyond the machine itself.

Another interesting trend on digital printing is the shift to digital functionalization, namely using the principle of digital printing to achieve much localized fabric functionalization. This trend is still at research level (e.g. in FP6 Project Digitex) but close to industrialisation and commercialisation around 2015.

2.2.3. TECHNICAL AND SMART TEXTILES

Technical Textiles

Technical textiles are defined as "textile materials and products manufactured primarily for their technical performance and functional properties rather than their aesthetic or decorative characteristics" according to the Textile Institute ´s publication "Textile Terms and Definitions". Technical textiles definition does not depend on the fibre, yarn or textile structure type or on the technology which is used on its production: it's the end-use of the product itself and its application that defines a technical textile product. Technical textiles industry employs a wide and diversity of raw materials, technologies, processes and products[19]. In most cases the technical performance of the product, regarding parameters like mechanical resistance, thermal resistance or barrier protection against chemical or gases are critical and often defined in very rigid standards and legislation.

Therefore such kind of products demands high knowledge standard and deep knowledge on the application market, which will define the quality and performance standards for the product. In several cases a service component can integrate the product "package" due to specific and critical conditions for the installation of such a products. As an example, this is very often the case of tensile textile structures for architectural applications, where most of the leading companies provide the installation service. This complexity brings even more added value to the product itself.

Techtextil/Messe Frankfurt established 12 application areas of technical textiles, by end use and is presently a universal reference for the various agents concerning the technical textiles business. These areas are identified by an icon and a description. The area classified as Oekotech is not a specific textile end-use area, but it overlaps with several areas including Geotech and Agrotech[20]. Table 1 shows Techtextil classification of technical textiles.

[19] CIRFS, "World markets for technical textiles to 2012", International Newsletters Ltd, 2007

[20] CIRFS, "World markets for technical textiles to 2012", International Newsletters Ltd, 2007

Table 1: Techtextil classification of technical textiles

Description	Markets/applications
Agrotech	Agriculture, aquaculture, forestry, horticulture, landscape gardening
Buildtech	Building and construction including membrane construction, lightweight and solid structures, earthworks, hydraulic engineering and road construction.
Clothtech	Technical components in the manufacture of clothing and footwear
Geotech	Geotextiles for landscaping, road construction, civil engineering, dam construction, waste site construction
Hometech	Technical components in the manufacture of furniture, upholstery, floor coverings and carpets
Indutech	Mechanical engineering, chemical and electrical sectors including filtration and cleaning
Medtech	Medical and hygiene products
Mobiltech	Products used in automobiles, aircraft, shipping, railways, aerospace
Oekotech	Environmental protection, waste disposal and recycling products.
Protech	Products used in personal and property protection
Sporttech	Sport and leisure products, outdoor equipment
Packtech	Packaging

In 2003, David Rigby Associates UK consultants for the textile and nonwovens industries, published a set of reports describing and forecasting world markets for technical textiles and nonwoven, from different points of view: by end-uses world consumption volume and value, by major fibre type, by major fabric type, by products, etc. Considering the perspectives set on these reports, the volume growth of technical textiles consumption forecasted was on average by 3.5 % per annum between from 1995 to 2010[21].

In 2007 the CIRFS report "World markets for technical textiles to 2012" by International Newsletters Ltd, examined and forecasted technical textiles sector until the year 2012. According to this report, the global market for technical textiles is forecast to develop rapidly until 2012 and growth will provide significant market opportunities for the world´s fibres producers, product manufacturers and machinery producers. However, this growth will intensify competition among both developed and developing countries suppliers. European production of technical textiles has indeed risen since 1995. In Western Europe output rose from about 1 million tonnes in 1995 to about 1.3 million tonnes in 2005[22]. According to Chemical Fibres International 3 September 2011 magazine news, the technical textiles world market during 2008/2009 was 21 million tons and it is expected to increase to 26 million tons by 2012.

According to IVGT[23], the biggest textile industry association in Germany, technical textiles are now more than 50% of the industry turnover compared to one-third 10 years ago and the range of potential applications for technical textiles is wide and continues to grow.

IVGT estimated that technical textiles grow 5% per annum over the long term[24].This also supports the dominance of Germany when it comes to patenting activity regarding textile & clothing, since most of those products are frequently innovative and therefore protected by patent applications.

The Strategic Research Agenda[25], developed within European Technology Platform and published by EURATEX points out that technical textiles are fruitful land for innovation and that this kind of products can stimulate the European Engineering, Transportation and Construction Industry. Based on fibre usage the same source refers the following breakdown of textiles production into 3 sub-sectors: Industrial & technical textiles (26%); Clothing (41%); Home & Interior Textiles (33%).

[21] David Rigby Associates, "Technical Textiles and Nonwovens: World Market Forecasts to 2010", Manchester UK

[22] CIRFS, "World markets for technical textiles to 2012", International Newsletters Ltd, 2007

[23] Industrie Verband Garne – Gewebe – Technische Textilien

[24] Textiles Intelligence Limited, "Technical Textile Markets: Business and market analysis for the world´s technical textiles industry", No 86 3rd quarter 2011

[25] EURATEX, ETP, *Strategic Research Agenda",* 2006

According to a recent publication of the Textiles Intelligence[26], considering the global potential growth by segment, medicine and health, environment, including energy efficiency and architecture are the most promising fields. From the point of view of the leading markets segments in terms of volume, the segments with higher potential are: transport and mobility, industry and geotextiles: this is connected to the fact that China is the world´s largest car market and it is expected to continue growing in the next few years.

Sustainable consumption is one of the main consumer trends in Europe. Key words are ecology, reuse of fibres, long-lasting materials and sustainable textiles and clothing manufacturing[27]. Also, in the global technical textile sector, environmental and ecological issues increasingly influence the new developments. Another trend in Europe is that European populations are reducing in size while growing older, due to declining birth rates and improved health .

This trend brings opportunities for some technical textile markets such as the Medtech area. In fact, the increasing proportion of older people has a strong impact in the healthcare sector, due to the multiples uses for technical textiles in the medical field.

In Sporttech market, the changes of demographic and sociological factors, including the increase of leisure time, increase of middle age people interested in sports/health practises, increase of female participation in sports, increase of accessibility of sports such as skiing, golf and sailing, the growth of sports facilities, will strongly influence the development of textiles in this area. Beside these factors, high performance, light and safe products, are also drivers in sports equipment and clothing industry.

The growing of technical textiles for the Protech Market (Products used in personal and property protection), is promoted by the level of industrialisation which can requires new protective devices approaches, and also by the increase in health, safety and hygiene legislation. This is particularly interesting and relevant for the clothing manufacturing companies in the Personal Protective Equipment sector, which is a technical market segment and which drivers are a better ratio between comfort and protection. Very R&D intensive, this application sector moves towards the usage of advanced textile materials and innovative welding techniques, which can improve product performance regarding risk protection improving the user comfort at the same time. This application market should be seen as an interesting entrance door for clothing manufacturing companies into high added value and more technical products, as an alternative to more traditional markets.

Consumer lifestyles namely favouring pre-packed foods and legislation to protect food against external contamination are drivers in Packtech industry. For technical textile industrial uses, such as conveyors belts, filters and tarpaulins, the main driver will be the growing industrialisation of the developing countries. The construction industry will benefit by the increasing demand of technical textiles for infrastructure. The increase of population in developing economies is also a significant driver for technical textiles industry.

---

[26] Textiles Intelligence Limited, “Technical Textile Markets: Business and market analysis for the world´s technical textiles industry”, No 86, 3rd quarter 2011

[27] European Foundation for the Improvement of Living and Working Conditions, “Trends and drivers of change in the European textiles and clothing sector: Mapping report”, 2008

The rising needs for mobility area will promote the use of technical textiles which can contribute in reducing of weight, improving efficiency, safety and comfort. In this way, the automotive industry will be able to comply with EU directives which intend to increase environmental protection and energy efficiency. For instance, by 2015 the automotive recycling legislation in Europe will require 95% of each section of an automobile to be recyclable and of the recyclable sections, 85% must be reused. Therefore, manufacturers will be pressured to ensure that solid waste is managed in an environmental and economic sustainable way and the products produced are easily disposable[28].

In general, technological innovation plays an important role in the global market for technical textiles, for instance the development of new materials based on, for instance, biotechnology, nanotechnology, materials and information technology, contribute to multiplying the opportunities for using textiles in other industry sectors. A growing demand for higher performance products will require more strict fibre requirements. For fibre industry, the development of finer and high strength fibres, new fibre variants and new polymers will be the main focus. For machinery industry, the main goals are to increase productivity and improve processes manufacturing concerning to environmental issues.

Smart Textiles

According to the standardization working group CEN/TC 248/WG 31, a smart textile material (intelligent textile material) is a functional textile material, which interacts actively with its environment, i.e. it responds or adapts to changes. The "Smart" concept can in fact address a textile material per se or a smart textile system, which exhibits an intended and exploitable response as a reaction either to changes in its surroundings/environment or to an external signal/input. The existence of such working group, which is particularly active, reflects the strategic importance of such product category.

A major trend in this product category is the continuous search for higher degrees of electronic integration, profiting from the use of conductive polymers towards the development of lighter and more simple solutions, which can avoid the dismantle of complex wire and power supply systems. Energy supply systems and clothing/system maintenance (washing under domestic conditions with no special care) are crucial aspects which still need to be solved towards a wide adoption by the market.

Most of the existing applications available in the market are addressing the medical and healthcare market or the sports market and are based in the capture and measurement of vital signs or parameters, like surrounding temperature, body temperature, heart rate, etc. In most cases the approach for product development is a push movement from the textile & clothing sector which explores the benefits of a flexible and well known material such as knitted textiles to offer innovative solutions to those application markets. In some cases ready to integrate systems are offered in real commercial versions, like the case of Connected Wear© which was presented in Techtextil 2011 and which offers a complete set of control systems for garments, bags and accessories. These systems can be used in any garment as an interface to different electronic devices. The Vitaljacket© shirt offered by Biodevices is a good example of a product available in the market, that monitors ECG waves and heart rate levels and that can be used for sports, fitness, and medical purposes. However the number of products which are effectively being commercialized is not yet significant and the barriers to overcome in the near future are related to full electronic integration, power supply systems and the facility of product maintenance.

[28] CIRFS, "World markets for technical textiles to 2012", International Newsletters Ltd, 2007

Smart Products Through Functionalization

A different approach towards a smart product development is through the functionalization of textile materials, towards the addition of supplementary functions or properties addressing specific needs. The functionalization is a process which provides functional properties to textile and clothing materials by the bulk modification, surface modification or by an engineered combination of materials with complementary properties (water proof plus breathability, for example). The major trends within this specific area are in the field of multifunctional textile materials (combining different complementary functions within the same material), localized functionalization (addressing specific product parts or components), surface activations and modifications, etc. In the case of functional products there are several examples available in the market, in several well-known brands within the sports and health care market or even in the fashion business, like water repellence, antibacterial properties, thermochromic and photo chromatic properties, self-cleaning or easy cleaning textiles, active cooling, fragrance release, etc. In most cases the materials and technologies available, resulted from a combined development integrating chemical companies, fibre producers and the textile industry, addressing specific trends or needs mostly driven by the sport garment industry or health care product brands. Gore©, Nano-Tex©, Schoeller© or HEIQ© are good examples of market available solutions, which are normally commercialized within the textile and clothing industry through licensing systems.

Present trends regarding this specific development area are addressing issues like self adaptive functionalization (the function and property intensity varies according to an external stimuli or to a specific need), like in the case of controlled chemical substances release by a textile material or a chromatic change within a specific, very precise and pre-set temperature range. Another important trend is the reactivation of certain functionalities through domestic laundry/treatments as a way of extending the durability of certain functions even after a significant number of washing/drying cycles.

Nanotechnologies as Enabling Technologies For Smart Textiles

Nanotechnology is being seen as one of the most promising technology route for the 21st century. Its impact is being reported on the development of new and optimised products as well as in decreasing the ecological impact and consumption of natural resources. Nanotechnology is playing an important role within textiles, namely as catalyser or as enabling technologies to some of the functionalities that have been described in the above sections. Several applications for fibres and textiles incorporating nanomaterials include: stain resistant wrinkle-free clothing, anti-odour for sportswear, anti-microbial medical textiles, hydrophobic and water repellent fabrics and textiles, UV protection, infrared radiation blocker, odour absorption or increased strength and shock. Several applications have been commercialized with proven effectiveness and practicality from stain repellent fabrics to wound dressings and patches for delivery of anti-microbial and aroma therapeutics.

A number of nanoparticles have already given results such as titanium dioxide or silicon dioxide and are widely used by the textile industry to promote functionalities such as the easy cleaning or even self-cleaning effects, imitating the one based in the lotus effect[29] present in nature. Examples of market available solutions based in nanotechnology are the silver wound dressing (©Smith & Nephew), eco-fabric (©Greenyarn), stain repellents for

[29] The lotus effect refers to the very high water repellence (superhydrophobicity) exhibited by the leaves of the lotus flower (*Nelumbo*).[1]

clothing (©Nano-Tex), NanoMask© (Emergency Filtration Products), stain repellent textiles (Schoeller Textiles AG) or the lotus-Effect finishing (©Degussa).

Beyond future developments in terms of applications addressing several of the above functionalities with lower material amounts and better treatment efficiency, most of the research and development is pointing towards a wider use of nanofibres (nano scaled produced fibres) or implanting specific nano materials in the fibre surface. Nanomaterials with switchable and adaptive properties, new surface functions, self-repairing systems and sensors based on fibres also open a huge field for the development of new textiles constructions.

However the discussion about the risk and side effects of nanoparticles for humans and the environment is still open. The different processes and methods for applying nanomaterials onto and into textiles, namely if nanoparticles are directly incorporated in the fibre or if they are applied to finished fabric afterwards through a coating or deposition technique, has an important influence in the possible detachment speed and ratio of the particles from the product. Therefore the study of such risks, towards a definitive clarification of industrial users and consumers, is expected to continue in the upcoming years.

2.2.4. COMMERCIAL INNOVATIONS

Commercial innovation is a wide domain also often considered as non-technological innovation. It covers a wide range of subjects such as design, organization and technologies in retail and logistics. The interaction between non-technological and technological innovation is complex and intense. Each has an influence on the other. We mention a number of trends, not being exhaustive. Some interactions are further explored in the regional cases.

Non-technological innovation is increasingly recognized in the industry but especially by policy makers as a driver of change to be acknowledged. The main non-technological innovation mentioned in the T/C industry is design. Design as a function is increasingly recognized as a relevant, also in terms of policy and many member states, regions and cities have developed policies to promote design and interaction between design and industry (especially in UK, Netherlands, Denmark, Finland). In addition some member states have identified creative industries as a top sector and fashion/clothing is often an important constituent part of the creative industry. However in France and Italy the design sector is already long seen as a constituent of national identity. In other countries the creative industry did well, even without public attention.

However the importance of design is increasingly recognized with fiscal measures. In France there is a “credit-import collections”. This is a partial tax break based on the costs of design and sample making. However the logic of design and fashion as both factors of differentiation and change are since long time acknowledged. Design is an important cost and value driver for apparel, representing between 5 and 15% of wholesale price.

The cost of design is a substantial barrier for shifting from a subcontracting to a hybrid or branded business model. It requires specific equipment and staff, but also substantial travelling and an adequate business environment. Exposure to the end market is an important element but also an iterative process between grasping trends and developing a brand narrative. This puts companies based in a vibrant and diversified market at an advantage compared to companies operating out of regions with less developed and differentiated demand. Classic fashion cities (Paris, London, Milano) have an advantage, but it has been noticed that smaller and alternative fashion cities

have re-emerged (Antwerp, Copenhagen, Riga, Arnhem) but these cities often lack critical mass and production facilities for smaller designers.

Design is also integrating industrial design, which is a new discipline for textiles and clothing: n fashion aesthetics were the primary aspect, but functionality is becoming increasingly important. Sport and work wear are the most developed sector where industrial design methodologies are integrated in the design process. It is very likely that industrial design extends into technical textiles and home textiles. In the latter sectors the design process is often starting from specification required by the client, however a trend can be signalled to start from a user based or use-based design approach with all methods of industrial design (scenario's, persona, simulation, etc...) where industrial design and fashion design are close to each other, either in education or in industry one can notice more cross-overs. This is noticeable in the UK when it comes to product and fashion design, Netherlands and Germany when it comes to architecture; Italy in sports and furniture. Promoting more intense interaction between industrial design and material technologies is of great importance to unleash applications of technical textiles.

An important role in the industry is played by marginal differentiation. In truth the textile sector has an immense range of differentiation in terms of fibre (blends), yarn construction and fineness, fabric patters, colour and prints, finishes, additions, style elements and shaping. The total number of combinations is more than 100 billion, and new combinations emerge constantly because of new fibres, new finishes and modification of processes. This seems to be a constant factor, although taking as example the jeans market, incremental innovation/differentiation has increased in the last years while fundamentally new products have been less frequent than between 1970 and 1990. Marginal differentiation through washing or creating a destroyed look is much stronger than increasing the life time of jeans by adding for strength a fraction of aramids.

Those innovative combinations are still today the most common and frequent live example of innovation practices in textile companies. In parallel, service has become an important non technological field for innovation namely for those countries where the labour cost is not by itself a comparative advantage anymore and the only way of differentiating the offer before lower cost countries is through innovative approaches on the service side.

The liberalization of trade in 2006 has led to some interesting qualitative trends. Especially 2006-2008 saw the emergence of a very labour-intensive fashion with patchwork, embroidery, special washing effects and mechanical treatments (e.g. half-destroyed jeans). In addition the removal of quota for linen fabrics and clothing from China led to an increase offer of products at mid-price (linen men shirts for EUR 39-59). However the effect of both trends peaked out around 2008 to move towards a more subdued fashion style and more importance on fabric quality and appearance over special treatments.

The design approach itself is also changing. Design is partly integrated in CAD[30] systems which increases the diversity, reduces lead times and costs of design. The shift to design and fashion has led to a dramatic increase in the use of ICT tools to support the design process. This entails CAD/CAM systems for creative design, pattern making and product data management. These technologies have emerged in the end of the 1980's and are now common practice in the clothing industry. Most design is now computer enabled. Product data management is less established in general but is standard in larger companies. CAD/CAM is also standard in subcontractors in the

[30] CAD stands for Computer Aided Design. CAD is a computer technology that helps with designing. CAM is a 2.5D design in which is also taken account for the depth of fibres.

newer member states since they often receive only a basic pattern and have to make the cutting plan themselves. Only smaller make and trim companies lack CAD systems.

Fashion is an important innovation factor that influence dynamics of clothing companies, together with the other manufacturing sectors involved. More than 50% of fashion products are renewed every season and than 1/3 of products are sold below full price or unsold at the end of the season, since they where not in fashion. Fashion is mainly a feature of clothing, but is also increasing in impact in home textiles. While traditionally in home textiles less than 20% of products were replaced each year, the rate of product change is now reaching 35% per year. Only in technical textiles fashion has no grip, although the product life cycle also applies: the lifecycle of a type of synthetic turf is around 4 years. However in workwear and in textile architecture aesthetics plays an increasing role. In the period 2000-2009 increased attention for corporate image and style was an important driver of growth of the workwear sector. In some countries workwear is now replaced every 3-4 years instead of 8-10 years in the 1980s. It is impossible to assess a shift in fashion or in design orientation in the industry. Some observers tend to say that the breakthrough of fashion occurred some 10 years ago. However this statement is made some 40 years now and is often more a reference to the age of the observer, than of the trend itself.

What has changed over the last 10-15 years and the turnover time of capital and hence the faster fashion cycles and more fashion cycles a year. Scheffer[31] has analyzed retail data and has noted that amongst leading retailers the number of fashion cycles has moved from 3-4 in the 1990 to 5-6 in the last decade. Agins[32]notes that the increasing speed also affects the luxury sector. These brands also launch several collections a year and increasingly work on a just in time production mode.

The logic of increasing fashion cycles has several drivers. Most often it is referred to as driven by the consumer. This claim is not documented. It is only known that frequent changing shop window activates consumer desires. It is also claimed that faster turnover times foster production in Europe over China. However since many retailers plan new collections more than 6 months in advance, and can very well accommodate fast fashion with far away production. More convincing is the hypothesis that faster turnover of capital is an effective way to increase profitability of working capital. This is a credible hypothesis since the fashion sector is a capital poor sector with high gearing (ratio won capital /total capital between 20-25% before the crisis).

The speeding up of fashion cycles has possible impacts on production. One of them is to foster technologies that enable to differentiate products as close as possible to market introduction. This has fostered processes as washing, embroidery, digital printing and garment dyeing. It has also favoured dyeing and printing at the expense of differentiation in yarns and woven. This trend has supported the import of standard grey fabrics to be finished in Europe. However suppliers of spinning and weaving equipment have responded by developing machines that offer more differentiation at low volumes.

Commercial innovation has led to changes in the organization of companies. The main challenge was in the restructuring of the commercial organization from a strict hierarchy directed by a commercial director dictating

[31] Scheffer, M. 2009, CRISIS AND LONG TERMS CHALLENGES: RESPONSIBILITY IN THE CLOTHING INDUSTRY, Saxion University

[32] Agins, T (2000): "*The End of Fashion*" William Morrow and Company Inc.

style, price and conditions, towards a team approach in which designer, salespeople and logistics would work with the client in developing new products. This also led to a change in pricing practices of cost price based calculations to end price based calculations. The traditional way of calculating retail prices by starting from production costs only applies in the top end of the market. An element of this commercial strategy is to make the designer responsible for the commercial success of a product, in order to achieve better product-market match in terms of style while at the same time there is a commercial stimuli for the designer himself towards the success of the collection.

Another consequence of faster fashion is smaller production runs and shorter delivery times. The trends in this respect are dramatic. In 1990 six weeks would still count as a short lead time in Europe. Nowadays 3 to 4 weeks is short lead time in Europe whereas 6 weeks is possible in the Far East. The shortening of lead times has largely been enabled by information technology and competitive pressure, less by reorganization of production. In Europe the shortening of lead times has been made possible by reorganization of factories into smaller groups and more multi-skilled workers. This has happened especially in the new member states, such as Lithuania (see Task 4, restructuring). In textiles the shift has been towards discontinuous processes and shorter set up times. Nevertheless the reduction of batch size has led to a loss in productivity in weaving and in textile finishing, unless new technologies (e.g. digital printing) reduces economies of scale.

An important innovation trend in clothing is verticalization. This concept entails the downstream investment of brands into retailing. This trend had pioneers in the 1960s (e.g. Rodier) especially as spin offs from the Northern French wool industry, had a very successful follower in Benetton the 1970s and generalized in the 1990s. Nowadays retail concepts are standard features in the strategies of brands. Verticalization is a must in luxury segments but trickles down to all market segments. It is however a strategy requiring substantial investments. During an interview it was mentioned that a known brand for their store in Paris involved more investment than a new factory in Romania.

The main cause of verticalization is the fragmentation and vulnerability of independent multi-brand retailing. This is especially true in Southern Europe where traditional independent retailing is strong. It led however to low sales surface per brand, little impulse for product development, limited visibility on market needs and most of all long payment terms. These arguments are also valid in Northern Europe but to a lesser extent. In addition the age structure of entrepreneurs in independent retailing leads to fears on the viability of this distribution channel. The second cause of verticalization is to be found in the desire of apparel manufacturers to be less dependant from the buying power of large retailers. However this implies a more complex strategy of first developing brands and then developing retail outlets. This strategy has rarely been successful since it is a risky strategy requiring a step by step implementation over a period of more than 10 years. The third cause of verticalization is export. As in most emerging markets there is no professional retail structure, setting up own stores is an often used strategy.

The strategy of verticalization is mainly carried out by larger companies and does also affect negatively the conditions for SMEs as is also shown in tasks 3 and 4. SMEs with brands (or those willing to launch a brand) require multi brand retailers. However it is the vulnerability of the smaller retailers that exactly prompt verticalization by larger brands. The consequence of concentration and verticalization is that smaller brands can only serve or start in a declining distribution channel. It is often said that smaller brands need first a firm basis in the EU before exporting outside the EU. This is relevant both for the strength and visibility of the brand but also for the increase of financial and organizational capacities of the firm.

A large area of modernization over the last twenty years is the revolution in retail technologies. This involves collection of sales data at the point of sales (EPOS), electronic data interchange in the supply chain, enterprise

resource planning and logistic tracking systems based on barcodes, then RFID codes and now QR-Codes. These technologies impact of manufacturers either because they have to integrate it in their operations (e.g. put RFID tags on a product) or/and in their strategy.

In practice the process and technologies of supply chain management have been a battle in the industry over the last 20 years. Large retailers and large brands have taken the lead to organize their supply chain. Each retailer has imposed its own standards and methods. This is manageable for manufacturers with few clients such as for Marks & Spencer. However for manufacturers supplying for a large number of retailers the costs are substantial. Over the last 25 years neither the large retailers nor independent retailers have succeeded in standardizing information interchange. Large retailers have in addition been reluctant to share retail data with their suppliers, limiting the latter's ability to pre-empt market trends.

For larger brands, the fragmentation of ICT standards has been one of the reasons to verticalize. Verticalization requires technological conditions and leading brands have worked hard at meeting these conditions. The first one is to obtain excellent order fulfilment. Having won stores requires keeping a constant full stock of merchandise in store, fast replenishment and reordering. This requires investment in enterprise resource planning systems and automation of warehousing. The second condition is to improve control over the supply chain by adopting forecasting software (including investment in analysis of sales patterns and development of algorithms) and by improving communication between store and warehouse through EPOS and EDI, and with upstream suppliers through ERP systems and PDM and sourcing software platforms.

A corollary consequence of verticalization and the investments required in a technology backbone is that it enabled the setting up of on-line shopping. Handling internet orders sets very demanding standards on logistics in terms of quality and cost control. Especially sizing aspects demand a very good order picking and management of returns. The latter aspect is the main profit reducing feature of on-line sales. However the potential profit of direct contact with consumers and the elimination of intermediates, outweighs for companies considered the disadvantages of online sales. By 2010, Internet sales have become a visible feature with a market share above 10% in at least Germany, the UK, France and the Netherlands. Annual growth rates are above 20% even in years of crisis. Online sales are developed by brands and large retailers. It has been observed that SMEs (both retail and manufacturers) have not invested in the IT backbone to be able to get on that band-wagon. The ICT innovations are presented in the Baden-Württemberg case.

A new trend is mass customization. By 2010 mass customization for some niches had reached in some countries the 10% market share. This is the case for suits in Netherlands. Mass customization is still mainly a men's affair when it comes to clothing. After suits, shirts are the most established product. Both suits and shirt made to measure build on a narrative that goes back long in time to bespoke tailoring. However advances in sizing systems and in ICT has led to a revival from 1990 onwards, with much experimentation, and a breakthrough in the last five years.

The breakthrough is largely enabled by Internet enabling the presentation of a wide offering, with fast improvements of rendering of fabrics and of products and advancement in speed of internet and fast and reliable payment systems. Made to measure requires also a good ICT backbone, largely an extension of CAD software used for making cutting schedules. In addition it requires a manufacturing organization able to handle efficiently orders for single products. This trend was largely supported by the overall reduction of lead times and order size in the upper middle of the market. The trend to made to measure clearly supports manufacturing in the Euro-Mediterranean zone, but except in Italy, it hardly has employment impact in the old member states. Made to measure has also a positive upstream effect on fabric manufacturing. This case is explored further for Lombardia/Piemonte (see paragraph 3.1). Industrial made to measure is also an important trend in the curtain market for which we have

evidence in the UK (see Task 2, research) and in North Portugal and Galicia (see paragraph 3.3) in the best practice case of the Portuguese sport garment producer P&R further on presented.

3. REGIONAL CASES

3.1. LOMBARDIA-PIEMONTE

3.1.1. THE REGION AND TEXTILE & CLOTHING SECTOR OVERVIEW

Lombardia and the neighbouring district of Biella in Piemonte are mainly oriented towards classic textiles for apparel and home. In these segments the industry is still organized by type of fibre processed. The wool industry is mainly based in the province of Biella while the Northern part of Novara, the main specialization is fine animal hair (e.g. cashmere). The cotton industry is concentrated in the provinces of Varese, Milano, Bergamo and Brescia. The silk industry is concentrated in Como. There is a textile district specialized in supplying the furniture sector and it is spread over the provinces of Monza and Lecco. Knitwear is a major industry in the province Mantova. The clothing industry concentrates in Milano, but actual manufacturing is spread over the entire region. Lombardia is also the first Italian region in technical textiles (but only the fifth region in Europe), that historically evolved as a spin off from the restructuring of the silk industry.

The textile industry in Lombardia is part of a wider complex of industries. Traditionally the linkages to the machinery sector (meccanotessile) are important, and still are. Lombardian firms are at the forefront in developing machines for plasma-treatment and for digital printing. The fibre industry has lost of its pre-eminence, although the hosiery industry is still a leading client for polyamide production. The chemical industry is still of relevance for the development of new dyes and finishes. In both machines and chemicals, the Italian firms are rather niche players compared to the German ones, leaders in the sector. Traditionally they were working very much in co-makership with their Italian clients. Nowadays the market volumes are in Asia, hence this leads to a more plug and play approach to machine building and to a concentration of companies: machines are developed on a modular basis and are easy to install and to use.

In Lombardia there are 4.767 companies operating in the textile industry and 8.525 in the clothing industry. The textile district of Biella in Piemonte counts 1440 units[33] The highest concentration of textiles industries is in the provinces of Varese, Milano, Como and Bergamo. The "traditional" districts of productive specialization refer to the more consolidated and mature areas where qualified productive systems have been present for a long time.

Lombardia combined with Piemonte is the leading textile and clothing region in Europe. It is also the second region for textile machinery after Nordrhein-Westfalen and a significant player in textile chemistry. It is mentioned by most technology suppliers at ITMA 2011 to the industry as the leading launching market for new fibres, chemical

[33] http://www.fondazionefieramilano.it/static/upl/QF/QF.Distretti5_unito.pdf

auxiliaries and machinery. However this leadership is most pronounced in apparel textiles and apparel, less so in home textiles. In technical textiles, the region has a second tier position compared to North-West Europe. The industry in the region is highly demanding on technologies enabling differentiation and productivity in small volume production, technologies enabling to maintain leadership in luxury markets. Touch, look and feel are important characteristics of differentiation. In addition the industry is highly sensitive to technologies enabling to reduce the cost of energy and water.

The focus of the leading firms in the textile machinery industry is very much to incremental innovation and to technologies that are ready to implement. Hence the constant and iterative relation with textile machinery manufacturers and chemical suppliers is very relevant. In textile machinery Lombardia has a strong position in dyeing, finishing and printing equipment (Reggiani, MCS, Robustelli, Arioli). It has also a substantial position in fibre processing and spinning equipment (Savio). It has also gained a strong position in weaving through the acquisition of Sulzer by ITEMA. It has also a strong position in upcoming technology such as plasma (GRINP, Arioli, HTP).

In addition to the original equipment manufacture, Lombardia has a refined network of smaller engineering firms being able to modify and adjust machines.

Overall a number of leading positions can be identified:

- Lombardia is the leading region in application of biopolymers in textiles
- Lombardia is the leading regions in silk processing, Piemonte in wool
- Lombardia is still an important production region for polyamides
- Lombardia and Piemonte are leading regions in application of novel textile finishing methods such as biotechnology and plasma
- Lombardia is the leading region in Europe in digital printing
- Lombardia and Piemonte are the leading regions in Europe for mass-customization

Lombardia and Piemonte have leading positions in both textiles and clothing and the innovativeness of the textile industry is very relevant to the clothing industry. However since the region is the first producer of high quality fabrics, this role goes across the region itself.

In order to understand the dynamics of innovation we have focused on two subcases. In digital printing the dynamics start in the textile industry but impact on the clothing industry. Mass-customization is a trend initiated in the clothing industry but that had an upstream impact on the textile industry. In both cases the dynamics between textile clothing firms and machinery suppliers has been essential. The role of R&D has been supportive, although in some instances seminal to develop knowledge that later trickled down in industry.

3.1.2. SUBCASE DIGITAL PRINTING

Digital printing has become in the last 5 years a proven technology. Lombardia is worldwide the leading region where this technology is now being implemented in the textile industry. Hence it is possible to understand the drivers of change and the impact of a technology developed over the last 20 years.

Figures for production of digitally printed fabrics do not exist; official statistics do not distinguish by type of fabrics. Insiders speak of annual growth of 20-30%. Based on shipments of inks we have compiled that around 20 Million

meters of digitally printed fabrics were made in the EU in 2010. It is also estimated that 80% of inks used in textile printing in Europe are used in Italy, the remainder being in France, UK and Portugal. Outside Europe, Turkey and India are the main clients. China is not yet relevant. In Northern Europe and USA digital printing is mainly relevant for publicity printing (banners and flags).

Digital textile printing can be considered as the most relevant innovation for the textile industry in the last 15 years. It is in fact the transfer of technology from paper printing to textiles. It enabled textile printers with a level of flexibility and competitiveness also in small lots that in order to be able to follow the new trends of the clothing industry. It reduced dramatically the labour intensity of the process, making the printing process comparable with the one from low-cost of labour countries.

Although it is a process innovation it had important consequences also in terms of product: the cost of designing and sampling new prints dropped consistently so that textile printers are now able to invest more resources in developing new designs and variations, and propose them at fairs and to fashion designers. Digital printing made possible the realization of new designs that were not possible before because of the level of details needed, of the numbers of the colours or the lengths of the screen or the circumference of the cylinders.

The textile district of Como, specialized in the knitting and finishing of silk fabrics, still represents the biggest textile printing pole in Lombardia and in Italy. It also one of the last that remained in Europe after the decline of the French textile printing districts of Lyon and Mulhouse, as well as the textile printing industry in Germany. Despite the conservative tendency of a traditional district in accepting new technology due to the small size and family management that characterize the industry, the diffusion of digital printing gave new boost to a declining sector, enabling some companies to innovate and create growth and development.

Digital textile printing is described as any ink jet based method of printing colorants onto fabric. At the beginning the technology offered only low-volume printers derived from the paper printing industry targeting advertisement and visual communication industry (e.g. print on t-shirt and promotional materials, flags and banners).

The ink-jet machines producers (e.g. Mimaki, Epson), in the mid 90s adapted their platform for the print on a textile substrate delivering low-volume printing systems with mediocre results in terms of resolution, quality and productivity. They were almost exclusively used for sampling purpose, while for the main production lots the design was converted for the use of traditional machines. Companies producing hardware for digital inkjet printing were proposing solutions adapting existing platforms for printing on paper to textiles. The level of quality and productivity (close to 1 m per hour) made possible only the use for sampling and prototyping, introducing at the same time challenges of reproducibility of the digital sample in the analogue machine.

While the concept of digital textile printing was developed in late 1980s as replacement of analogue screen printing, textile companies in the district of Como started to consider the possibility of printing directly on the textile media through a digital ink-jet technology derived from the one used on paper only 10 years later, in 2000, also thanks to the European funded project “Tieprint”. The project “Tieprint”, co-financed by European Union (LIFE 99 ENV/IT/00122), aimed at developing an integrated digital process flow from the creation of a design till the production phase. It gathered three of the main textile printers of the district, one of them interviewed for the purpose of the study.

Digital printing potentially delivered several technological benefits in terms of:

- Colorants savings
- Water savings and depuration

- Savings in terms of surface occupied surface occupied by the production machines
- Improved environmental impact in terms of noise pollution
- Energy savings

On the other side textile companies were facing increasing challenges to respond to the requests of their customers, especially when it comes to produce in smaller batches, with easier repeats and generally short lead times.

The textile district of Como is characterized by the presence of a high number of small companies specialized in the realization only of a specific phase of the process. Looking at the market of textile printing, it was mainly formed by small companies or workshops, employing and an average of 10 people, working for a converter or directly for the final client. In many case the design was given by the purchaser while some companies decided to integrate the design process presenting their own collections of prints every season.

By the year 2000 the mainstream fashion industry was characterized by a six months fashion cycle organized in two seasons; niche players in the area of Pronto Moda (ready-made fashion as explained in the Prato Case in Task3, SME) were able to compress the fashion cycle to only 1 month and presented more collection per year with continuous re-assorting. The work on the traditional fashion cycle entailed a rigid protocol of collaboration between designers and printing companies in which the printers presented their samples either directly to the designers or during exhibition (e.g. *Premier Vision* in Paris), a production order was made and the actual production followed after 3-4 weeks, provided the grey fabric was available.

Players in the *pronto moda* niche were able to exploit the lead time between the presentation of the collection and the delivery to the shops of the products by producing low cost garment inspired by the collection of main designers that arrived on the market weeks before the original pieces. While the *pronto moda* niche was often associated with low quality and prices. This particular business model, which is described in detail in Task 3 (SMEs) is being used by the Chinese community in Prato (Italy) to deliver “Pronto Moda” apparels to European customers in the low-end segments.

After the year 2000 the clothing industry evolved towards the more dynamic approach of the *pronto moda*, increasing the launches on the market during seasons (up to 6 a year) with an intelligent re-assorting of best sellers designs or variations during the cycle. This approach, known under the name of *Fast fashion* is used by big retailers such as Zara and H&M. The new approach resulted in an increased pressure for the suppliers, including printers and the requests for compressed time to market between the sampling and the production and the same time improving the capacity of being competitive in smaller production lots. The time to market between acceptance of the sample and delivery of the lot is counted in terms of hours and not anymore in weeks.

Moreover textile companies were facing the increased level on competition of global producers being able to sell a similar quality for a lower price. Since the main production of grey fabrics was already delocalized in low labour cost countries, the integration with printing would have represented a major threat for the printing companies in the Como area. But the shift towards fast fashion gave a competitive advantage to European firms since the geographical proximity to clothing companies’ headquarters and designers played a crucial role in the phase of prototyping and accepting a new order for a print.

In general from 2002 onwards textile market was characterized by the following trends:

- Diminishing average length of the lots
- Need for the company of increasing the numbers of samples in order to encounter the taste of the consumers

- At the same time the need of keeping the cost of sampling low because of the increased cost pressure
- Fashion designers were asking for an increased number of colours for each variation of design
- External drivers of going towards a green process
- Increasing cost of storing cylinders and screens influencing the economics of the process

Being the main textile district in Europe, Lombardia developed also some of the main producers of textile machinery in the world. Textile printing machinery producers, leaders in the construction of silk screen and cylinders systems are traditionally very close to the needs of their customers, representing one of the main dynamics in a production district. They had a very good position to understand the new trends coming from the clothing industry and, more important, the knowledge to integrate the new digital ink-jet technology with the traditional textile printing flow process.

Reggiani, the textile printing machine manufacturer integrated in 2003 a complete inkjet printing system supplied by the Israeli company Scitex (now HP) with the fabric transportation system of their silk screen machines. The result was the introduction in the market of a new generation of printing machines that were able to respond to full scale production requests and not only small scale sampling. The possibility of realizing samples in the same machine used for production without incurring in substantial set up costs gave the advantage of avoiding problems of reproducibility of the design with two completely different technologies.

After 2000 the development of the technology had an important push thanks to the collaboration among textile machines producers, print heads suppliers, software developers and chemical companies and in a few year the performance of the machines improved terribly increasing quality, resolution and, more important, productivity. In fact productivity jumped from few meters per hour to 70, enabling textile companies to use digital for bigger production lots. Compared with traditional printing the productivity is quite low and the price still high but the benefits in terms of flexibility and set-up cost led to the diffusion of the technology.

The reaction of the companies in the textile district of Como followed a typical diffusion of new technologies curve[34]. Industrial district are usually slow in accepting a shift in new technologies[35], and in Como there were only few traditional printers that opted for an early adoption. An example is “Achille Pinto” (interviewed for the study) that, passed a phase of profound crisis in the 90s, while leader (such as Ratti and Mantero) companies in the district were doing reasonably well. For this reason and for a far-sighted understanding of the above mentioned, the trend is to dismiss some of their traditional machines (considered that at a time where they had still a value in the second hand market) and to start sampling and production with digital technology. The share of digital production increased constantly during the years to the detriment of traditional printing. In 2011 Achille Pinto, achieved the breakthrough of having more then 50% of his turnover coming from digital in respect to traditional. The objective is to reach a share of 60% from digital and 40 % from traditional in the next years.

On the other hand printers like Stamperia di Lipomo, converted to digital printing part of their production only after 2006, when the machines started to reach performances coherent with their scale of production. Before that they were subcontracting the orders that were more convenient with a digital system to small workshops, without any background in traditional printing that with an investment of few thousand euro’s and a small factory were

[34] Rogers, Everett M. (1983). Diffusion of Innovations. New York: Free Press. ISBN 978-0-02-926650-2

[35] Bottinelli L., Pavione E., Distretti industriali e cluster tecnologici: strategie emergenti di valorizzazione e ricerca dell’innovazione, Pavia, 2011

able to fill the gap. After this fast increase of the adoption of digital printing methods in the district, digital ink-jet technology become a standard and all the printers interviewed had a major share of their turnover coming from digital. Surprisingly the erstwhile leaders, Ratti and Mantero were late adaptors to digital printing, only catching up for industrial production in 2009/2010 after having started in the 1990s with sample production.

The transition from analogue screen and rotational printing had indeed an impact in terms of labour organisation. While traditional methods required at least one or more operators per machine, now one operator can operate more digital ink-jet machines can. In terms of knowledge required, the job market in the district had to train some new professional staff that combined knowledge from printing and textile processing to IT and software to control the machines. The presence in the Como district of skilled operators focused to the product more then to the process itself facilitated the shift.

The exponential development of digital printing influenced dramatically the offer creating the possibility of an open competition between producers and standards. Prices of the main components dropped consistently in the last 5 years. Key elements are the costs of printing heads and the costs of inks. Digital textile printing system is formed by the integration of components coming from different areas of knowledge

1. Machine producers: they come from the analogue printing sector and act as the system integrators. In fact they were able to use their knowledge in terms pre and post treatment of fabric, transportation and reaction of the fabric to the print. Their development influences the productivity and the reproducibility of the process over time. Some machine integrators they are also supplying the software connecting the machine itself to the printing system. But this option can also be left open to other developers. Producers of machines are: Reggiani (It), Robustelli (It), Stork (NL), Xennia (UK/NL) and Zimmer (De).

2. Printing heads. A printing head is the heart of a digital printing machine, consisting of a device that physically deposits the ink drop to the substrate. There are different technologies but at the moment the standard is a piezoelectric system for the guide of the ink drops to the substrate. Producers of printing heads Epson (Jp), Kyocera (Jp), HP (USA), Xaar (UK).

3. Inks: Inks and printing heads represent a very delicate subsystem of the machine and the strive to improve reliability and duration of the printing heads lead to different approaches and the creation of different standards. Producers of inks are: Dupont (US), Huntsman (US), Xennia (UK), Dystar (DE) Epson-For.Tex (IT/Jp).

Relevant is that Europe has a small role in manufacturing components, with only a head/inks cluster around Cambridge, with leading positions for Japan in heads and USA for inks. Europe has a leading role in machinery and technology integration. Europe is also the leading market for digital textile printing.

At the moment of the purchase of a digital printing textile machine, one of the main decisions is to choose the kind of printing head-ink system. This will influence the economic viability and the future lock-ins a textile company may have in the future. There three possible standards at the moment in the market: open, semi open or closed.

An open system entails using a certain type of printing heads and the company is free in the choice of the suppliers of the inks. The assistance of the machine producers is delivered in any case and the textile company can take

advantage of a large choice of colorants and of the benefits in term of prices certain inks can bring. The problem is that printing heads are very precise instruments and their speed and precision increased together with their vulnerability to low quality or instable inks. The use of a not conform quality of inks can easily destroy a printing head in a matter of minutes with a damage of usually several thousand Euros. Also the study of parameters that assure compatibility with printing heads is at this stage defined by some operator in the market "closer to alchemy than science".

A closed system is the approach chosen by the collaboration between Epson, machine producer Robustelli and For.Tex as supplier of inks. At the moment these represent the standard for the market for most of the printers. The choice of a Robustelli machine that use Epson technology for the printing heads requires the user to buy the inks only from the authorized dealer For.Tex. The Inks supplied by For.Tex, studied in collaboration with Epson, are the only ones tested for the machine and the producer limits his guarantee only to the use of the tested inks. This system guarantees the highest levels of reliability of the market but on the other side the printers needs to pay for the inks a price 40 to 60 percent higher compared to the competitors and has access only to a limited range of colours.

A new approach is a semi-open system chosen by the machine producers Reggiani. They in fact use an open system of internally testing for their printing heads (Kyocera) certifying inks from the inks producers. The purchase of the inks can be done through Reggiani or, if the textile company has long term relationship with an ink producer because of the traditional printing background, it can be done directly as far as they use a certified ink. This system enables the textile company with the advantage of lower price inks and a wider choice of colours and technologies

The opinion among all the operators is that digital textile printing have still margin for development. One opportunity is to come with simpler and more robust machines that can print large volumes at substantially higher speeds but with fewer colours (based e.g. on the Dutch Osiris or the Italian MS LaRIO machine). The machine concept has been tested but the machine is not yet reliable at industrial scale. Digital dyeing, which requires a deep penetration of inks and ink systems without binders, is also a future challenge. This extends into the concept of digital finishing or coating that involves functional fluids to be disposed on a fabric. This has been researched and demonstrated in the FP6 Digitex project. However industrialisation presents still problems in ink formulation and reliable processes.

Integration with other industrial processes remains an important issue. While digital printing is a clean technology giving substantial savings in water, chemicals and energy, it only represents 10-20% of the footprint of textile processing. Fabric preparation and finishing is still based on traditional water and heat based processes with large use of chemicals. Bioscouring and plasma treatment may improve fabric preparation while e-beaming and UV-curing are possible alternative finishing methods. However the development of a factory of the future is still a major endeavour. An FP7 proposal to this aim submitted in 2006 was not selected for funding.

We have seen at one factory an already patterned printing of a fabric, following the cut for the model of the garment. The benefit is to save inks and to have a print design placed on the garment. This echoes work done by Lectra and Stork in the 1990s and in Leapfrog from 2005 onwards. A further growth area is to integrate digital printing in mass-customization concepts (see below). This means an extension into other markets than those currently developed for mass-customization since menswear involves traditionally few prints. The main challenge is to develop mass-customization not of colour but of protective functionalities..

The digital printing sub-case presents an interesting case of iterative relations between textile manufacturers and textile machinery manufacturers. After an initial involvement of public research and public funding most

developments in the last decade have been done without substantial public involvement or of involvement of RTO's. This can largely be attributed by the incremental character of innovation (step by step increasing performance)and the fact that digitally printing rarely concerns products for highly regulated markets.

Environmental concerns have played a role, but to attain a breakthrough in sustainability a more comprehensive approach to a factory or value chain of the future is required. An extension of digital processes into dyeing and finishing may also require a more fundamental and broad approach. Lombardia is with its textile industry and textile machinery base a possible leading player, but it shall probably require linkages with other hubs (e.g. Cambridge, Ghent, Twente, Stuttgart) to broaden the knowledge base. European funding is an appropriate tool to attain such a venture.

3.1.3. SUBCASE MASS-CUSTOMIZATION

Mass-customization implies the making to measure, for a single consumer/customer, a product while using (modified) techniques of mass production. Mass customization requires a set of technologies in preparing garment making and needs a good support of the textile industry in terms of a diverse and broad offer and quick response. Both in terms of textile and clothing production Lombardia and Piemonte play an important role in mass-customization. The regions produce the top level fabrics for menswear that are sought after in tailored products. The regions also host leading brands and start-ups in made to measure concepts, offered in-store or on-line.

Mass customization is a trend identified in the clothing industry since 1990. Indeed around 1988 first experiments of clothing made to measure organized through an ICT interface were proposed. This trend has amplified since the emergence of Internet around 1995/96. In those years several projects are engaged to understand the potential of ICT to develop mass-customization concepts. The agenda for mass-customization is led by better consumer fulfilment, relocalization of production to Europe and a more sustainable form of consumption and production.

Mass-customization is somehow new, in the mobilization of IT, but also a traditional way to consume clothing. Until 1960made-to-measure garments represented the majority of clothing consumption. In the 1960s industrial prêt a porter has replaced made to measure almost entirely a ladies wear and leaving only a small and exclusive bespoke tailoring segment for menswear. In 2010 industrially made to measure clothing seems to have reached a critical mass. In Netherlands, Germany and Italy estimates are that 10% of men suits sold are made to measure. This growth does not lead to growth of the category as a while rather to a substitution of ready-made suits by made to measure suits.

The Lombardia and Piemonte case is essential in the revival of made to measure suits and shirts. In the first place the region hosts a number of brands and manufacturers that lead the way in the upper middle segment of made-to-measure. Typical brands are Corneliani and LBM (both in Mantova), Boglioli (near Brescia), Canali (near Milano) and Nervesa and Zegna (near Biella). For made to measure shirts we have identified more than 20 brands/companies in Lombardia alone offering made to measure in-store or online. In the second place the majority of fabrics used in made-to-measure concepts come from Northern Italy. Loro Piana, Vitale Barberis Canonico, Reda and Guabello (all located near Biella, Piemonte) are market leaders in woollen fabrics for made-to-measure. Albini, Oltolina (Lombardia) and TESTA (Piemonte) are leading suppliers of shirt fabrics for made-to-measure.

For both clothing manufacturers and wool weavers the adoption of ICT based made-to-measure was a modernization and extension of an existing business model. All brands above were offering a tailoring service for odd sizes and weddings (for unusual models). This strategy fitted with their tailoring image, a certain vision of Italian style, a service to retailers and customers. Hence the adoption since 1995 of ICT supported made-to-measure was a modernization fitting in a pre-existing business model.

The development of made-to-measure was one of the elements of the companies to defend and develop a leading position in the upper middle menswear market. Other elements were the development of classic menswear brands into broad lifestyle brands. In the case of Zegna and Corneliani this strategy was complemented by an active strategy of opening own brands retail outlets, especially in emerging markets. A made-to-measure offer was an asset for markets such as Russia and China (from 2005 onwards) as wealthy consumers demand such an offer.

Of relevance for the Italian case is that the development of made to measure production contributes to keeping high added value production in the EU. In two cases it has accelerated the delocalization of more standard products to Romania and Slovakia. On a more global scale the development of made to measure production has also led to developing production in Tunisia and Morocco that would have been otherwise be delocalized to Asia. The implementation of made to measure production in a factory is quite complex and requires experienced workers and an organization already attuned to frequent model changes, small runs and high quality of product ad process. This applies also to the fabric suppliers. The development of production for made to measure has improved the relative competitive position of weavers such as REDA and Vitale Barberis Canonico relative to the erstwhile leader Botto, that has favoured a high efficiency big volume approach or the French and German wool weavers that have also missed the trend.

Of interest is the emergence of mid-market made-to-measure concepts, sometimes web-based (e.g. Bivolino see Task 2, research), more often offered as packages to retailers (e.g. Munro in the Netherlands) or as retail formula (Dolzer in Germany). Whereas the Italian brands offer made-to-measure suits in the 800-2000 euro range, these formula offer suits with a comparable fabric base at retail prices from 400 till 900 euro. Most recent growth of made-to-measure concepts has mainly been in this segment. This formula offers lower prices because the clothing making is carried out in Morocco, Tunisia, Slovenia, Hungary or Romania. This is often carried out in factories owned by EU principals. Surprisingly the Netherlands is a leader in the trend with in 2010 more than 10% of suits being sold were made to measure. One explanation was the presence of early innovators such as Possen, Oger and Houtbrox (working closely with Italian brands) the other the strong position of independent retailers in menswear in the Netherlands, which contrasts to the overall pattern in Europe. This can be explained by the fact that Dutch independent retailers often own their buildings, have large sites in small towns and villages (that are destination shopping features).

The conditions for development of a made to measure production system are five:

1. The development of an adequate sizing system
2. The development of software programs translating the customer order into a bill of materials and a cutting pattern
3. The development of software interfaces for consumer interaction
4. The ability of weavers to manufacture and supply in small volumes
5. The reengineering of the clothing factory to single products

A key enabler in each of these conditions is the development of IT systems. We will address these conditions more in detail.

The emergence of adequate sizing systems is largely a result of the advent of bodyscanning methods in the first half of the 1990s.The expectation that the bodyscanning would be used in-store was a trend around 1995-1996 that did not go beyond experiments. More important was the Caesar project conducted by TNO (NL) and CNR (IT) to measure some 1800 men and women in Italy and the Netherlands in the period 1998-1999. The choice of these two countries was justified as they represent the extremes of morphology in the EU-12, but a side effect was that the database was far more reliable and accessible in these two countries. This project created a database of measurements that helped to predict correlations on measurements based on a more restricted set of measures (e.g. length, weight and age). The anthropometric data was partly taken up by a company CAD modeling, based in Firenze (IT), that was later hired by Italian clothing manufacturers for made to measure. This result is largely a spin off of research funded by the ministries of defense and the automotive industry: in fact the apparel industry only covered 5% of the six millions budget required for the CAESAR project. The anthropometric data has hardly been taken up by the clothing industry for modernizing their sizing system. Hence the majority of the EU industry works with 40 year old anthropometric data. New data is certainly in demand, but the industry is not able to organize the process of funding and exploiting the collection and distribution of data.

The development of software to generate bill of materials and cutting orders was mainly developed by private companies such as Lectra (France) and Investronica (Spain). The solutions were comparable but Lectra was market leader in Northern Europe and Investronica in Southern Europe. Private companies were building on the results of TNO but also working together with IFTH (France) and Hohenstein (Germany). In Italy, Politecnico de Milano was also supporting the setting up of algorithms and software. This development occurred mainly in the period 1995-2000 with some public funding. Because of the structure of the Italian clothing industry, oriented to small volume production, Italian menswear firms were in the 1990s the most active in uptaking software for efficient single product production and was also the most active in acquiring machines for single ply cutting (needed for customized products).

The development of consumer interfaces started around 1998-2000 in the first *dot.com* wave. Start up in made-to-measure products was one of the most attractive ventures at the time. These spin offs were often but not always from ICT departments of universities. Most failed (Bivolino –see Task 2, research) being an exception) for lack of knowledge of clothing production and lack of access and credibility to the market. After the bubble busted, many assets were up to the grabs and integrated in more established firms. Bivolino but also some Italian firms did not go for the spin-off route but developed Business to Business or Business to Consumer interfaces together with universities (e.g. Politecnico di Milano) but also within consortia (e.g. led by TextileItaly a subsidiairy of the Associazione Tessile Italiana) . Some of these projects were funded by the European Union under FP5/ICT and involved the University of Stuttgart Denkendorf and IFTH. Once again Italian firms were early movers partly to service existing sartorial product lines and partly to establish new service offers.

The re-engineering of manufacturing lines was also an effort of public research centers and private technology providers. The made to measure trend was able to recuperate investments in lean and flexible production systems investigated and developed since 1985[36]. These concepts were developed by TNO in the Netherlands, CETIH (now IFTH) in France, ITV Denkendorf and IfN in Aachen and prominently presented at international Clothing Machine Fairs (now defunct) in Cologne in 1987, 1989 and 1991. Sewing machine makers Pfaff, Rimoldi and Toyota were active protagonist of industrial concepts made on highly skilled workers making single items in a lean production system. The larger Italian clothing firms as mentioned above (but also the now defunct GFT in Torino) was an active

[36] It was the topic of the master thesis of the coordinator of this study in 1988.

adopter. Besides Italian firms, it were a limited number of firms in Northern Africa, Turkey and Eastern Europe following this initial lead. These could largely rely on the experts involved in the first stage of development. Here European funding (BRITE[37]) was instrumental in providing building blocs but national funding was also of relevance.

Finally the necessary enabling condition were weavers able to support the commercial concept and to provide the necessary logistics and ability to provide for re-orders. Italian wool weavers had a tradition of supplying the bespoke tailoring segment (whereas German and French wool weavers were mainly targeting mass markets, and now no longer exist). The challenge from 2000 onwards was to organize the ICT infrastructure and to predict future production volumes on the basis of small sales. Companies like TXT-Solutions and TextileItaly were important in developing the algorithms. However the level of complexity in backward integration seems limited. Although men may be able to choose amongst more than 100 fabrics, 10% of designs (grey, blue, stripes and herringbone) represent 90% of sales volume. It seems that differentiation in size and in details satisfies most men.

Also of relevance is a business model and a business case in terms of value creation and control of working capital. Essential has been because of improvements of IT that the handling costs of single orders has declined to a level that made to measure is only 15-20% more expensive than ready made products in a comparable quality. Made-to-measure has thus become an affordable luxury. This situation was reached by 2006/2007. Thus a long period of gestation starting around 1985-1990, and the coming to maturity of ICT structures (Internet, Broadband) created conditions for a breakthrough around 2005-2006.

Evidence from the Netherlands (Saxion, 2010) showed that made-to-measure concepts gained market share during the recession. Current growth rates in the Netherlands of the made-to-measure segment is around 20% per annum. The main motive is that made-to-measure products do not involve stocks in the supply chain and for the retailer it leads to an inversion of the capital cycle: the retailer is paid before he supplies the good. Hence in a situation of credit crunch, as we have since 2008 made-to-measure is a generator of working capital hence of a leverage to increase pre-ordering or to decrease financial risks. Retailers have since 2009 become far more active in promoting made-to-measure concepts, have given this offer more prominence in the store and guided consumers towards this offer. In addition some retailers have used made-to-measure production channels to make mini collections or to reorder standard products.

We have positioned this case in Lombardia/Piemonte which is justified by the considerable market size both weavers and suit manufacturers of this region have gained in the industrial made to measure segment. Although the segment of Made to measure suits and shirts has a foothold on the market it remains a niche played by less than 30 firms in Europe at some scale. A large minority of clothing manufacturers is from Italy, and an overwhelming majority of weavers; however the entire segment represents less than 100 millions euro turnover in fabrics and below 400 millions in retail value. This is probably less than 10% of output of fabrics out of Biella. In the overall industrial picture it is part of a broader trend towards offering differentiation and value added service to the consumer.

However the odd feature is that alongside the Italians, the Dutch appeared to be the other first movers, using Italian fabrics but clothing making in Northern Africa. Of interest is that both Italians and Dutch have been most entrepreneurial while the French and Germans were more afraid that made to measure would cannibalize there ready to wear lines, as interviews highlighted: German menswear firms preferred a wider size range than to shift to

[37] Research program in FP4 and FP5 for industrial and material technologies

made-to-measure. The Dutch and Italian have been the most visionary and eclectic in combining and comparing technologies developed over a period of 20 years in several regions of Europe. Of difference between the Italian firms and the Dutch firms is that the former integrated made-to-measure in existing business models while the Dutch set up new business models.

The role of local research centres is of relevance in their role of interface with companies but also in the period 1995-2005 to tap into research and results obtained in other regions. It seems that competing projects and research groups led to a logic of emulation and for industrial firms an offer to choose from. Private research and development is not to be underestimated in the range of players. The trend has also been assisted by developments in the ICT sector that were successfully transferred to the clothing/ textile industry. The role of Textile Italy was instrumental in the period 2000-2004. Textile Italy was a joint-venture between the Associazione Tessile Italiana and Project Automation, a spin off of Philips. Hence an intermediary between research centres and companies is appreciated, especially when a large number of projects are conducted in parallel.

What it also shows is the long period of incubation of emerging technologies and their wide application. It seems that a myriad of different projects with competing approaches over a period of ten years have led to different entry moments and diversified approaches. The only limitation of the multiplicity of small projects is that no concentration of efforts on a large anthropometric survey was conducted. The seeds of success were essentially sowed by BRITE projects and many small national and regional projects. It was also supported by collective research centres with at the time sizeable clothing technology departments such as CETIH, IfN and large sewing machine and clothing technology departments with large R&D departments such as Pfaff, Rimoldi or Lectra. None of these centres and none of the sewing technology firms have kept their size and authority after 2005. Nor have the countries, such as the new member states, with sizeable clothing industries developed research capacities. The model is thus hard to reproduce now.

In comparison larger FP6 and FP7 projects such as Leapfrog, Servive and Open Garments still have to prove that their results are implementable, as interviewees told us. The projects that laid the basis for mass customization where shorter in time, smaller in consortia size and more focused in objectives. Therefore they had clear industrial leadership. Moreover these projects were accessible for larger companies whereas now only SME funding lines would fit to this theme. The companies engaged in customization are critical whether public funding is an essential factor now. They are in general aware of funding opportunities, but declare that the take-off in MtoM is now one and that project funding would lead to market distortions (benefitting second movers at the expense of the pioneers).

Beyond the scope of discussions, the made to measure trend still has potential in womenswear, where it has a very limited foothold on the market. This has to do with technical problems, mainly related to more variety in sizes but also with commercial factors. Price elasticity for women is lower than for men. Moreover womenswear manufacturers have a less developed engineering basis to adopt made to measure technology and are less often integrated backwards into manufacturing. Finally relations with fabric suppliers are less stable.

Another emerging trend, which is partly addressed in the analysis of digital printing, is to work towards customization in fabric design or in fabric properties. Dedicated manufacturing technologies such as CO2 dyeing, plasma treatments and digital finishing are the technological enablers of such a potential. The project DIGITEX has shown the potential of digital finishing for applying localized and customized functions on a fabric, but the knowledge is years from full scale industrial and commercial application. This notwithstanding that R&D on

dedicated functionalization methods has started more than 10 years ago, and has been supported by EU, national and regional funding: in these technologies Lombardia also has the potential of being a first mover.

3.1.4. CONCLUSIONS

In Lombardia-Piemonte we choose two subcases of innovation related to clothing textiles and clothing. The first one focuses on digital printing and highlights process and product innovation in the textile industry. The second one focuses on made-to-measure and impacts both on the textile and the clothing industry, but more on the second one. We could have examined other subcases, such as the uptake of biopolymers or of biotechnology in textile finishing, but their uptake is as yet too limited and unstable to draw conclusions from.

The two subcases are interesting as they reveal a number of elements.

Both technologies highlight a trend of the supply chain moving towards small scale production, more rapid production and less use of working capital. Both technologies are in tune of the times and able to overcome the constraints of the post-financial crisis period. Especially the impact of reducing working capital and speeding up the turnover of capital, reducing commercial risks is timely at time that retailers and brands have less capital at hand. Indeed both digital printing and made-to-measure suits have reached the rapid growth stage of innovation diffusion and are reaching market shares that are visible and relevant. However both changes were implemented in a situation of established market leadership. Lombardia is the leader in high quality textile printing, Piemonte in top quality woolen fabrics.

Both technologies show a very long gestation. It took 20 years between initial experiments and market take up. The stage of research and development involved several components such as international alliances, regional clustering, European, national and regional funding. It involves logic of cooperation and of competition. It also shows that ultimately critical mass in a region is of relevance. Also of relevance is the interaction between the textile industry and machinery makers or ICT suppliers. Less relevant was the interaction between textile industry and regional research centres. Also of importance is the time-lag between public funded projects and practical implementation.

In the case of Lombardia and Piemonte lock in factors were as far as the technologies concerned of little impact. Digital printing required substantial investments but a gradual shift from traditional printing was possible. Mass customization involved little investment, rather a re-engineering of processes. Cognitive lock ins were substantial in both cases. In digital printing it was first expected to make existing designs with new techniques, however the discovery of new designs came after implementation. Since both innovations were in lowly regulated markets, institutional lock-ins were of little relevance.

3.2. BADEN-WÜRTTEMBERG

3.2.1. THE REGION AND TEXTILE & CLOTHING SECTOR OVERVIEW

Baden-Württemberg is the second textile region of Germany, after Nordrhein-Westfalen. Around 200 companies are registered with the employers employing around 22000 workers and a turnover of more than EUR 4 Billion. The sector declines annually by 5% in turnover and 10% in employment, with a slightly stronger decline in 2009 and a strong recovery in 2010 (+7%). The automotive textile sector had a very strong decline in 2008/2009, but also a good recovery.

Two subsections dominate the region: fashion and technical textiles. The fashion sector is largely relying on outward processing except for some knitting production. Large European players have their headquarters in the region: Hugo Boss, Betty Barclay, Strellson and Mustang. Baden-Württemberg is the first region in Germany in knitting with more than 50 companies (2/3 of the German total). Knitting companies are still active in apparel, but increasingly in technical textiles.

In textiles the technical segment dominates with Freudenberg (filtration and hygiene) and Paul Hartmann (medical). Both firms are active in non-wovens, a segment with also some medium size players in the region. Of importance is the presence in the region of leaders in the car industry (Porsche, Daimler) which leads to an important supply base in automotive textiles (Benecke, Mattes&Amann, Prevent G&V, Freudenberg, Eschler, Rokona, Eissmann). The presence of key end-users is possibly a key determinant why innovation works.

Classic textiles have almost disappeared with Brennet and Lauffenmuhle being now only medium size companies compared to their once dominant position in cotton textiles. Wool weavers such as Calwer Tuch and Gaenslen&Volter have shifted to technical textiles. The latter has even been taken over by the Prevent Group, a large supplier of components to the automotive sector. Gutermann and Amann are still important layers in sewing thread. Home textiles are small in Baden-Württemberg. The industry is spread over the entire state, with the Upper-Neckar (Reutlingen-Albstadt) valley as its hub. The ample presence of water and the specific structure of the labour market contribute to the scattering of the industry over the region. The regional system extends over its borders. Within Germany the industry extends into Hessen, Bavaria and Rheinland Pfalz. The industry also benefits of linkages into the chemical industry in Ludwigshafen (BASF), Frankfurt (Hoechst), the Danube Valley (fibres and auxiliaries). Upper Alsace, Basel and the North of Switzerland as well as western Austria (Vorarlberg) are also connected in terms of industry, suppliers and knowledge centers.

3.2.2. ACTORS IN INNOVATION

Besides the textile industry itself, the innovation system entails other players in the supply chain. There is no fibre industry in the region itself, but linkages with performance fibre manufacturers in other regions are of importance: such as PHP (Hessen), Teijin (Nordrrhein Westfalen), Kelheim (Bayern), Lenzing (Austria), and Kermel (Alsace). In textile chemistry the region hosts innovative medium size suppliers such as Petry (Reutlingen) and CHT (Tubingen). BASF is close by, as is Huntsman (Bayern), Clariant (Basel), and Dystar (Frankfurt).

Germany is the first textile machinery producer of the world. Although it exports 95% of its output, the local industry is still an important testing zone and Baden-Württemberg has a substantial share in machine production. Fleissner and Dilo are important machine builders in non-wovens; Bruckner is an important producer of finishing machines. Groz-Beckert, the world leader in needles and weaving parts, is a key player with an important technology centre. IST-Metz is a growing firm in UV curing. Not to be identified as a textile machinery firm, but an important technology provider is SAP which has developed an ERP platform also adopted by the textile and clothing industry.

Some important machine supplier are just across the regional border such as Lindauer Dornier(Bayern), an important supplier of innovative weaving looms and Karl Mayer (Hessen) in knitting looms. Northern Switzerland is also an important area for textile machinery, and German textile firms act often as launching customers.

The two main textile research centers in the region are Hohenstein (connected to the University of Freiburg) and ITV Denkendorf (associated to the University of Stuttgart). Both institutes operate with a high degree of independence. Hohenstein is privately (family) owned and has more than 30 direct and associated sites in the world. Hohenstein performs applied research, testing and training. ITV has an associated status to the University and is the largest textile research centre in Germany, also combining research, testing and education. Furthermore schools like Reutlingen University, LDT Nagold and Hochschüle Albstadt-Sigmaringen are relevant for training and applied research. Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA) in Sankt Gallen (CH) is also relied upon, especially with regard to personal protective equipment.

The industry is organized by the South Western German Textile Association based in Stuttgart. This association has mainly a role of employers association, being responsible for social affairs. The national knitting association also has its headquarter in Stuttgart and is also involved in animating research projects. However the activity of the associations cannot be considered as making it a cluster. More akin a cluster is the organization Dialog-Textil Bekleidung, based in Munich but with a substantial membership in Baden-Württemberg (25 companies). ITV Denkendorf animates some groups (such as one on medical textiles) but this is rather a thematic gathering than a cluster.

3.2.3. TECHNICAL TEXTILES CASE

We have examined with regard to technical textiles two subcases: textiles based on aramides (hence the innovation is in the fibre) and automotive textiles. In both instances we have a combination of process and product innovation. For firms shifting from classic textiles, the technical textiles market demands also more innovation in service and in organization. An important commercial issue is to assure conformity with market demands including standards, and hence assure acceptance of new products.

The period 1980-2000 can be characterized as a technology push during which new products, based on new fibres and new finishes were brought to the market. The period after 2000 sees a maturity in the market with clients being more pro-active. The market drivers differ for each market, but higher regulatory demands are often mentioned. In personal protective equipment growth was pushed by higher safety standards. In automotive textiles was sought after as an alternative for steel (weight) and plastics (aesthetics). In medical markets textile provided a good platform for additional functions, e.g. more dedicated wound management. The market for filtration was promoted because of higher standards in air quality (in house and for exhausts). Higher requirements were met either by working on fibre blends and/or with finishing or coating.

The development of new products and processes with regard to technical textiles is an iterative and heuristic process: in fact the textile manufacturer is in continuous consultation with fibre, chemical and machine suppliers to develop new combinations. The clients' end-use specifications act as an implicit or explicit bench-mark, but when a textile firm has long standing relations the demand of the client is often explicit. In both cases, as technical textile markets are regulated, the products need to be tested and certified.

With regards to aramides the main challenge is in a number of processes: spinning, weaving and finishing. The main partner in product and process development is the suppliers of fibres. Both Dupont and Teijin Twaron, the main suppliers of aramide fibre have been very active in structuring the supply chain and in providing technical assistance. Both firms work with licensing models which implies certification of clients, technical assistance and a license to use the fibre brand name. Both firms support their clients with a technical marketing team (working on site with clients, and further companies in the supply chain) and with a technical pilot plant. Teijin gives support from Wuppertal in Nordrrhein Westfalen and Dupont from Geneva and Luxemburg. Some elements of development have been taken up by other machine suppliers when it comes to machine parts, tooling and setting of machines. Groz Beckert, a designer and manufacturer of tools and system of nonwovens production in Albstadt, is of importance since the use of aramides involves abrasion of machine parts. The presence of many machine suppliers in Baden-Württemberg is of importance to implement new processes.

The role of public research centers in the adoption of aramides is limited when it comes to production processes. The suppliers of the fibre are dominant in providing technical assistance. Some interviewees mention that growth of the market is now in blends of fibres. Such blends offer a better mix of properties and also a lower price since aramides and similar high performance fibres are very expensive.

Fibre suppliers are not always of help since some foster a policy of 100% use of their fibres (e.g. Dupont). Other firms such as Lenzing and Twaron are also advocating a policy of blending in order to differentiate from Dupont. Nevertheless some manufacturers explicitly mention to rely more on public research centers when it comes to develop blends and research on processes and properties of blends. The technical universities ITA Aachen, ITV Stuttgart and TU Dresden are equally mentioned as partners.

However public research centres are extremely important when it comes to validation and certification of end products. Almost all products made of aramides are required to meet norms and standards or specific requirements of firms. This always requires an independent test. The names mentioned before are important players when it comes to validation of processes although some do not yet (but aim at) integrating testing functions.

In Baden-Württemberg, Hohenstein is an important centre for testing (of para-) medical products. ITV is also an important testing centre. EMPA based in Switzerland is an expert in PPE testing. But regional TÜV centers are also used for routine tests. More specialized tests are carried out in specialized textile centers or in application oriented centers (automotive, constructive and PPE). Routine tests are carried out by TÜV. The advantage of the former ones is that they can assist in problem shooting and problem solving.

The freedom of choice for clients is quite limited since norms and standards determine the characteristics of the product (e.g. in military and civil protection uses). An important element is that end-users often develop their specifications and terms of reference in close contact with research centers. ITV Stuttgart and EMPA are important players with reference to protective equipment, Hohenstein for medical and hygiene products, and ITV Stuttgart for technical textiles in general are important player.

Funding of innovation has almost exclusively done by funding from firms own resources. Some smaller public funded projects have had a more exploratory character. One project funded under the BRITE program, involved two partners in the region on the (relevant) combination of aramides and plasma treatment. The development of application of aramides is often short term whereby results are expected within a year – which does not lend itself to a publicly funded project approach; moreover the development work is often iterative and does not fit in a project model. Companies are aware of funding opportunities but do not find the schemes attractive, especially not since they are perceived to be oriented towards SMEs. Most innovative firms in technical textiles are not SMEs.

With regard to coating and lamination the innovation paths are more complex. In the first place the relation between substrate, processes and functionality is more complicated and requires a good knowledge base inside the company. In the second place there is less of an oligopoly when it comes to suppliers. There are some broad 20 suppliers of chemical auxiliaries for textiles as well as many specialists. The market for textile auxiliaries is European, but for product development nearness is of importance. Baden-Württemberg is particularly well positioned since leading innovative suppliers are in the region (CHT, specialized in chemicals, in Tubingen and Petry, specialized in auxiliaries in Reutlingen). Many are closely such as Dystar, known for its dye and auxiliaries in Frankfurt, Clariant, an important producer of chemicals, in Basel, BASF, one of the biggest chemical companies in the world, in Ludwigshafen, Huntsman, also a chemical supplier, near Augsburg and Tanatex, an important chemical producer too(former Bayer) in Leverkusen. Equipment for finishing, coating and lamination is also predominantly made in Germany and manufacturers of weaving and knitting looms are also in or close to the region (Germany and Switzerland).

When the product is differentiated by finishing or coating, the fabrics are increasingly sourced outside Germany either for cost reasons or conform quality in large volumes. One pattern is to shift weaving to new member states but sourcing by specification in Asia is also relevant for polyester fabrics. Volume, differentiation, quality and price are important factors. The added value in Germany is in the finishing process. In standard qualities sourcing prevails, in smaller volumes production remains nearby. However with the recent credit squeeze and political uncertainty sourcing close by prevails over sourcing in Asia. Most added-value is in mastering the combination of finishing and often several layers of fine coatings.

Companies moving into and developing technical textiles can rely on a broad range of suppliers at hand. The textile firms act more as directors of the innovation process and the interaction with the end users primes. Chemical suppliers and machine and suppliers are supporting players. Sometimes a triangle is in play, for example in the development of some chemical treatments, a textile firm works together with CHT for chemistry development and with Benninger, a textile finishing and cord producer, for the process development. However some textile firms are also reluctant to involve too much their suppliers in product development especially when it comes to fine tuning processes in order to protect their intellectual property.

A trend for SMEs is that chemicals suppliers (e.g. Huntsman) develop compounds including several functionalities with a standard application process. The benefit for SMEs is that it makes entry into technical textiles less difficult. But there is no free lunch; in fact the downsize is that with more competition the added value and profit margins are lower. Hence there is a dichotomy in technical textiles between larger firms with well protected positions in markets with high barriers of entry and smaller companies (e.g. some knitters in Reutlingen) that combine job-work and some more advanced customized product development, but in both instances with low margin.

Partnership with research centres becomes also more intense when new challenges appear. Freudenberg, the largest textile firm in the region, works together within several other companies and research centers to address new challenges in air filtration, especially with regard to fine dust particles and nano-particles. Freudenberg also

works together with BASF and Lohman and Rauscher and two research centres in developing understanding and application of spider silk. In coating a new trend is to apply solar foils on textiles. This also involves alliances between machine suppliers (Coatema in NRW) and research centres (e.g. Fraunhofer in Munich) and chemical suppliers (Hereaus in Frankfurt). The partnership here is also cross regional and involves national funding.

All these projects involve public funding (mainly national, sometimes European) but are also often cross regional. The most regional project that we encountered in several interviews was a project led by ITV Denkendorf with a group of companies focused on medical textiles. This one was funded by the regional authority and aimed at bringing new firms to medical textiles. The state aid framework is relevant when it comes to research on new challenges, but regional and national funding is preferred over European funding, especially because of the SME criterion. We noticed that companies preferred to be loosely associated to public research than to be fully involved in projects. Most public funded projects were not oriented to short term applications.

Also of relevance is the organization of round tables and dissemination activities by ITV (the so-called *zukunft-werkstatt*) to envisage new products in technical textiles. This is funded through a grant of the state. Finally ITV Denkendorf has a pilot factory. This has been build and tooled partly by public funding but companies use the facility with a cost-covering fee. The pilot plant is of importance for complex product development involving several stages of production not present within a firm. It enables to develop new products without sharing IPR or for addressing complex problems without using production equipment.

The automotive textile cluster is very much an end-user led sector. Daimler and Porsche are leading and innovative end-users in the region itself. Audi and BMW are based in nearby Bavaria. The supply chain is highly structured with textile companies supplying into automotive components manufacturers, that in turn supply to system manufacturers and then to automotive companies. Hence textile suppliers are often third tier or fourth tier suppliers. Baden-Württemberg has all players in its region. This is of relevance since product development and logistics concern all interactions in the supply chain: visual product development often is an interaction between textile manufacturer and car companies when it comes to seat upholstery and filtration materials involve a partnership between non-woven manufacturer and filtration system manufacturer. Increasingly labour intensive operations of assembly of components and systems are delocalized close to car assembly plants e.g. in Slovakia.

All production arrangements are on a quick response basis with very high standards in quality of product and of operations. This market is hence very demanding in quality of operations, and each supplier in the automotive supply chain has to be certified by the end user. Hence the entry barriers into automotive textiles are high.

The market conditions are fostering both product innovation and process innovation. A supplier often gets an exclusivity contract for a product over the entire life cycle of a car model. This exclusivity is granted after a competition (akin to a tendering procedure) and entails product development and supply. Prices are often declining over the lifetime of the car model and according to volumes, but are set for the period. Hence the exclusivity is associated with an arrangement with declining margins. This is an impetus for process innovation and productivity increase. It is also an impetus for developing new models or modifications to models.

Overall the automotive sector has high entry barriers, high pressure on prices but little competition from low-cost suppliers. It is also a very cyclical industry. During the conduct of interviews for this case in June and October 2011, the economic cycle was still good and the entire supply chain produced normal volumes. In fall 2008 the researcher did also a survey of automotive suppliers and the entire industry worked on holiday schedules or where closed. This creates a dilemma for the supply chain. On one hand it is attractive to have the volumes and exclusivity of the car industry in good economic times on the other textile firms desire an alternative market during downturns. A

weaving company like Gaenslen & Volten is now part of Prevent (car components) and is entirely focused on automotive, such as Baenecke (part of Continental). Independent knitters such as Rokona and Eschler focus more on niches and tend to reduce risks by diversifying into several markets; especially into the medical market, which is also demanding in terms of innovation, quality and logistics but also a good anticyclical sector.

The innovation process in automotive textiles is almost exclusively market led. Car companies have clear demands in terms of specifications. These must be met by tested and tried technology. However European regulation, e.g. on car safety, fuel use and fine dust particles or on recycling of the car, is a strong impetus for innovation. It is especially a strong impetus since higher standards are often set for a reasonable dead line that enables the supply chain to prepare for it. Unlike the textile industry, the automotive industry has a very pro-active attitude to future regulation: it drives this attitude upstream into the supply chain, hence also to its specialized textile suppliers.

Public research centres play a double role. In general automotive companies have become important clients of textile research centres, mainly for developing new product and material concepts. Especially composites and three-dimensional fabrics are of interest to automotive companies. The knowledge developed is mainly used to develop specifications for new materials. Centres need to have an industrial production equipment and staff in order to be relevant partners. Public research centres do also play a role in assisting in the engineering of production processes and testing of materials to be commercialized.

Public funding plays a limited role in innovation processes. For end user and most players in the supply chain, new materials are a must have, hence research is funded with one-to-one contracts whereby the client gets exclusivity of the proceeds of research. Also testing is done on a commercial basis. The volume of commercial research and testing is very substantial and partly explains the size of an institute like ITV Denkendorf which has about 200 employees. Public funding does often concern more exploratory research for long term product development. Advanced filtration, light weight composites and biobased materials are themes for such research. For these kinds of projects companies in the automotive chain, and especially the end-users go for safety in numbers. As they are very much demanded to join regional, national or European projects, they can afford cherry picking.

3.2.4. ICT IN BADEN-WÜRTTEMBERG

A second subcase we are looking at in Baden-Württemberg is innovation in supply chain management. This field covers a wide range of issues such as electronic data interchange and radio frequency identification but also the internal company backbone as provided by Enterprise Resource Planning. The combination of these technologies enables an E-Commerce strategy. However they also contribute to lower costs in logistics, better management of stock and work in progress, better visibility of sales in store and a feedback into product development. All these technologies are basically technology transfer from other sectors. Although each technology has it specific aspects, they can be analyzed together as they present common challenges.

The implementation of these technologies is not unique to Baden-Württemberg, and the innovation system is not properly regional. But, although other countries have also taken up these technologies, it is probable that Germany is front runner in implementation of supply chain management tools. The introduction of these tools should also be seen in connection between the battle for the control of high streets between retailers and brands since the beginning of the 1990s and for control of Internet since 2000.

As Germany is Europe's main clothing market (ca. EUR 50 Billion) and still has a sizeable independent retailing, and large retailers as well as brands with own stores, it is more than any other large country a battle zone for supply chain control. Moreover Germany has a sizeable market share for mail-order. Brands are swift in adopting online

business, either directly or through middlemen such as Zalando or traditional mail-order firms that went online (e.g. Neckerman, Otto and Baur). Most brands in Baden-Württemberg have an online presence, support web shops of middlemen or of retailers such as Breuninger and many others.

However if the metaphor of a battle applies, so does the model of partnership, since no single brand or retailer is able to impose a standard and since automation of processes and stock-keeping in clothing presents specific problems due to the large number of stock keeping units (abbreviated as SKU, often more than 1 Million) and their rapid change (80% changes each year) companies have looked for support in forming a joint platform towards ICT-suppliers and towards retailers. Joint platforms were set up in the UK (Apparel and Textile Challenge), the Netherlands (National Kleding Dialoog) and Germany (Dialog-Textil-Bekleidung). The Baden-Württemberg case enables to examine the Dialog Textil-Bekleidung (DTB) approach.

In the introduction of ICT technologies four factors are of relevance. In the first place early adopters closely related to leading ICT players. In the second place a constant flow of seminar and conferences on ICT and fashion (often largely sponsored by ICT providers) and thirdly the creation of user groups and communities of practice as Dialog Textil-Bekleidung. In the fourth place ICT and logistics was recognized as a significant profession for which talent outside the industry was attracted. The introduction of ICT in the clothing industry has three key elements: The sensibilisation towards the importance of ICT; the implementation process itself; and the management of sectorial specific issues related to ICT.

Sensibilisation

The importance of ICT in managing the business was mainly felt through the transformation of the clothing business. ICT was seen as a key enabler to a wider differentiation and rapid change in products, faster lead times, better stock and store control, better interaction and monitoring of the clients. This transformation created in itself enough awareness, hence there was no need to promote from outside the importance of ICT. The intense flow of seminars and conferences on ICT and fashion should rather be seen as events where a community of practice meets, than as sensibilisation events.

The German industry has a track record of twenty years in investment in logistics. This heritage derives from a very demanding local market in terms of promptness of delivery, order fulfilment, possibility to reorder. Germany has also adopted long ago a policy of wide choice in sizing and fit, hence has on average twice the number of SKUs than the average in Europe. The SKU is a unique number for a specific product in a commercial branch: hence it follows that a high number of SKUs entails a lot of different products. The logistical function was also enhanced by the early internationalization of production (in 1970s) and growth in exports (in the 1980s).

For the German clothing industry the complexity in managing was increased by exports (especially outside the EU) which required specific sizing, labelling and pricing and by the early use of outward processing production and sourcing. This often led to more than 100 possible combinations of production countries and export countries, in addition to more than 1 Million possible SKUs. This was increased, e.g. for Hugo Boss, by a policy of making every order of a client, independently of its size. The costs of administrative handling of orders increased in the 1990s.

In the combination of global production, export and service the German industry is unique in Europe. Scandinavian and Dutch firms also use sourcing extensively but were less export oriented. French and Italian firms were also export oriented but had a simpler production organization. It can also be said that there is a connection between delocalization of production and the increased costs of ICT. It has been identified earlier but the increased investments in ICT could be well funded if there was no commitment to invest in manufacturing. With the opening

up of Eastern Europe after 1989 there was no a longer a strong case for further investment in mechanization and automation (at the time, at the cost of flexibility in production) while lower cost production had become available within hours driving. The investment capacity could hence be diverted to ICT systems that at rates of 2000 would cost from 1 to 2 Million Euro even for a medium size firm.

Implementation

Implementation of ICT was the main issue. In addressing the development of ICT in company the individual approach and the collective approach were in competition. In the 1990s the collective approach prevailed with the attempt to have a joint analysis, a set of industry wide standards (e.g. in EDI) and platforms of users to negotiate with ICT suppliers. After 2000 the approach has become more individual. This is partly fed by the failure to come to standards and joint approaches. We will expand this point later when it comes to DTB. It is also fed by the reduction of costs of ICT when hardware became cheaper and faster, databases became cheaper, SME oriented software platforms were developed and externalized web-based services were offered. The latter are lower in costs of investment but more expensive in costs to operate.

For textiles and clothing, the term "early adopter" is somehow misleading. Textile and clothing companies have started to engage into ERP software at the end of the 1980s, which is some ten to fifteen years later than companies in automotive industries. Hence the textile and clothing firms were invited to use already developed and tested platforms. SAP (also based in Baden-Württemberg) was an important regional resource especially in having worked with companies such as Daimler-Benz, Robert Bosch, BASF, etc. Hence in the 1990s fashion and textile firms could already benefit from ICT developed; not for them but to be used with adequate modifications.

Implementation of ICT is a labour intensive effort of data structuring and entry, but also of analysis of company processes and alignment of processes. It is also an intensive process of team work in-company. Implementation of complex ICT infrastructure presents a considerable investment in money for systems and for consultancy and a comprehensive process in company demanding strong management while fashion changes and seasons go on. All companies report that ICT implementation is lengthy, costly and risky. Several companies have gone bankrupt because of a mismanaged ICT implementation. Besides the high costs of ICT implementation, a poor transition leads to a high rate of faults, returns, longer delivery times, which may impact strongly on customer satisfaction and to loss in sales in profit. In some instances this led to a bankruptcy.

Adaptation

The problem was more that fashion and textile companies have specific issues and less financial and organizational resources. Automation was long seen as complex because of rapid model changes, the large number of SKUs and a business model that combines aspects of making to order and making to stock. The organizational problem is the rather smaller size of companies in which information technology is a long seen as a supporting function to accounting. ITV Denkendorf was instrumental in assessing the specific needs of textile and clothing firms in ICT.

Organizations as Dialog Textil-Bekleidung (DTB) have played an important role in both attempting to set joint standards but more in exchanging best practices and issues related to implementation. DTB has a working party on ICT (under different names) that brings together textile firms, ICT suppliers and consultants. Main topics have been

ICT in general and EDI. Now the focus is on e-commerce. RFID and supply chain management in general. Besides working parties DTB organizes seminars and publishes reports and recommendations.

The setting of joint standards has not been successful when it comes to joint approaches in coding of messages and products. This is related to four points. In the first place retailers were not willing to engage in a dialogue on electronic data interchange. Large retailers had their own standards whereas smaller retailers did not form a critical mass. In the second place the industry was never able to come to a joint platform at European level. In the third place the issue became less relevant when larger brands set up their own retail chains. In the fourth place the costs of ICT declined and with the advent of internet it was possible to distinguish the front and back end of automation so that standards were less urgent. Hence standardization of data is now merely of importance to SMEs, but SMEs do not provide and organize the critical mass in for this process.

DTB has been of importance for developing ICT skills in fashion companies, and has been a good platform for larger companies to exchange good practices. It has also enabled SMEs to team up and to learn the do's and don'ts of ICT introduction. It has not provided a platform for standardization and through this platform a reduction of costs. DTB had not sufficient SME members to organize such a platform and the funding of DTB (through a relatively low membership fee did not provide the critical mass. As far as we know no industry in any country in Europe succeeded in organizing SMEs to set up common standards of ICT towards retailers.

Innovation in ICT has hardly been supported through public funding. The process of implementation is not seen by firms as lending itself for state aid, and the funding instruments in Germany did not allow for support for implementation of ICT. Although ICT implementation is considered complex and risky, it is not seen as the type of risks that require subsidies. Some companies were even explicitly expressing a fear that state support to implement ICT would create distortion of markets, for companies having it paid from own resources. Only platforms of companies could be funded, e.g. as for RFID, which enabled to set up a community of practice and to develop courses in higher education.

ITV Denkendorf has been involved in EU funded projects on ICT but these were not related to basic introduction of ICT but rather on knowledge management, E-Auction systems and management of complex subcontracting networks in textile production. The latter two projects were implemented in Lombardia, but not in Baden-Württemberg. The reason was that the demands came from Italy with its specific subcontracting structure. Italy lacks a textile institute with a strong management and ICT Competence as ITV has. ITV has worked in the region mainly with regional or national funding.

3.2.5. CONCLUSIONS

For Baden-Württemberg we choose two unrelated cases. The first one focuses on technical textiles, with an orientation on technology push (aramides) and on market pull (automotive textiles). The second one focuses on ICT implementation in the clothing industry. In both instances the long lead times in innovation is striking. Also in both cases it takes around 20 years between introduction and market uptake. In the case of aramides, this does not include the work on the fibre itself. In that case the introduction till take up took over 40 years. The two subcases are distinct so less common conclusions can be drawn.

A common conclusion is that market pull is essential for successful innovation. In all subcases this was the case. Protective equipment makers were searching for strong and lightweight solutions. Car companies and component suppliers were looking for lighter materials with more design freedom. Clothing retailers were asking for more

variety, smaller orders and quicker response. Consumers desired to order from home for products of well known brands. Germany is the main market for technical textiles and clothing.

Also dominant in the two subcases is the interaction in the supply chain between suppliers, textile/clothing firms and their clients. In the aramides subcase the focus is very much on the interaction between fibre suppliers and their clients. The partnership is still classic “technology push” and involves a lot of technical assistance and some exclusivity to take the profits of investment in complex products and technologies. Exclusivity is also a feature in automotive textiles, although it is granted for a specific product from the client to the supplier. The combination of high barriers of entry and exclusivity makes investment in technical textiles worthwhile. In ICT the interaction with suppliers was essential and also here the step by step approach created the condition to engage in an online strategy and created its barriers of entry.

Lock in factors are once more of relevance. Functional lock ins are of limited importance. The transition to technical textiles always involved additional plant and rarely the writing off and replacement of existing plant. In ICT investments were also additional to the existing production base. However in ICT investment went often at the expense of investment in manufacturing itself and was rather a corollary of more delocalization and subcontracting of production. Cognitive lock ins are substantial both in transiting to technical textiles as in implementing ICT. Both demand high standards in quality of implementation. ICT also requires specific skills, often recruited outside the industry. Technical textiles requires thorough understanding of regulations and procurement procedures. Institutional lock ins are insofar relevance that the presence of a sophisticated environment and of knowledge basis is importance. Both innovation require to go across the frontiers of the textile industry.

In both subcases the role of public research centres and of public funding is limited in terms of fundamental innovation. In all cases their role is rather oriented towards problem solving in engineering and in product testing. However the volume of engineering assistance and testing is so substantial that it funds a significant portion of activities of research centres. Indeed some centres have developed substantial pilot plants (Prakticum). Also of relevance of organizations that bring together companies in sharing knowledge and implementing standards. In the case of technical textiles research centres have played a substantial role, and public funding was involves. In the case of ICT associations where instrumental and public funding had only marginal significance.

3.3. NORTE PORTUGAL & GALÍCIA

3.3.1. THE REGION AND TEXTILE & CLOTHING SECTOR OVERVIEW

According to a recent publication of the European Commission[38], manufacturing plays a similar role in Portugal than in the EU as a whole (14.6 % against 14.9 %). Portugal is highly specialized in labour-intensive (low-skill) industries (wood and cork, cutting and finishing of stone, made-up textile articles) as well as in capital intensive (cement, refined petroleum) and marketing-driven industries (footwear). At the more aggregated sector level, Portugal features specialization in low and medium-low innovation and education sectors (wood and cork, leather, wearing apparel). Its share of exports to the BRIC (Brazil India and China) countries is low, thus not taking full advantage of the opportunities offered by these high-regrowth emerging economies. Within Task 3 (SME) a more detailed characterization of this particular region is presented.

The same source[6] refers to the improvements regarding innovation performance that has conducted the country to a leading position in the group of moderate innovators identified in the Innovation Union Scoreboard 2010. Its relative weaknesses are the low business R&D investment and low high-tech exports. On the other hand, its strength is a relatively high share of science and technology graduates and an impressive evolution in the number of doctorates (859 in year 2000 to 1.569 in 2009)[39]. R&D expenditure reached 1.71 % of the GDP in 2009 (close to 1/2 in the private sector). Portugal made a considerable effort and adopted a wide set of public policy measures promoting R&D and innovation in the recent years, which led to a consistent growing in companies interest in innovation oriented projects and services. The number of companies' personnel working in R&D activities within the companies (full time equivalent) during the last 8 years was more than doubled (13.448 in 2001 to 52.312 in 2009).

Looking at the specific importance of the Textile & Clothing business in the Portuguese North Region, is responsible for almost 84% of the total textile & clothing business of the country[40] , therefore accounting for a total income of EUR 5.140 million with an employment force of around 128.000 people distributed within an estimated number of 7.000 companies from which SME represents certainly almost 95% of the companies.

Looking at the share of textile/clothing companies in the North Portugal region, textile companies represent approximately 30% of total number of companies.

[38] Member States Competitiveness Performance and Policies 2011 SEC (2011) 1187

[39] Source: Manuel dos Santos Foundation (www.pordata.pt)

[40] According to ATP (2010 figures) – 6.120.000 (1.000€)

Looking at exports, the North Portugal region sector has a well consolidated export vocation with a share of total exports representing 61% of the total business and with a positive balance when comparing at imports. Looking at the North Portugal exporting goods there are no dominant company group and the most representative product in terms of exports (49% of total) are knitted clothing garments and accessories spread over a significant number of different companies.

Major destination T&C exports is the EU 27 market, with Spain (37%), Italy (13%), France (8%) and Germany (8%) being the more important markets. In terms of products knitted clothing items they represent almost 40% of total exports. However some special articles like piled fabrics or coated fabrics had experienced interesting growing rates in exports during the last years.

Regarding the North Portugal T&C sector present situation, it can be characterized by a certain positive wave, resulting from the return of several clients that were placing their orders in far Asia and that now are looking back for partners and suppliers in Europe. According to ATP figures, when comparing first semester of 2011 with the first semester of 2010, Portuguese exports increased by 13% and the most important markets remain Spain, France and Germany. However at the same time, this positive trend is counterbalanced with a very difficult and restrictive access to credit due to financial crisis in Portugal that is making money less available and more expensive.

At the same time there is a clear breakdown in consumption that is negatively impacting the clothing retail business within the internal market – according to a recently published study performed by Kantar Worldpannel[41], in the first six months of 2011, 47% of the Portuguese consumers didn't bought a sole piece of clothing.

According to ATP, today's priorities for companies established in the North Portugal region can be placed in three pillars on the following order: 1st) Access to finance, 2nd) Increase Exports & Internationalization and 3rd) Innovation & creativity.

According to the annual report of the Galicia's economy published by the CIEF of Novacaixa Galicia, the regional economy of Galicia had in 2010 a better performance than the Spanish economy. In 2010 Galicia's economy grew 0, 1% of the GDP while the Spanish situation is characterized by –0.1%.

Industrial activity in Galicia almost stagnated in 2010 showing a decrease of 0,5% that led to a loss of 22.450 workplaces within the secondary sector. According to IGE data, the income of the transforming industry was to be reduced by 13,7% in 2010 and the contraction of the industrial activity had heavily impacted consumer goods business. Regarding innovation, Galicia invest 0,96% of its GDP in R&D and is the sixth Spanish region with a lower investment in such kind of activity ranking quite below the Spanish average which is of 1,35%. Regarding the international trade, Galicia has performed quite well in 2010 as a result of a positive performance of its most important clients. Consumer goods exports grew 7,1% ranking Galicia as the sixth more important exporting region of Spain with a share of 8,1% within he total Spanish exports.

Looking at the Galicia region the number of textile and clothing companies according to IGE is of 1.862 where SME also represent 95% of the total figure. The textile & clothing companies of Galicia are responsible for almost 12% of the Spanish textile & clothing production. In terms of textile & clothing employment the Galicia region has a total of 21.191 employees, which clearly shows that in Galicia the average number of employees per company (11,7) is

[41] Kantar World Panel is the world leader in consumer knowledge and insights based on continuous consumer panels (http://www.kantarworldpanel.com)

smaller than in North Portugal (18,2). In fact, most of the companies in Galicia (80%) are micro companies, with less than 9 employees.

The total income of the textile & clothing sector in this region accounts for EUR 1.428 million representing 12% of the total Spanish textile & clothing business. It should be underlined that since the year 2000 until 2010 the representativeness of Galicia within the textile & clothing Spanish business has almost doubled. Regarding exports, according to IGE, the sector exports accounts for a total of EUR 2.513 million while imports reach EUR 1.757 million. However, exports from the Galicia region are highly influenced and dominated by companies and brands belonging to the INDITEX[42] group, installed in La Coruña. Looking at the share of textile/clothing companies in Galicia, textile companies represent approximately 25% of total number of companies.

The most important markets for Galicia's textiles and clothing exports are France, Italy and Portugal. The ranking of importance of those markets changed within the first six months of 2011. According to data provided by COINTEGA, France is now the more important market followed by Italy and Portugal. Exports to Italy and France have been growing in a sustainable way within the last three years while Portugal lost its second position to Italy, confirming a trend of slows down within the commercial exchange between both regions.

3.3.2. INNOVATION PLAYERS, INNOVATION PRACTICES AND DRIVERS

The innovation path followed by textile companies and by clothing manufacturing companies is different and they address different priorities disregarding this dimension. North Portugal & Galicia textile companies are normally more engaged into a combined approach that addresses both product and process innovation, towards innovative finishing or the usage of innovative fibres/materials. Most of the textile companies engaged in innovation processes try to differentiate their products by following a path that is more on the side of incremental product innovation than radical innovation (new to market and new to firm). This kind of approach, addressing new markets with radically new products is almost an exclusive of a few bigger companies with a clear leading position in the market and with internally consolidated critical mass regarding R&D and new product development competences.

Regarding clothing manufacturing companies, innovation strategies are mostly focused on product innovation, namely through the development of incremental innovation processes. This is leading to an increase in product functionalities or in some cases to the entrance in new markets, like the sport market or the personal protective equipment market. Companies operating in the fashion business and those which are producing in a combined model where production for private labels and for its own brands coexist next to each other, tend to innovate mostly through incremental product innovation. The latter happens through incorporating special effects or special finishing. In general, marketing innovation is considered of strategic importance for those companies, but in particular for those companies controlling retail and distribution and using the retail floor to collect consumer inputs towards product development. Companies from the hybrid model, clearly consider that innovation through service can be strategic to differentiate the company in the market, even in the cases where creativity and product development is part of the product package offered to the client.

[42] INDITEX GROUP Brands – Zara, Pull & Bear, Massimo Dutti, Bershka, Stradivarius, Oysho, Zara Home and Uterqüe.

Process innovation in clothing manufacturing companies is in most cases being pushed by product innovation or by product specifications, leading to the search of innovative material welding techniques, particularly in the case of companies working with less traditional materials. New design tools aiming at better and faster product design and simulation, integrated with production chain are still very often pointed as process innovations adopted by the companies. Other examples of process innovation in the clothing manufacturing companies is the adoption of RFID technology, that can be found in a few companies but with growing interest, aiming better and more effective process control and tracking for orders and samples. All those companies have in common the fact of handling a significant amount of samples and prototypes and in most cases controlling their own retail channel.

Regarding ideas generation processes and inputs for the innovation process, most of the companies agree that in most cases either the ideas are generated internally or they are answers and reactions to the client's challenges (external source). There are no frequent examples of formal practices or methodologies for activities like technology forecast, competitive intelligence, technological surveillance or trend watching, with exemption of bigger companies producing exclusively for their own brand and managing their retail and distribution process. However, there is a growing perception by the companies in general for the importance of such kind of processes.

International product exhibitions and fairs are considered as the first option towards the monitoring of product and technology trends. SMEs, more often than bigger companies, particularly tend to look into R&D centres or universities for new ideas and for inputs. In this respect, CITEVE, CENTI, Minho University (In Portugal) and Vigo University (In Galicia) have been pointed out as relevant players, regarding the innovation processes, either as supporting organizations for R&D, and either as relevant information sources for innovation.

In general, most of the companies that were addressed either during the round tables, or during individual interviews have identified that raw materials suppliers, chemical products suppliers and clients, are the most relevant cooperation players and partners for their innovation strategy. The less ranked position in terms of cooperation for innovation is obtained by specialized consultants, which are considered not relevant at all by most of the companies, while institutes, research centres, universities and technology/machinery suppliers, rank in between consultants and the more important players.

The major objectives for innovation strategies within the region are process efficiency towards lower production costs and shorter lead times and product differentiation towards higher value products that can be profitably produced in Portugal, despite the actual increasing trend of production costs. Technical textiles are recognised as an interesting area to shift to but at the same time companies realise that barriers to enter are quite high, mainly due to need of having deep knowledge on the application market and in some cases complex regulatory standards and legislation. Lack of information on very specific niche markets and the high economic risk of innovation are two barriers frequently referred to by SMEs in particular, which today are amplified by the lack of financial resources. In fact, a study published in 2007[43] , about the manufacturing sector, points out that the three major barriers to innovation in Portugal are by this order: the high cost of innovation, the lack of financing and the lack of skilled personnel.

[43] Barriers to Innovation faced by manufacturing firms in Portugal: How to overcome it? 2007, Silva, Maria; Leitão, João and Raposo, Mário

The third factor can also assume particular importance when it comes to shift the business strategy from conventional textiles to technical products. However, according to data provided by the directory of technical textiles in Portugal[44] in 2004 there were 44 companies producing to this market and in 2010 this number increased to 77. The most relevant application markets addressed by those companies are: sporttech, clothtech, hometech, mobiltech, protech and medtech markets.

Looking into funding for innovation and R&D, in Portugal most of the schemes are managed by ADI (Agência de Inovação) belonging to the Ministry of Economy. In Spain there are national and regional funding schemes. The national funding is managed by the Ministry of Science and Innovation, through The National Scientific Research, Development and Technological Innovation Plan. The regional funding in Galicia is ensured by the Directorate General for R&D and Innovation of the Xunta de Galicia - the public entity in charge of management, planning, coordination, implementation and monitoring of competencies for the promotion of research and technological development attributed to the Autonomous Region of Galicia.

In the case of Portugal, looking at the years 2001-2011, the Textile & Clothing Industry has been involved into 187 funded national projects and activities, within the field of applied R&D and innovation, with the participation of 52 textile companies, 34 clothing companies, 58 companies from other sectors, 18 R&D centres/Institutes and 17 Universities.

The topics addressed by the projects are mostly within technical textiles and smart functional clothing (53%), new process development (21%), new machinery and control devices (11%), biotechnology and environmental technologies (8%). CITEVE, CENTI, Minho University and CTCP are the most represented scientific and technological organizations in those projects.

Looking at Portuguese participation in textile & clothing related projects within FP6[45] Portugal was engaged in 13 projects, all of them in the field of process development or process management. Seven textiles & clothing companies were engaged in those projects and the other participating organization identified were: Minho University (6 projects), CITEVE (5 projects) and CTCP (2 projects). In what FP7 is concerned and looking only into contracts signed until 2010, Portugal was engaged in 7 projects, 6 of them in the field of process development or research cooperation and only 1 in the field of product development. Six textiles & clothing companies were engaged in those projects and the other participating organizations identified were: INESC (2 projects), ATP (2 projects), CITEVE (1 project), CENTI (1 project). The preference for national funding schemes is mainly related with better success rate in proposal approval and with the availability of some funding instruments oriented to smaller projects which are more suitable for short term product development.

However, national funding schemes are considered to be more bureaucratic than European funds in what project proposal submission and project reporting activities are concerned. An exemption to this is the innovation vouchers[46], which is a very simple scheme and well adapted for short term developments either in a preliminary

[44] Directory of technical textiles from Portugal - CITEVE, 4th edition 2010

[45] SOURCE: FP's Portuguese National Contact Point and Cordis database

[46] Innovation Voucher, is a national funding scheme supporting very applied development stage and very easy to aply through a very short and simple form, which is presented within a call for proposals system. Only companies can apply for it and in the case of approval, the company gets a voucher that supports 75% of a maximum cost of 33.000 Euros, which can be used within a certified network of R&D suppliers for different technical topics.

stage for bigger projects or for short term product development. Regarding Galicia and concerning FP6 and FP7 there is no record of a textile and clothing company participating in a Project. Vigo University and Santiago de Compostela University are engaged in several projects but always in other areas of expertise or application than textiles & clothing.

In the years 2006-2011 there has been a significant increase regarding entrepreneurship promotion towards the creation of new companies[47], either as a result of R&D developed at universities, either as individual initiatives coming from former managers and technicians of textiles companies that lost their jobs recently. In most cases, such initiatives are addressing high tech innovative products and they are based in incubators or technology parks available in the region, where facilities and supporting services are provided at very reasonable prices.

Some of those new entrepreneurial initiatives, which are being installed within the region are taking advantage from the strong installed textile & clothing production capacity in the region. Three examples of those of initiatives are: NEW TEXTILES[48], a company producing innovative textiles for preventing atopic dermatitis; NG WEAR[49], a company producing shirts with mosquito repellence function and FOLLOW[50], a company providing digital printing services.

Regarding clustering towards innovation a brand new initiative that was created recently is the Portuguese Textile Innovation Club (PTIC). PTIC brings together a unique group of companies, as so as scientific and technological organizations, based and/or operating in Portugal, fully engaged on the strategic value of Research, Development and Innovation as distinctive values of their products and business models. PTIC members are engaged on the complementarity of its industrial, technical and scientific skills and valences, therefore promoting textile innovation in the global market. PTIC aims to improve the perception of knowledge and innovation as a common value of its members, made competitive through research, design and manufacturing in Portugal to all other business partners, customers and consumers, globally. PTIC is an invitation only club of companies and organizations, identified and qualified as innovative, according to the mentioned standing values and practices. Companies based and/or located in Portugal may therefore be invited to sign the Innovation Manifest of PTIC, following a proposal by its pairs or by CITEVE, which acts as the facilitator player for the initiative. Innovation specialists from each participant company are enlisted to become members of working groups for relevant scientific and technical topics. An online collaboration platform is being developed to support information gathering and sharing. Presently, the main topic under development is the Roadmap for Innovation of Portuguese Textiles and Clothing 2020 and accompanying measures. This “Innovation Club” was set up with the support of a national project within the field of technology intelligence, IMATEC, and it’s supported by national funds.

[47] Only in the Portuspark incubation network (Regional Association of Incubators) there are 13 incubators within the North region. (http://www.portuspark.org)

[48] www.newtextiles.pt

[49] www.ngwear.pt

[50] www.follow.pt

At this moment 23 industrial companies from different field of activity have formally joint this initiative and six of them are clothing manufacturing companies. In order for a company to formally be part of PTIC, the following criteria are taking into account: the yearly investment on research and innovation; a relevant participation in R&D projects involving national and international scientific organizations; the existence of a formal R&D and innovation team, the individual curricula of its members and whether their R&D and innovation activities are accounted as such within the company records and reporting to the national scientific and innovation survey; a certification of the R&D and innovation activities according to national standards aligned with the works of CEN/TC 389 "Innovation Management".

3.3.3. THE INFLUENCE OF INDITEX IN LOCAL BUSINESS PERFORMANCE

The INDITEX group subcontracts a significant part of its production within the North Portugal and Galicia region, closely to its product development and logistic management centre in Arteixo, A Coruña. The Euroregion North Portugal -Galicia is part of a production circuit that INDITEX identifies as the short circuit, which includes the following countries/Regions: Portugal, Galicia, Tunisia, Morocco and Turkey. This short circuit is also responsible for the so-called "flash orders", mostly responsible for product reposition in INDITEX's retail stores within Europe. Proximity is a critical factor due to its major influence when it comes to delivery time reliability within product development and production cycles which have been shortened dramatically for the last 10 years and which are now between 2-3 weeks.

This pressure for a very short delivery time results from a key factor of the INDITEX business model: having the capacity to adapt the product offer to consumer's wishes at the retail shelf, in the shortest possible time. The success of INDITEX's collections resides in the capacity of assimilating the constant changes in fashion trends, designing new models in every moment, which will address the final consumer wishes. According to *Revista Gallega de Economia* (2010), only 40% of INDITEX products are manufactured in INDITEX own structures, while the rest is placed to subcontractors. These subcontractors have to fit into this complex value chain, in order to allow INDITEX system to work effectively. The following four company cases, are from SME's located in North Portugal, where this average company size is more represented and where the influence of INDITEX is strongly felt.

A2 is a clothing manufacturing company employing in total 120 people active since 1999 which produces mostly under the private label model, mostly to small brands within the premium business segment, but providing also design and creativity to its customers. The company works for INDITEX during the last three years. A2 has a global turnover of EUR 13 Million and 40% of its business is with INDITEX. According to Mr. Asdrúbal Azevedo, A2's CEO, INDITEX is sourcing more than products – It sources new ideas. When trying to understand which kind of evolution in the company was somehow induced or motivated by the fact of working with INDITEX, the main aspect are clearly flexibility, fast response and a significant improvement in logistic/ production control. Design and creativity are considered to be essential today to provide the client with a complete and integrated offer and INDITEX is not an exemption in this matter, but the evolution in such competence can't be linked directly to the INDITEX relationship.

There is no learning process regarding technical aspects, but the INDITEX production cycle demand very often a 2 weeks lead-time, which comparing to the traditional four to six weeks in clothing manufacturing, puts a lot of pressure in production management and logistics. A higher domain in production control and in product and materials handling is also something in which the company has evolve due to the relation with INDITEX. Within the different production spots belonging to the short circuit, the kind of products and fabric which are allocated to Portugal and to Galicia they are normally not the more complex, with higher production minutes, but the more

delicate, with more expensive fabrics/materials and accessories or with more sophisticated applications or printing effects.

Until a certain point it seems to be a sort of a risk management approach by INDITEX. The group relays more on the know-how and experience available within this region to deal with orders using more expensive and sophisticated materials, reducing the risk of possible defects, bad product handling or bad productions setups. This concern of INDITEX about the risk associated to production and product handling in the case of the more sophisticated orders which are frequently given to companies within the North Portugal and Galicia region, supports the idea that besides having capacity to deal with very short lead-times at high quality operational standards, companies engaged in this circuit, must take the necessary precautions to minimize or eliminate any product or material damage.

This conscience has lead most of the companies working in this business to improve the efficiency and the accuracy of their quality control and process control procedures. It is also true that some have mention that this growing trend of more sophisticated materials is somehow recent and is resulting from a new product strategy, particularly for ZARA Woman which has raise up the mark up and the quality standards significantly.

A similar vision is shared by Tetribérica with particular emphasis in aspects like fashion trends interpretation and its relevance in the relationship with INDITEX in what concerns the design offer before winning an order. Tetribérica is a trading company with a global turnover of 10 Million Euros which has been working with INDITEX for the last 18 years and in some years that business represented shares of 40% of the total income.

According to this company the relation with INDITEX brought higher relevance to aspects like trend watching and interpretation, in order to propose at first time the right design/texture/colour that will conquer INDITEX interest. The way this process happens is a sort of “no second chance” phenomenon which means that either you match the client expectations and emotions in the first proposal, or most probably there will be no follow up.

This feeling that there is “no second chance” gives to trend watching and interpretation a major importance when it comes to present a product proposal to INDITEX and according to Tetribérica this capacity has being developed and consolidated in the company as a result of the work with the group. Besides of course know-how, another aspect which is mentioned as a typical characteristic from companies is “rhythm”. Transforming the product development and production cycle into 2/3 weeks, like in the case of INDITEX, demands a precise and accelerated rhythm and every supplier company which has been working within INDITEX programs, has developed such capacity towards the accomplishment of such tight lead times.

This has forced several companies, like Tetribérica, to invest in advanced systems for orders and production management in order to have a precise control about every detail concerning each order. Another interesting issue mentioned in this case, is the fact that the relationship with INDITEX works as an attraction element to work with other international brands, since it is understood that those working for INDITEX are in the “state of the art” in what fast fashion trends concerns. This company also shares the idea about more delicate and expensive materials being introduced within the North Portugal and Galicia circuit as a result of a riskless strategy based in the higher know how and experience available within the local companies.

POCARGIL is another INDITEX supplier, which accounts in total with 300 workers and it’s active in clothing manufacturing, including dyeing and finishing of textiles. In this case, 50% of its business relies on the INDITEX group. According to this company the key factors for INDITEX are time (short lead times) and proximity, towards easy and more reliable logistic management. The shortening of lead-times in clothing manufacturing, to cycles

between three to four weeks and the higher importance of accomplishing precisely the accorded delivery time, has put a lot of emphasis in production management and quality control, not only in accuracy but also in criterion.

As a direct effect of the INDITEX relationship POCARGIL understands that must evolve in flexibility and in creativity/innovation, more than in production capacity or know how. Within the last investment project of the company, made in 2011, the biggest share (70%) was oriented to immaterial investments, towards design, creativity and human resources capabilities.

POCARGIL case supports the importance of product control and lead-time management specifically regarding the INDITEX business, while in the case of design and trends information, seems that those are relevant assets which any company working successfully under a private label model during the last 10 years would certainly have developed.

According to ATP (The Portuguese Textile & Clothing Associations) there are around 200 companies working for the INDITEX group in North Portugal, either in textile production, or in the clothing manufacturing sector.

Looking at the common factors from this four cases within the Portuguese side of the Region, it would be fair to state that in general, those companies working for INDITEX have developed their skills and have improved their capacity in three major fields: 1) Product development (independently from the degree of trend interpretation and from the audacity of the style and design proposals incorporated in the product); 2) lead-time management – having the reliability and self-assurance security to assume compromises for very short lead-times, without having the risk of systematic failure; 3) Product control – Having implemented routines and systems for product and production monitoring, inspection and testing in order to have reliable information about product quality and delivery time accomplishment. According to most of the statements, is possible to say that while factor 1 is not the reality for every single company working with INDITEX, most probably factors 2 and 3are present in almost every company.

When trying to frame the above skills and competences within the innovations categories, it is clear that the INDITEX effect is much more felt in the organizational innovation field than in the product innovation category, despite the fact that incremental product innovation cases are normally present within any of the mentioned cases with more or less relevance.

3.3.4. CASE OF PORTUGUESE SME'S ENTERING TECHNICAL PRODUCTS

New Textiles

New Textiles is a recently founded Portuguese micro company employing six people and with a turnover of EUR 400.000 in 2011, with an estimated growth up to 700.000 Euros in 2013. The company produces clothing articles under the brand Skintoskin© (medical devices) for the prevention and treatment of several skin diseases, particularly atopic dermatitis. The idea was born in 2008 and it was developed by a Textile expert which has decided to start its own business after being challenged by a skin disease case within its family. The project was supported by a market detailed study, regarding the technical and functional textiles for the health care sector, which attracted a private investor. New Textiles present CEO, Mr. Claudio Carvalheira, was engaged in the

development of the company's business plan at the time and now is responsible for managing the company, which is based in Guimarães, North Portugal.

According to him the highest barrier for business development in this case was product regulation and legislation. In order to achieve a class III medical device certification New Textiles has to go through a complex path of different organizations and approvals. The barrier effect for innovation resulting from product legislation and regulations, particularly in the health care sector has been mentioned before. According to Mr. Carvalheira there are too many unclear areas within the regulatory directives, which in many cases leave room for several interpretations, which can block completely the product release stage. These directives are produced mainly by the pharmaceutical industry which seems not be very open to the development of textile materials with innovative medical properties.

The success of new business projects based in innovative textiles for this high added value applications can somehow be compromised or at least slow down, due to excessively complex legislation and regulation for this kind of products. Another challenge in the early stages of the company was the development of the product communication strategy.

Communicating a technical textile to be sold in a pharmacy demands a completely different approach and specific knowledge. Therefore the partnership with medical science organizations and professionals was not only relevant within the product development stage but equally important when it comes to work in the product packaging, communication and marketing strategy. This is considered to one of the key success factor for the project, either for the traditional distribution channels, either for the on-line retailing (http://www.skintoskin.eu/).

In most cases there is a strong focus in product development, when most of the risk can reside in choosing the strategic retail and distribution strategy and developing the appropriate product communication language and package. In such kind of products, when the value perceived by the consumer has to go far beyond aesthetic or fitting properties (like in fashion articles) is critical the consumer understands what is the product for. Here once more, according to New Textiles experience, the link with the application sector is considered to be critical for success. One of the strategies used by the company to improve this perception by the final consumer is to provide specific training to the pharmaceutical staff, in order to clarify different aspects for the final user. Also consumer or end user information is considered to be a critical factor for both, product development and product optimization already in market stage. This information is considered to be very valuable. When asking about how important or influential was for the project to be located in a textile region, the answer is that it was relevant and crucial. Profiting from an existing productive value chain and all the local available knowledge in different kinds of organizations (Universities, R&D Centres, etc.) .It was very important to have easy access to experienced production facilities, testing and service providers and other kind of partners.

The New Textiles case shows that regarding new business development or new companies based in technical products for special applications, the relevance of engaging the application sector from the very beginning is critical, from development stage until market stage. In this case the partnership with a dermatologist was extremely important from the very beginning until the release in the market. The deep knowledge about textile production and about the textile value chain, brought to the project by the founder, should be highlighted and considered also as a critical factor.

There was no reference at all to the administrative process of creating a new company or to some difficulty in establishing the business and having access to the market, despite the regulatory aspects, which in the case of medical devices are a recognized barrier to entrance of new comers in the business. Comparing to other cases, suppliers were not considered a relevant source of information or knowledge, which can probably be explained by

the fact of mostly of the productive process being subcontracted. Product communication and marketing have been once more highlighted as critical factor for success, confirming that in the case of public funded programs this aspect could be somehow be addressed and perhaps considered as eligible.

Fernando Valente

Fernando Valente is an SME, warp and weft knitted manufacturer with 40 employees and a global turnover of 5.5 Million Euros. The company is active since 1977 and actually is exporting 70% of its production, mostly to the Spanish market. Fernando Valente's technical products represent today 25% of the global turnover, mainly for the automotive sector but also for the health care market (contention products) and more recently for the building and construction market. All technical products are warp knitting fabrics or raschel knitted fabrics.

According to the company's CEO the positive evolution of the technical products is mainly resulting from a deep product and production know-how, only resulting from the fact of being an industrial company. Only companies with an internal solid industrial structure can explore such level of know-how when it comes to develop new products and solutions for technical applications. Fernando Valente success arises from a strong cross linked knowledge of both the products and the production technologies. According to Fernando Valente those companies which have abandon or lost the industrial part of the textile value chain, will face higher difficulties to evolve and develop in innovative technical product's segments, since still is industry that generate and develops most of the relevant knowledge. Only industry has the capacity to train its own staff intramural and that capacity will make all the difference in the near future.

Very often, new opportunities are identified when listen to the clients and understanding how their needs can be fulfilled with the resources available within the company. In this sense, clients are considered the most important source of information for innovative products, since they represent the knowledge from the application sector. Regarding the importance of suppliers, fibres, yarns and technology, they were much more important in the past than today. They would still be valuable but they are not available anymore. Today, most probably as a result of a cost reduction strategy, most of the suppliers do not have a solid technical staff available in Europe anymore. It's not clear if they have move to other strategic markets, but the fact is that this kind of support is becoming less available.

Since most of the business regarding the textile machinery market has moved to Asia, there is also a very high possibility that most of the technical staff is now following up the business in that region. For instance, most of the fibre and special materials suppliers' activity within the present value chain are considered to be essentially marketing activities, instead of technical support or cooperation as an after-sale service. This is an important phenomenon which should be somehow followed up, due to its importance for the competitiveness of the European Industry.

All the product development stage happens within the company and the clients play a critical role in this process. Links to Universities and R&D centres are more relevant to crosscheck information or obtain information about specific product testing standards than to actively participate in development. Technical magazines and publications, from the application sectors are considered to be a relevant source of information, also in terms of product communication strategies, which is very often the key differentiation factor in the market. One more the subject of product communication and marketing assumes particular relevance when it comes to technical products for specific applications.

Regarding product legislation or regulations as a barrier to market entrance or to market development, Fernando Valente thinks that this is more a particular case of the health-care and medical sector. Regarding the automotive sector Fernando Valente is not an OEM (Original Equipment Manufacturer) therefore does not feels such kind of shield.

But regarding the medical market, Fernando Valente faced some difficulties to enter with its own products and recognized that it's a market dominated by very powerful companies which see textiles as a cheap and not very technological product; however with a very resistant and resilient industrial rank, it could somehow achieve an interesting position in this business in the future. Still there is a lack of knowledge in the medical sector about the real potential of transforming textiles into the premium interface between patient and wound. Is more like the textile sector talking to itself about the potential of textiles in the medical sector than really presenting this potential to the end users and buyers. Fernando Valente has put a lot of effort into this kind of communication, believing that in this particular market, a complementary effort in product and marketing communication have to be done.

Last but not least the importance of having at hand a completely integrated industrial value chain (from yarn to final product) within the region and in such a concentrated way (50 Km radius from Porto) makes it possible to relay in different partners, like for instance special and innovative finishing suppliers, simplifying significantly all the logistic. Fernando Valente believes that in such a period where Europe is becoming industry minded again, this existing value chain can have a very important role for companies shifting from the fashion business into more technical products.

GULBENA

Gulbena is a special knitted fabrics producer, 100% working for the corporate business and for sport applications. Founded in 2005 Gulbena has a global turnover of 2.3 Million Euros. Gulbena was founded from the need of a dyeing and finishing company named TTT, now belonging to same group, in moving from a dyeing/finishing service provider position to a product/solution provider position. Gulbena was built upon a good knowledge base resulting from providing dyeing and finishing service to a wide variety of clients, with many different kinds of fabrics, but mostly in the field of knitted fabrics. The startup process was developed around an innovative product branded under the concept Corporalis, which was presented to market seven years ago and that included a set of different microencapsulated special functional agents. This concept has evolved and today Gulbena offers several different special functional and technical knitted fabrics each one under a specific branding concept.

All the knitted fabrics and sometimes the final product itself is developed internally, profiting from exclusive knowledge licensed by strategic partners and from a solid network of productive subcontractors like TTT for the case of dyeing and finishing and local suppliers for some knitted articles. The basis of Gulbena strategy was to develop a very strong partnership with key fibre and chemical products suppliers, allowing them to use Gulbena's knitted product portfolio, to demonstrate the potential of their solutions. This was the entrance passport to several clients which were attracted by the final aspects and performance of the fabrics.

Today, Gulbena manages a portfolio of seven brands, each of them addressing special performances for specific field of applications. According to the CEO of the company, Mr. Rui Teixeira, this branding strategy tries to reinforce the communication to the final client, which is considered to be very important in this kind of products. He stresses that behind each solution accepted by the client there is a significant amount of developments until a real business is done. The interaction with client starts from a standard basis proposal that is developed according to the client

specifications for each kind of application. Therefore, fibre, materials and chemical suppliers as well as the information and knowledge brought by the client, are considered critical inputs for the success of the final result.

When asking about the relevance of technology providers inputs for this process, Gulbena's CEO believes that their importance is not that relevant. He agrees about a certain reduction in the technical support which is provided by machinery and technology constructors today in Europe, referring that 10 years ago 3 different experts (mechanical, electronic and technologist) were engaged in the technology set up of a new machine, while today one technician with a wider knowledge base ensures all the processes. According to Mr. Teixeira this reduction is probably resulting more from a cost reduction need than for a shift movement to other strategic markets. However, that has pushed Gulbena into a process of preserving more of its internal knowledge.

The relation with institutes and universities is punctual, depending in the arising of specific problems or service needs, but there is no systematic approach to this kind of organizations, which are still considered important parts of a competitive regional value chain, also due to their role of information filters and disseminators. In fact, the existence of a structured value chain, than somehow provide a sort of variable geometry to the available production capacity, is considered to be an important competitive asset, regardless the type of product or market.

Relevant Common Factors and Findings

Looking into the major common factors that one can identify in these cases, it seems clear that the regional dimension played a role in the success stories and that the industrial base know how was very important to achieve an effective product development process and to build a successful integration with the final client, towards the development of products that meets their needs and expectations.

Regulatory and legislation constrains have been identified as a difficult barrier to overcome, both for new product development and for market entrance, only in case of medical textiles or products for health care applications.

Lack of funding or difficult in access funding for projects support has never being pointed out as barrier for innovation performance. It's also true that nowadays companies, mainly the SMEs, are struggling to have access to credit not only innovation, but for financing working capital.

The importance of product communication and marketing has been underlined in every case as critical aspect and it seems clearly more important for those companies working in more technical products than for those working in the fashion business.

The role of technology suppliers are considered relatively important but at the same time less available in Europe or at least less prepared to play that role. It should be however pointed out that the importance of a differentiated technological appropriation process, towards process differentiation, built upon the same standard machinery platform, will depend a lot in the technology itself. For instance is certainly less relevant in dyeing and finishing technologies, than it is in knitting or weaving technologies. Raw materials and chemical products suppliers have been playing an important role in every case, therefore this link within the value chain should be considered strategic together with the final client interaction. This is exactly in line with the statistic findings regarding Innovation cooperation partners in innovators on the T&C sector;

The capacity of understanding how the textile product can solve a new problem and create a new market, within a new application sector, by replacing or not an existent different material, is a key competence asset for those companies shifting from fashion products to technical products.

3.3.5. SUCCESS STORIES, KEY INFLUENCING FACTORS AND TRENDS

The following individual interviews allow to highlight some interesting cases and to confirm some of the findings and perspectives gathered during bibliographic research, round tables and workshops. In the case of NP&G 4 different cases were selected: A big producer and retailer of denim trousers that is internationally established and that has built its development strategy upon product innovation (SALSAJEANS). A clothing manufacturing SME that has successfully shifted from traditional to technical articles and from CMT[51] to its own brand production (P&R). A big knitted underwear production company that is producing under its own brand and that has recently released a new to market and new to firm innovative product (IMPETUS). A Spanish clothing manufacturing SME, operating in Galicia, and representative of the medium size companies of the region, producing its own brand mostly for the internal market to multi brand stores (PAZ RODRIGUES).

SALSAJEANS is a Portuguese company producing Jeanswear, specialized in jeans trousers, under its own brand (Salsa) and distributed globally through its own retail shops. The company has a global turnover of EUR 100 million , with a total workforce of 1.000 people that ensures all important steps of the value chain including design, a small part of clothing manufacturing, denim washing and finishing, distribution and retail. With 250 shops distributed by 36 countries plus several corners in important department stores all over the world, from Brazil to Abu Dhabi, the company operates globally.

SALSA products are for medium high segment, competing in the same price and product range of Pepe Jeans©, Levi's Straus© or Diesel©, and the product values are fitting, innovation and washing finishing. One of the biggest success stories of SALSAJEANS was the innovative Wonder trousers, branded under the concept "push up" that was even followed by its competitors in concept. The "wonder" concept, which follows the same ideas behind the present wide offer of shaping and tight underwear, provides a particular fitting, allowing to push up the women's curves in such a way that improves significantly the body shape in that specific part. This effect is entirely achieved through a special clothing pattern combined with a special denim finishing. In this business and product, SALSA can be considered as innovation leader, through an innovation process that is clearly incremental and non technological. The wonder product development project, took one year from idea to the shop shell.

According to the company, the interesting aspect of this innovation process is that is not only a product innovation process but an integrated product – process – marketing innovation concept. All dimensions were addressed in the project in a very integrated way, and that is one of the key success factors. When we asked about the idea generation process and the sources for such process the answer was very clear: The process is all ensured by internal staff with a very close involvement of the top managing structure and is fed by market research data, global trends and specific information collected on the shops, during a direct interaction with the final client. The

[51] CMT – Cut, make and trim production

process is mostly informal, with no special methodology, but benchmarking was identified as used tool during the process.

According to Salsajeans this kind of approach to innovation, in this specific business is only possible when you control the retail point and you can use that information to influence the creative and development process, matching your final client expectations.

For companies that have not yet evolved from the CMT business model or even for those which supply design plus manufacturing for other brands, is much more difficult to profit from client and consumer information towards innovation. Regarding the development process itself it was also completely ensured by the company creative and development staff with a few interactions with the production area, but within the company. Along the value chain, raw material (denim) suppliers were considered to be the only external source relevant for the process. No special interaction or cooperation with other elements was considered as relevant. The "wonder" development and marketing process also led to a collateral innovative result, which was a specific product exhibition display, which allows demonstrating the effect of different denim finishing types and the product fit in a leg. Theses displays are an independent business today and are sold to department stores or to multi brand retail shops in an autonomous way.

Regarding IPR the company has only realized its importance when competitors started copy , following the same concept. Today, most of the developments, designs and concepts are protected either through registered designs and models, either through patent. For this specific process the dependence of an external consultant office is clear. In early stages this was a barrier due to the very specific terminology, concepts; when asked about supporting programs or schemes to fund this kind of activities and about its match to the company needs in this area, the company refers the difficulty of framing this kind of non-technological innovation in existing programs: - "It seems that only medical textiles or more scientific oriented products can be innovative".

In this kind of development the timing is very important and should be something in between six months and one year. The typical two to three years R&D project and the kind of activities that are normally demanded for such projects, clearly do not match with the kind of innovation processes developed by the fashion industry.

On the other hand, the importance of product communication, packaging and branding is so important for such kind of innovation that its development, should somehow be considered as a key element within a product innovation funded project. Regarding product communication it must said that SALSA's strategy was to communicate a jeans trouser like a technical product, explaining every detail in such a way that brings a technical dimension to a fashion article. This concept was also considered to be a key element for success and was even followed by several competitors in this business and it's not very different from the approach followed by some other retailers, when trying to explore some basic technical aspects introduced by specific materials performance for instance as Gore-Tex©.

Today the Salsa wonder's development process has been adopted by the company as a standard methodology for innovative product development, and presently SALSA releases in parallel with each new collection a set of innovative trousers that are the pillars of the company's brand image.

P&R is a Portuguese clothing producer founded in 1982 which by that time was producing traditional sportswear mostly made of jersey and interlock knitting fabrics under CMT regime for international brands like La Perla. In the 90s the company realized that the future was not in CMT and started a development strategy focused in technical sports garment as well as shaping underwear and tights and thereby moving into an hybrid model producing under

its own brand and to other important sport brands. The company invested in concept and product development working with innovative technical materials like neoprene or laminated materials. In 2000 P&R consolidates its strategy with its own brand ONDA, specifically oriented to niche outdoor sports like surf, body board, kite surf, triathlon and mountain bike.

P&R realized that for those uses, innovative combination of materials and well adapted welding and joining techniques for such material were key to position the company's product as an innovative. The ONDA product portfolio allowed P&R to focus on niche markets which are not in competition with its most important clients in the private label business model. Within the second stage of development, the company started to develop and produce high-end garments for top athletes, both national and international. Within this strategy the company introduced a second relevant innovation for optimizing fitting and performance, both for top athletes and for the regular models produced under brand Onda: Body scanning technology.

Today the company uses body scanning technology to develop "made to measure" competition garments for important private label clients, as well as for its own brand products. This innovative product development/service approach, brought to P&R important "clients" like Olympic gold medal Nelson Évora (triple jump), Olympic silver medal Vanessa Fernandes (triathlon) or Olympic gold medal Ussain Bolt (100 meters run), whom competition suits were developed by P&R namely for their sponsoring brands Adidas (Nélson Évora), ONDA (Vanessa Fernandes) and Puma (Ussain Bolt). The possibility of body scanning the athletes to improve the particular fitting of the garments and to inspire the fitting of the commercial versions of the same products was proposed by P&R as an innovative service component, initially to the contracting brands. After that first experience, P&R adopted that process to its own brand.

According to the company, the combination of product innovation mostly through constant innovative combinations of materials is one of the key innovation development lines and for that, fabric suppliers and technology providers are considered to be important partners. Technology providers are very important to achieve optimal and perfect materials jointing techniques. On the other hand, the company keeps a constant link to research institutes, as an important inspiration source to develop new projects that can led the company to enter new markets or to generated new knowledge.

Two examples of those innovation projects developed under national funding programs were the Pellisaquae suit (a special suit for hidrocinesiotherapy) and the YEXS jacket (an innovative alpinism jacket with integrated GPS system, body and surrounding temperature monitoring and communication system to camp base).

The company mentioned that both projects were very important, in the sense that relevant knowledge and development experience was fixed in P&R, but they still sceptical about the very last part of the projects, devoted to bringing the products to the market. "In both cases we ended with interesting product prototypes, better in the case of YEXS, but relevant activities in order to optimize the product and to really launch into the market were no supported by the project. " As an SME we do not have time or resources to invest in this stage which is very demanding in terms of market knowledge and marketing, and normally the innovation projects do not include this kind of activities". According to P&R, made to measure customized production can be further explored within the technical clothing development and production concept, namely towards extreme fitting conditions which are essential for competition purposes.

P&R believes that regarding its products, final consumer information and material knowledge are the more important sources for innovation and that better results can be achieved with the correct links to other companies and research institutes, promoting the convergence of complementary fields of expertise within projects. Today,

ONDA© products are sold in specific corners in multi brand retail department stores like El Corte Ingles (Portugal and Spain) or Bike Zone (Portugal) and the company turnover is 6.3 Million Euro with 120 employees.

IMPETUS is a Portuguese knitted underwear producer selling under its own brand and through licensed brands, to more than 30 different countries, either through department stores or multi brand retail shops. The company, that already has an on-line shop, has a global turnover of 40 Million Euros and 900 employees. It features within the group a dyeing and finishing company. IMPETUS' product values are: Quality, design and fitting, and the product portfolio follows the concept of Unconventional Underwear, which the company likes to use as a sort of product label. Creativity and innovation are present values within the organization which assumes a position of innovation leader more than a follower, focusing its development strategy on the fashion business and promoting constant incremental product innovation, always followed by a strong marketing innovation attitude.

The company has recently released a new innovative product (new to firm and new to market) which has resulted in a patent application, besides a trademark register and that will allow IMPETUS to enter a completely new market (medical devices market) that will be exploited through a completely different retail channel (pharmacies). PROTECH DRY©, which also being marketed on-line through a specific e-commerce website, is a textile absorbent, made of a patented multifunctional fabric with a large absorption capacity. Its use is similar to a piece of underwear and it is especially recommended for occurrences of light urinary incontinence. Through an interview with the innovation manager of the company, the major drivers, practices, and barriers regarding innovation were addressed in order to identify possible best practices and trends confirmation that would support the global findings of the study. To overcome the complexity of filling a patent application, IMPETUS used the supporting services of a local University technology transfer office (TECMINHO), which usually supports researchers in the patenting process and manages to establish a good link between the company's needs in this specific field and the IPR regulatory framework procedures. The fact that a researcher from that same University was collaborating in the development worked as a facilitating force in that process.

The process of idea generation towards innovative product development doesn't follow very formal methodologies or tools but they absorb inputs from the creative dynamics of group meetings, put in practice by the marketing department. Top managing structure plays an important role as a catalyser for new ideas generation. Trend monitoring and product exhibitions are considered relevant sources as well as constant contact with Universities, R&D and testing institutes. The final customer vision and expectations are critical and they are monitored and followed closely in each market, through the company agent or distributor. The fact of not controlling the shop ground floor as a gate to final consumer information is not considered to be a barrier to incorporate the consumers' wishes in the company innovation pipeline.

When looking into partners and cooperation during the development stage, yarn suppliers are considered strategic and cooperation within companies of same the Group is the more frequent situation. In the specific case of PROTECH DRY©, University played an important role as well as an interface institute specialized in technology transfer and IPR managing. Technology and machinery suppliers were involved somewhere within the process in order to provide support at process modification level but they are not considered as relevant as the yarn suppliers. Private consultants were not mentioned as being engaged or relevant during the process, as well as any governmental agency or association, with exemption of the national authority for medicine and medical devices regulation and certification.

When discussing the success factors when it comes to work an R&D and innovation project, from the basic idea to the market, both the innovation and the brand managers consider that when the company itself is responsible for

the idea and is the major driver of all the process, the success rates are higher. In that sense, each idea and each innovative product development project should have a business plan from the very beginning, in order to compromise the budget for every developing stage.

This compromise will ensure that even the last phases of the innovation process, which could be very demanding in terms of financial resources, like marketing, promotion and advertising, are not compromising the overall result. In the case of an SME this is much more difficult to achieve and in several cases the projects results do not reach the market effectively, either because the driving force is not the company itself (but an institute or an university), either due to a lack of financial resources to heavily invest in the new product marketing, particularly in more risky situations associated to completely new market approach. The excessive bureaucracy associated to the product certification by national authority for medicine and medical devices was considered the sole "barrier" the companies have to manage during the process.

According to the company, marketing innovation related activities and promotion at international exhibitions, namely when linked with an internationalization strategy, should be integrated within the R&D project funding pipeline. These activities are as critical for an innovative product success as the research and development itself.

PAZ RODRIGUEZ is a Spanish SME located in Vigo, producing children wear under its own brand, with a global turnover of 4,5 MILION EUR and employing approximately 60 people. 80% of its production is for the Spanish market, namely for major retailers or to small multi brand shops while the remaining 20% are exported to international markets like Portugal, France and Italy. The company supplies both knitted and fabric based garments, but only knitting fabrics are produced within the Vigo facility. Regarding clothing manufacturing, 50% is produced within the company and 50% is subcontracted locally, either in North Portugal, either in Vigo to small manufacturers. All the design process is done within the company and all the designers are coming from local fashion schools. The interviewed Managing Director of the company is running the business which is within the Paz family since 1941 and is presently in the second generation. When we asked about key aspects regarding innovation he highlights that besides creativity in design most of companies' attention has been going to process managing and control, towards an improvement in productivity and competitiveness.

Regarding cooperation for innovation, yarn suppliers are considered important from the product point of view. Despite referring to some cooperation with Vigo University, the company has no large experience in cooperating with R&D centres or institutes and does not think that for the kind of innovation that the company performs, which is not very sophisticated or high tech, that specific link is somehow very much relevant. Innovative finishing is considered as an interesting area regarding innovative product (incremental) differentiation.

Also here, cooperation with service providers has been the more explored way and the company has been recently cooperating with a Portuguese dyeing & finishing company, towards the adoption of new finishing process on its products.

Innovative technologies for marketing and for communicating the product to final clients within the retail shop floor, are considered to be topics to follow closely towards innovative marketing strategies.

The company has already been looking into RFID as an interesting technology that could improve process management control but has not decided to invest yet. Regarding the innovation environment the company highlights the role of the Local Association in aspects like promoting internationalization or actively motivating the companies to innovate and to explore new markets. Regarding the company strategy in the short term, it goes towards establishing its own retail shops, starting with the Spanish market.

3.3.6. CONCLUSIONS

Marketing innovation is perceived by most of the companies as a key competitive factor. Particularly in the case of companies acting in the fashion business with more or less control of the distribution channel and/or the retail management, marketing innovation is very often considered as strategic for the commercial performance as the release of new innovative products itself. The companies in the Galicia region, which considered all the innovative technologies in the field of client empowerment, product and brand communication within the retail shop floor to be of major importance for their future development.

Innovation in North Portugal and Galicia is following different patterns, mainly due to the stronger presence of textile companies in North Portugal, which makes the sector more diversified in that part of the region than in Galicia. The relation between textile producers and clothing manufacturing within North Portugal companies acts as en excellent hub for product and process innovation, which often contributes to the development of different business such as the corporate wear and PPE's or the emerging of new small companies acting in more technical products.

In North Portugal technical textiles and other product oriented innovations, towards specialized applications for new markets are more important, as well as process innovation leading to product differentiation (new finishing's, new fibre blends and new functionalities). The existence of different companies specialized in printing, dyeing and finishing is a key supporting element for the development of such kind of product development strategies.

In Galicia, the stronger presence of clothing manufacturing companies working in the fashion business mostly to the Spanish market (with the exception of INDITEX that represents 90% of the region exports), under a model which is strongly influenced by the INDITEX phenomenon, drives innovation through a path which is more focused on process innovation namely on logistics, retail management or marketing innovation. This kind of innovation path is also present in the companies of North Portugal which are working closely with INDITEX.

When trying to frame the above skills and competences within the innovations categories, it is clear that the INDITEX effect is much more felt in the organizational innovation field than in the product innovation category, despite the fact of incremental product innovation cases being normally present within any of the mentioned cases with more or less relevance. The importance of fashion, colour and texture trends interpretation have been considered by several players a key competence developed by those working closely with INDITEX.

Non technological innovation practices, namely through design and creativity, are strongly adopted by all textile and clothing manufacturing companies within the region of North Portugal and Galicia, disregarding their business models, which in this region and in the case of clothing manufacturing, is mostly assuming an hybrid model that combines private label with own brands production.

3.4. SLOVENIA

3.4.1. THE REGION AND TEXTILE & CLOTHING SECTOR OVERVIEW

Manufacturing contributes 19.6% to total added value in Slovenia against 14.9 % for the EU on average (2009). At the detailed manufacturing industry level, Slovenia features specialization in labour-intensive industries (sawmilling and planning of wood, made-up textile articles) and mainstream manufacturing (domestic appliances, other non-metallic mineral products). At the more aggregated sector level, Slovenia is specialized in highly innovation-intensive sectors (machinery, electrical machinery, R&D) in added value only, but also in the low to medium range of education and innovation intensive sectors (e.g. wood and cork)[52]

According to the 2010 Innovation Union Scoreboard, Slovenia is part of the second most advanced group of innovative countries in the EU, the innovation followers and has a high rate of improvement. Its R&D as a share of GDP reached 1.9 % in 2009, however the EU's objective is 3% GDP. Slovenia's R&D intensity is below average given its industrial structure[53], as is its position on the quality scale. However, in comparison with its group of lower income countries with export specialization in knowledge intensive industries, Slovenia manages a higher R&D intensity and better quality performance in labour-intensive industries

Table 2: : Slovenia Textile & Clothing Sector Data

Slovenia	Turnover		Investment		Companies		Employment	
	2009	2010	2009	2010	2009	2010	2009	2010
Textile	350,2	352,4	18,4	18,52	163	158	5.118	3.746
Clothing	139,8	133,10	5,58	5,31	239	239	4.069	3.861
T&C	**490,0**	**485,5**	**23,9**	**23,8**	**402**	**397**	**9.187**	**7.607**

Figures of turnover and investment (EUR Million); Companies and Employment in number

Source: EURATEX

Geographically, the Slovenian textile & clothing sector is mostly concentrated in Maribor, Kranj, Trzic and Ljubljana. For textile, clothing and also for leather processing sector the year 2009 was the worst year after the independence of Slovenia. After the slump in 2009, 2011 was the time for recover. The situation in textile, clothing and leather

[52] Member States competitiveness performance and policies 2011

[53] SEC (2011) 1187

processing industry started to improve. Production increased gradually because of higher demands from the foreign markets.

At the end of 2010 the number of employees in Slovene textile, clothing and leather processing sector was 13.050 people that represents 7% of all employees in processing industry of Slovenia. The number of employees in textile, clothing and leather processing industry was cut down by 10.4% (previous year -28.1%) and further job reductions are to be expected. Mostly because of bankruptcy of one big and important company in the Slovene textile sector; in 2011 23.4% of jobs were axed in these sector and 7.3% in clothing sector[54].

After great reduction of demand for Slovene textile and clothing products on the foreign market in 2009, Slovene export has grown in 2010 in textile and leather processing sector. The value of export of textile products increased by 16% last year and the value of export of leather products increased by 12%, while the value of export of clothing decreased by 3.1% and amounted together for EUR 727,7 Million.

According to the opinion of several organizations and companies, the textile industry is perceived as being more important than clothing manufacturing, either in the present, or for the future of the Slovenian industry. The total exports of textile & clothing in 2010 reached a global value of EUR 727.7 million, representing only 2,7% of the total processing industry exports.

Table 3: Slovenia Textile & Clothing Exports

Exports	2008		2009		2010	
	MILLION EUR	Quantity	MILLION EUR	Quantity	MILLION EUR	Quantity
Textiles & Clothing	760,7	98.971	625,1	101.122	727,7	107.976

Source: EURATEX

The UE-27 is by far, the most important Slovenian partner in textile & clothing trade. The EU 27 market absorbs 64% of Slovenian products, namely to Germany, Italy and Austria, that are the three more important markets. Regarding this the years 2009-2011, in average, textile products represent 60% of the total textile and clothing exports.

Last year more than 1.500 jobs were axed in the textile, clothing and leather processing industry in Slovenia. The average salary in textiles production amount to EUR 1.078, EUR 846 in clothing production and EUR 925 in leather processing industry. According to the figures provided by the Textile Association[55], in the textile and clothing sector the average salary was 13% higher than in 2010 because of the minimum wage raise. It was behind the average salary in all-processing sectors by 30%.

[54] Chamber of Commerce and Industry of Slovenia - Textile, Clothing and Leather Processing Association.

[55] Chamber of Commerce and Industry of Slovenia - Textile, Clothing and Leather Processing Association.

World financial and economic crises strongly affected Slovene textile and clothing industry. The situation in the first two month of 2011 is a little bit more optimistic than it was in 2009 at the same time. Textile production recorded a very small increase during first two month of 2011 (0.8%) as compared to the same period of the previous year. The situation was worse in the clothing sector where production went down for 7.9% as compared with first two months of 2010. In the first two month of 2011 new orders increased in the textile sector for 15.5%, especially non-domestic orders (+22.6%). In the same period total of new orders in the clothing sectors went down by -5.9%, but increased non-domestic new orders by 6.4%.

The textile, clothing and leather processing association report shows a comparison of figures between 2009 and 2010 for production, employment and productivity index. Figures on 2011 turnover and profit (or loss) are not yet available, but the association expects results to be poorer, though a little bit better than in 2009. The data on productivity shows an increase by 26.1% in the textile sector and by 6.5% in the clothing industry. Considering some previous data and estimates a negative financial statement can still be expected of the entire textile sector, clothing and leather processing sector. In 2009 the value added per employee in the textile sector achieved EUR 23.702 and in the clothing sector EUR 14.553.

Table 4: Slovenia Textile & Clothing production and Productivity index

Sector	Production Index 2010/2009	Employment Index 2010/2009	Productivity Index 2010/2009
Textiles	96,6	76,6	126,1
Clothing	98,4	92,4	106,5

SOURCE: Slovenia Textile, Clothing and Leather Processing Association

The small dimension of the internal market of approximately 2 million inhabitants and the geographical changes arising from the political changes of 1989, impacted Slovenia with the loss of the majority of the Yugoslavian market, while the Eastern-European markets have gone through substantial restructuring. Today, as a result, the textile & clothing sector exports almost the entire production mainly to the EU 27 market.

Slovenian National statistics on innovation show that only 7.3% of innovation-active enterprises have received information from different support institutions. The 2009 OECD annual report identified a lack of systemic support to enterprises as one of the key deficiencies of the National Innovation System (NIS). The number of innovation-active small enterprises has increased slightly in the period from 2004 to 2006 (CIS, 2006) to 27.7%, but the figure remains relatively low and no better performance is visible in CIS 2008 figures. The Slovenian RD&I framework needs stability in terms of measures and instruments to give companies a chance to get used to the offered support. The lack of interest in some industrial sectors for RD&I, and especially SMEs in these sectors, is the result of several, sometimes conflicting reasons: from lack of competition (certain services), to lack of financial and human resources in long-neglected sectors that were traditionally not considered as R&D important, for example

textiles and food processing. Nevertheless, as it will be highlighted further on in this report, the textile & clothing sector has been profiting well from the national R&D funding instruments and is considered to be one of the most dynamic sectors in terms of projects development.

3.4.2. INNOVATION PLAYERS, PRACTICES AND DRIVERS

Innovative products and product innovation are considered to be more important and strategic than process innovation or technological development by most of the interviewed companies. For SMEs, which are predominant textile producers (knitted or woven fabrics) which product innovation processes is heavily supported and dependent in innovative material combinations and material diversification (fibres or yarns), the difficult in assessing small samples or quantities at reasonable prices of differentiated products has been point as a barrier to more intensive product innovation activities. The small quantity orders are not convincing for big players in the fibres/yarns business for whom small orders are normally not interesting, this turns almost impossible (for price and cost reasons) to search and develop innovative textile structures as a result of creative combination of new materials.

There is an interesting set of good practices, success stories and positive results linked to environmental technologies and eco innovation within the Slovenian textile sector. The case of the ECONYL project developed by the company AQUAFIL is one of them and is detailed further ahead in this chapter.

Looking for the reasons behind such cases and trying to find answers within companies and researchers, the result we have been able to identify is that in most the cases there is a cost reduction pressure and legislation constrain, that works as an innovation driver for those innovation strategies that try also to profit from a positive branding effect coming from Eco innovation strategies.

Cost savings in key resources like energy, water or chemicals and REACH regulations have been stated as one of the drivers for a certain innovation trend for ecological and environmental aspects of textile processing. The defence industry could be a lead opportunity to promote more and better innovation, however it has been stated that public procurement is not yet sufficiently well organized in order to have a significant impact in the Slovenian textile industry performance. There is a defence cluster promotion by the public sector but at the end all the public purchasing strategy and procedures are not really inducing innovative product development by the companies. The potential exists and can be explored.

Innovation promotion is not a problem. According to several testimonies, funding has been available in the last years and there are several public agencies promoting the importance and the relevance of innovation for today's competition in the global market. This kind of promotion is performed by the Slovenian Technology Agency and by other services of Ministry of Science and Education, either through electronic newsletters or written publications addressing Universities and the business or industry related organizations and Associations. Also important for this promotion activity is the proximity and open position shown by the representatives of the public sector towards the textile & clothing industry representatives, that was possible to observe during the workshop organized in Ljubljana.

The Slovenian innovation systems in what the textile sector is concerned and regarding key players within that system, misses an interface player that could establish the link and the bridge between universities and companies. The absence of a technological centre, an innovation institute or a sort of applied research & development centre,

even within the scope of the Universities is a weak point in the system. The universities are not organized in such a way to answer in a professional and effective way to companies challenges and needs in terms of innovation or short term applied research. Despite the good level of research that is being performed at universities with textiles & clothing competences, they miss an internal unit or an interface centre, which can be fully dedicated to more applied development or to better link with industry.

Looking at Maribor University for example, despite the fact of the good level research that is being performed, the well-equipped laboratories and a certain dynamic in terms of European projects, the fact is that most of the staff is busy in lecturing and in fundamental research which is relevant for careers development and that normally is not so interesting in short term for companies innovation strategies. There is no structure within the universities that can bring the research performed there into the playfield of innovation, which is closer to the market and therefore more easily bought or incorporated by the companies into its product and process development activities.

A Slovenian Textile Technology Platform is established and managed by IRSPIN, which is an innovation Centre in the field of spinning technology. The structure and mission of the Centre hat seems to merge or confuse its position with the Platform itself. There was no clear evidence of the platform dynamism as an innovation facilitator or as link building within the innovation system. Despite the name of several companies being involved there was no significant mentioning of the platform activity, which major output seems to be the adaptation of the ETP Roadmap to the Slovenian sector specificity.

Looking at today's priorities for companies and particular for SME's innovation is being kept at a secondary stage of importance, while access to finance and promotion in international markets aiming an increase in exports are seen as top priorities. However, innovation is considered by far as the core for any development strategy to be put in place for the textile & clothing sector within Slovenia.

Regarding funding as well as innovation promotion, the general opinion is that both this aspects are not a problem and cannot be considered as barriers for innovation activity.

In fact, the representative from the Ministry of Economy stated that the textile industry is one of the most dynamic ones in what project funding attraction is concerned regarding the national program. The textile industry has achieved excellent success rate in their project proposals and is one of the most performing sector within the national project funding scheme.

There is a funding scheme supporting the creation and development of R&D departments within companies. This program is run by the Ministry of Science and Education and supports the scientific staff salaries for a two year project. According to the companies is an interesting tool towards innovation within the companies and one of the company cases developed further ahead, Tekstina[56], has been profiting positively from such program.

Regarding clustering activity as innovation facilitator or drivers two relevant cases were identified. The Slovenian Defence Industry Cluster (GOIS) which has a professional management structure and presently incorporates 53 companies, some of them acting in the field of technical textiles and materials like, ballistic protection, rescue equipment, chemical protection, shelters and tents or footwear. According to the Textile, Clothing and Leather processing Association, this cluster can play an important role as a driver for innovation within textile companies towards the development of technical textiles. But the cluster must evolve in the way it is organized. It has a big

[56] Tekstina is a Slovenian SME textile producer of fashion fabrics and technical fabrics

potential, also due to the lasting tradition of several hundred years of military weapons and equipment production in the Slovenian territory, but it should be organized in a way that could be better and effectively exploited by the companies.

Another clustered platform, more from the side of R&D offer towards innovation is POLYMAT. This is more like a network of excellence bringing together researchers and organizations around activities that are based on the synergy and effective cooperation of the leading Slovenian researchers and research groups, knowledge institutions, enterprises, other successful companies in the field of development of polymer materials and related areas. This initiative counts with Maribor (Faculty of Textiles) and Ljubljana University but is more on the side of polymer research than on textiles.

Specific client's demands and needs have been pointed as the major innovation driver for companies, in particular for SMEs. In the sense that the more frequent innovative solutions or products have always been developed upon a request of a specific client and always are more incremental than radical solutions. For bigger companies, instead of specific clients, the market demand as a whole and its major trends is assumed to be the key driver, but still is the market that guides all the process and that defines the key strategic topics for innovative product development. The proactive investment in innovations by SME's in order to "surprise" the client or to pursuit a different positioning within a group of competitors is seen as more risky and therefore less interesting.

IPR managing knowledge is considered to be a barrier for more effective innovation. There is a lack of knowledge in Universities and in companies regarding how to exploit results or deal with practical issues regarding IPR strategy, patenting or licensing. The positive aspect could be the recognition IPR's importance for an effective exploitation of innovation and the assumption that there is a need for deeper and more practical knowledge in that field.

3.4.3. SUCCESS STORIES, KEY INFLUENCING FACTORS AND TRENDS

The following individual interviews allow to highlight some interesting cases and to confirm some of the findings and perspectives gathered during round tables and workshops. In the case of Slovenia three different cases were selected: a big company producing Nylon with an interesting case of eco-innovation (AQUAFIL); a textile SME, producing fashion fabrics and technical fabrics (TEKSTINA); a high-tech company combining R&D services with innovative product evaluation tools for clothing comfort assessment (BIOMED).

AQUAFIL is an important international company active in several different fields and bases in different locations worldwide but with an important part of its productive facility based in Ljubljana, Slovenia. The Slovenian facility is active in the field of Nylon 6 production and includes all the production stages: Polymerization, compounding, BCF spinning, twisting, texturizing and heat setting. This Slovenian facility accounts with 472 people and is the soul and body of an innovative process called ECONYL. ECONYL is in fact more than a new productive process technology based in product recycling. It is the overall concept that makes the possibility for a complete recycling approach based on three major pillars: Recover, recycle and reuse.

The recycled polyamide produced through the ECONYL plant based in Ljubljana, collects his raw material from the recycled end of life products, namely fishing nets and ropes (Polyamide 6), avoiding the deposition of such Polyamide products into landfill upon the end of their useful life (in the best scenario) or a more serious situation which is when they are thrown into the sea when they are no longer useful. The company manages the recycling and storage process of those products and process them using an innovative technology called ECONYL that is

running exclusively in the Slovenian facility. This innovative eco-innovation approach and technology is well highlighted in the Slovenian Government official website[57] as a good example of industrial innovation. This R&D conducting to this innovation that today is branded in the market as Recycled Polyamide ECONYL©, took four years and most of the driving forces for that innovation was the company strategy to pursuit a development path based on sustainability. The cooperation with all kind of companies and organizations within the supply chain was decisive regarding the development of the recycling (product collection) concept.

In terms of the technological process that allows transforming waste in raw material to be extruded and spun, most of the ideas, drivers and knowledge were coming from inside the company. According to the General Manager of the company, sustainability and Eco innovation is one of the key developing strategies within the synthetic fibre business. Regarding innovation and its management, considering the dimension of AQUAFIL, he believes that most of that activity should be developed within the company and that clients are very important to validate and confirm whatever new development they are looking into.

In any case it will always be for the market to decide into which direction innovation strategies should go. During the round table with different companies, the industrial director of this AQUAFIL business unit, confirmed that in several cases AQUAFIL is challenged by different SME's to supply small batches (specialties) of differentiated products that could be interesting for those SME's (mostly knitting producers) to achieve a certain degree of innovation or differentiation in their own products. The problem is that so small quantities are not interesting to supply for such a big structure like AQUAFIL.

When questioned if for such kind of more innovative and differentiated fibres the set up of very small plants, at the same time, would contribute to lever the innovation capacity of SME's, the answer is probably yes if these plants were close to a prototyping facility, which business would be to perform contract R&D and small batch production.

A small scale supplier of innovative specialty fibres that could keep a closely link to the SME´s participating in the round table, cooperating into innovative product development, was something considered to be an interesting idea to these SMEs.

TEKSTINA is a Slovenian SME, with 72 employees, based in Adjovscinna, 90 Km from Ljubljana. This SME is a textile producer of fashion fabrics and special technical fabrics, mostly for personal protective equipment and for protective clothing applications. The company history goes far back to 1828 and the world of the technical products is a recent strategy towards more high value added products. The technical division of TEKSTINA offers a complete range of technical fabrics with special finishing's and properties for different technical applications within the field of protective clothing, such as fire-fighters, gas and petrol distribution, power industry, metal, mining industry and chemical industry.

The company has its own R&D department since 2004 and today the technical products represent 34% of the business. One of the recent innovations that the company brought to market is a high visibility flame retardant product launched in 2008. The kind of innovation performed by the company is always led by a crossed interaction between client requirements and standards requirements for the application field. Most of the innovative related activity performed by such kind of companies, fall into the finishing area, namely trying to scale, optimize or adapt the application of innovative finishing products supplied (in standard ways) by major international companies, belonging to the chemical sector.

[57] This website is managed by the Slovenian Government Communication Office www.ukom.gov.si

Non technological innovation mostly in the field process innovation is resulting from that kind of R&D, namely when innovative properties or significantly improved fabric performance is achieved by an innovative combination of different chemical products upon a specific textile platform. According to the general manager of Tekstina, for SMEs most of the innovation ideas and drivers will come directly from the client that has a special request or challenge for a specific field of application. That client match innovation approach will always be more frequent than coming with something radically new (new to market) and presented to the market as such. This kind of approach demands significantly higher financial resources and involves higher risks of success. For the strategy followed by TEKSTINA, cooperation with the chemical products suppliers and the yarn/fibre suppliers is critical to build the basis where the company will develop its innovation process.

BIOMED is an interesting innovative company, with a particular approach resulting from installed competence in research performed mostly on the Josef Stefan Institute. This Institute addresses automation, robotics and biocybernetic as well as human physiology comfort testing with human subjects, in a research oriented approach.

The company addresses the field of comfort and clothing physiology, providing consulting, testing and development, using simulation and modelling, either through measurements in humans, either in mannequins. The Institute's R&D group started to build thermal mannequins and spare parts (foot, head, hand), but the first whole body immersion mannequin was built by BIOMED.

Soon, a next generation of thermal mannequins will be brought to market by BIOMED profiting from R&D driven by the company and that is now in progress at University of Maribor (Faculty of Mechanical Engineering) and Josef Stefan Institute. BIOMED provides comfort and clothing physiology including simulations and modelling services upon the basic knowledge available in the Institute. The interesting thing about this 6 people organization with an approximately yearly turnover of KEUR 500, is that provides high tech and high added value services, for top international brands like W.L. Gore & Associates or Lenzing, profiting from research previously developed and on-going, either within the company, but also in the Josef Stefan Institute.

One of the innovative BIOMED services which is a good example on how R&D can be transformed into marketable services, is a special application that allows performing and registering an objective evaluation of clothing comfort, through platforms like IPod©, IPad© or Blackberry©. The interesting thing about this case is the success of transforming research results into an innovative product that integrates also a component of service.

According to this small tech company CEO, the development of BIOMED came mostly from the need of achieving a higher degree of flexibility and focus regarding industrial clients and other companies, towards a more effective link with the market, namely comparing to the usual academic approach, that is not that effective when you want to offer technological services to companies, directly from the University. The "spinoff" of BIOMED and the development of a product and service portfolio offered to the market through BIOMED, upon the knowledge assets build upon past and present research experiences, was the best solution to transform knowledge into valuable innovative services".

The company mentioned that a good part of its success is the innovative and proactive way to combine existent researchers from different fields and to "package" that knowledge combination in such a way that becomes motivating and attractive to companies like Lenzig©, for example. The wrong approach is when Universities adopt a more passive behaviour which is only "excited" when a company decides to apply for a project proposal towards an innovative product or process and decides to look into Universities.

3.4.4. CONCLUSIONS

The Slovenian cases support the idea that innovation is clearly in the agenda of companies as an important competitive factor towards international markets, together with international promotion. There is a clear perception by the companies that innovation is the way for the sector to be competitive in the international scenery without disregarding the importance of international promotion;

Clustering practices and structures are not that developed in the specific case of the textile and clothing sector. A Slovenian Textile Technology Platform is established and managed by an innovation centre but the structure and mission of the Centre seems to merge or confuse its position with the Platform itself. There was no clear evidence of the platform dynamism as an innovation facilitator or as link building within the innovation system. However there is no lack on innovation promotion as such, since that most of the interviewed players have recognised that there is enough promotion and marketing about the importance of innovation for the companies' development.

Still on clustering, the Defence Industry Cluster is seen as an organization that could play an interesting role as a driver for innovation within textile companies towards a stronger development of technical textiles for that specialized market, but it should be organized towards a more effective interaction with the different production sectors while the public procurement practices should also be more oriented towards higher innovation appreciation.

Clothing manufacturing is not that representative within the Slovenian sector therefore most of the innovation path that is being followed by the companies are in line with fibre and textile related fields of development, with similar drivers to the ones found in North Portugal.

Eco-innovation and process innovation strategies towards more efficient use of resources are very often adopted by companies, which find a well-developed R&D capacity available in that particular field at University level. Process innovation strategies towards efficient energy consumption or efficient water management are mostly driven by economic reasons or by specific regulations, but they are perceived as an interesting differentiating factor in the market, if marketing and communication strategies are correctly developed.

The link between Universities and companies towards more significant innovation impacts within the market has a good margin to evolve, since no organization or agency playing an effective interface hub role as an a innovation facilitator within the sector was identified. Relevant knowledge and competences are present in both Universities with textile and clothing scientific related background but there is a lack of strength and consistence in the links with the companies, towards a stronger impact in the sector's innovation performance.

Client's and end user inputs are the major innovation driver for companies, in particular for SME's, as well as raw material and chemical suppliers in general. Frequently, innovative solutions or products are developed upon a request of a specific client and most of times rather following incremental approaches than radical or disruptive solutions. Once more, incremental innovation is perceived as more effective and profitable way of assuring the return on investment.

3.5. ROMANIA

3.5.1. THE REGION AND TEXTILE & CLOTHING SECTOR OVERVIEW

Manufacturing is more important in Romania than in the EU on average (22.4 % vs. 14.9 % of total value added). Therefore Romania is one of the EU Member States with the highest share of manufacturing in GDP. At the detailed manufacturing industry level, Romania is highly specialized in labour-intensive industries (preparation and spinning of textile fibres, sawmilling, wearing apparel and accessories), as well as in capital-intensive industries (cement), and marketing-driven ones (value-added only; footwear). At the more aggregated sector level, Romania features specialization in low innovation and education sectors (wearing apparel, leather), but also in medium-high innovation sectors (textiles, basic metals)[58].

The Romania Textile & Clothing Industry has a global turnover of 3.190 MILION EUR and employs 172.891 people, mostly on the clothing manufacturing segment, that in 2010 comprised almost 75% of the existent 6.097 textile and clothing companies.

Table 5: Romanian Textile & Clothing Sector Data

ROMANIA	Turnover		Investment		Companies		Employment	
	2009	2010	2009	2010	2009	2010	2009	2010
Textile	1.231,44	1.342,27	66,4	124,83	1.631	1.491	28.669	26.203
Clothing	1.844,10	1.847,79	110,7	110,92	5.313	4.606	169.190	146.688
T&C	**3.075,54**	**3.190,06**	**177,1**	**235,75**	**6.944**	**6.097**	**197.859**	**172.891**

Figures of turnover and investment (Million Euros); Companies and Employment in number

Source: EURATEX

With a value of EUR 3.147 million in 2010, the exports of the textile products and clothing represent almost 19% of the Romanian total exports. Another important fact is the high capacity of the textile and clothing industry to absorb the workforce. Having 172.891 employees, the companies from that industry absorb 20% of the total employees from the Romanian industry.

[58] Member States competitiveness performance and policies 2011 SEC (2011) 1187

Table 6: Romanian Textile & Clothing Exports

Exports	2008		2009		2010	
	MILLION EUR	Quantity	MILLION EUR	Quantity	MILLION EUR	Quantity
Textiles & Clothing	3.542	263.181	2.898	242.165	3.147	293.885

Source: EURATEX

The UE-27 is by far the most important Romania's partner in textile & clothing trade. The EU 27 market absorbs 93% of Romanian products, namely to Italy, Germany, France and UK, representing the first four more important markets. According to Eurostat data, Romania is the first EU-27 country regarding two indicators: 1-Number of persons employed in the manufacturing of wearing apparel business and 2- Level of specialization in terms of share in non-financial business economy.

Among the Member States, Romania and Italy had by far the largest clothing manufacturing workforces, each employing about a quarter of a million workers (the equivalent of a combined 35.6 % of the EU-27 total), followed by Bulgaria with a 10.1 % share. In terms of the value added generated by the clothing sector, however, Italy was by far the largest Member State. The EUR 7.2 billion of value added in 2006 accounting for almost one third (32.0 %) of the total across the EU-27. By comparison, the value added generated in Romania accounted for only 4.0 % of the total.

These differences in large part reflect the opposing ends of the clothing manufacturing spectrum. Clothes manufacturing in Italy is more focused on higher value products (including many designer and luxury brands), whereas in Romania production is concentrated more on the labour-intensive stages of clothing production and mass-market products (according to Eurostat Figures);

The figures below which are based on data provided by the Romanian Ministry of Economy, Trade and Business environment, show a relatively improvement of the economic situation of the textile & clothing sector, when comparing 2010 and 2011 within the same period (January to August):

Table 7: Romanian Textile & Clothing Sector Data

Industrial Production	*(Jan - Ago) 2010*		*(Jan - Ago) 2011*	
	Million EUR	(%)	Million EUR	(%)
Textiles	370,0	21%	492,6	24%
Clothing	1.407,5	79%	1.534,3	76%
T&C	1.777,5	100%	2.027,0	100%

Source: MINISTRY OF ECONOMY, TRADE AND BUSINESS ENVIRONMENT

Most of the Romanian companies are still working on CMT system, which means that basically they are workforce suppliers without a significant contribution to product design or to the technological content of the product. Customer-furnished schemes are the main basis for the development of apparel sector.

According to the schemes country imports fabrics, applied materials and equipment, and exports garments. The main factors of light industry[59] development are cheap labour, imported raw materials and modern equipment. Negative point is that active use of these factors by foreign companies for placement of large, but erratic orders, impact on the rhythm of development of Romanian light industries.

The low R&D performance of the Romanian textile & clothing sector companies, resulting from the predominance of the CMT model, is in accordance with the Innovation Union Scoreboard 2010 data for the Country, where Romania is classified as a modest innovator with a performance well below the EU average, partly due to a relatively low share of innovating enterprises and low business investments in R&D. According to Eurostat figures the group of countries with lower GDP/person than the EU average, and with specialization in less technologically-advanced sectors (group 4) consists of Bulgaria, Estonia, Latvia, Lithuania and Romania.

A recent communication from the European Commission on industrial policy and competitiveness [60] includes a country chapter about Romania that specifically refers to low levels of business R&D and innovation both in large firms and SMEs, and a certain reluctance of firms to take on financial and commercial risks arising from R&D and innovation.

According to The European Business facts and figures report from EUROSTAT there are a number of regions in Romania where between 8% and 15% of the non-financial business economy workforce were employed in the textiles, clothing and leather industry. According to information available on a website of the International Finance

[59] Textile, Clothing, leather and Footwear

[60] Communication from the Commission Industrial Policy: Reinforcing Competitiveness COM(2011) 0642 final; Member States competitiveness performance and policies 2011 SEC (2011) 1187

Corporation[61] there is no clear geographical concentration of the industry, but there are three spots where formal cluster initiatives are starting to develop as a result of a positive relations dynamic between companies and supporting organizations: Bucharest region, Neamt and Timisoara.

3.5.2. INNOVATION PLAYERS, PRACTICES AND DRIVERS

The field work in Romania was developed on two different regions with particular relevance regarding the concentration of the textile and clothing industry: Neamt and Bucharest.

During an ASTRICO NORD EST cluster meeting within a round table in Neamt there were several organizations present: the cluster management structure, representatives of INCDTP, representatives of IASI University and 5 textile & clothing companies. According to the presents the more relevant aspect about innovation is that it is a risky activity that demands therefore public funding support in order to share the risk. Therefore significant innovation (more radical, like new products or processes) can only be achieved with global consortia projects, supported by public funding, while within the companies, most of the innovation performed will always be incremental innovation and mostly oriented to process, aiming the improvement of productivity and production related aspects.

The meeting on project funding concept was even extended to the need of changing the kind of support and approaches that were foreseen in R&D projects in what concerns bringing prototypes to market.

According to the companies, the scale up process success and the production of new innovative products by the companies could be maximized if industrial scale machinery (or at least the upgrade and modification of existent machinery) could be considered as innovation related activities and therefore be financially supported within R&D and innovation funded projects. Despite considering this issue as relevant there was also the understanding that such approach could easily evolve into distort competition and trade inside the EU, due to obvious difficulties in assessing such kind of investments with a R&D and innovation framework.

It was clear that behind the above concern lies the applicability of research results, which is far from being solved and that in most cases at the end of a R&D project those results, are still far from being completely ready for industrial application. In most cases the lack of support for more close to market activities and less research intensive, is point out as the main reason for such gap.

Regarding the type of innovation performed by the companies and the relevant players within the process, most of the interviewed identified machinery suppliers, yarn suppliers and chemical product suppliers as key elements. In most cases this is an informal process; however it was also pointed out that the interaction between the companies and the clients during product development stage is growing as a result of shift movement from the sector from a pure CMT model to a more production partnership model.

This is the case of the Sofiaman and Smirodava companies, both Romanian knitted fabric clothing manufacturers where the clients are the more important drivers for both product and process innovations; hence the suppliers are key partners to reach the clients demands, expectations for new product approaches and new “service” offer. In

[61] http://www.doingbusiness.org

those companies ideas generation processes or market innovations survey activities are not strange concepts and creativity is considered probably more important than innovation itself (instead of part of the innovation process), namely for the companies operating in the fashion business market. However what is clear is that most of those activities are coming directly from its clients and not as a proactive systematically attitude of the company to surprise the client with something radically new.

Regarding the entrance in new application concepts and thus producing more technical articles for different and high added value markets, this is not in the agenda and most of the companies believe that the future relies on the fashion market; in fact that the shift for those technical products is only possible for a very limited number of companies. However it was stressed that it is important to monitor such kind of markets in order to follow the trends.

Regarding the role of the ASTRICO cluster in the innovation promotion, according to the participants there is a feeling that the recently created cluster can play an interesting role regarding the strengthening of already existing relationships and can be particularly relevant in the identification of all opportunities towards effective technology transfer activities or applied research funding capture. However, when evaluating the cluster communication documents, the emphasis is clearly on the promotion of the members' production and competiveness to supply high quality products, more like a business/producers grouping approach.

During the second round table session in Bucharest, a group of six companies with different profiles and three members of INDCTP staff were present to discuss the same innovation related aspects brought to discussion in Neamt within the ASTRICO cluster meeting.

UCO RAYMOND is a Belgian/Indian capital denim producer based close to Bucharest and employing 150 people, that exports 95% of its production to the EU market. The company, which is placed in a technological park, collaborates often with IASI University and with INDCTP, on testing and technical information acquisition, rather than on innovation supporting activities.

According to the local responsible for the company, most of the innovation drivers are coming from the clients and they are developed internally and put in practice by the company's staff which comprises both Romanian engineers from IASI University and Belgium or Indian engineers. Once more we are talking about incremental innovation, mostly for the same business and market already dominated by the companies. Chemical products suppliers were identified as a key partner regarding inputs for that incremental innovation, which in most cases, rather follows a cost reduction approach than new product developments.

According to the participants most of the attention of the companies is on focusing on the process productivity, through automation, process control and organizational methodologies. They do this by aiming at improving process productivity, product and service quality. This need for process innovation is resulting in several cases from price pressures imposed by clients. TANEX is a Romanian knitted fabric clothing manufacturing company that employs 800 people and produces under a complete CMT model for international brands.

For Tanex company's manager, technology providers are very important for process organizational innovation, namely to achieve maximum productivity and also significant reductions in lead time. For companies operating under the TANEX model it is clear that product innovation is not an issue yet, while operations catch all the attention.

A different operating and business model is followed by Datsa Textil, a knitwear producer based in BUZAU and employing 140 people. Datsa Textil has already shifted into a hybrid model that combines CMT with its own

production for its own brands. For the manager of this company, creativity is the key issue for business development. More than innovation, for those companies established within the fashion business value chain, the only way of surprising the client and increasing the added value of the product is by encouraging creativity internally. However, this kind of activity, mostly performed by designers, despite bringing constant and daily incremental innovation into the product, through innovative fabric structures, textures, colours or even concepts, is not eligible in most of the innovation funding schemes. Once more, this kind of activity connected to product development and thus more close to market, is often not considered under most of the R&D funding programs.

Regarding innovation promotion it was common agreement that there is no organization playing such a role and that there is a lack of innovation culture within the sector, that still has a dominant position of cheap production supplier instead of a product/concept provider. The recently created cluster within the Bucharest region – ROMANIAN TEXTILE CONCEPT, was pointed out to be in an excellent position to play such a role. In fact, the managerial structure of the association behind the cluster has a specific pillar devoted to innovation and technology promotion and dissemination, besides and important emphasis in internationalization and commercial promotion.

When looking at the Romanian participation in European textile & clothing related R&D projects, namely those funded under FP6 and FP7, it was possible to conclude that there were four participations in FP6[62] and 12 participations in FP7[63].

Looking into the thematic research topics addressed by those projects, all of them are within the field of technical textiles or materials or even within the scope of very innovative technologies like nanotechnologies or bio-based composites. When asking the presents about the possible impact of those R&D projects at industrial scale, taking into account the average reality of the Romanian sector, there was a common agreement that there is a gap between the needs and the general innovation maturity of the sector and the different thematic addressed by the European R&D projects.

Still on innovation funding, it was stressed by the participants that the national research program, which funds national projects was closed within the year 2009 till 2011 and they are now quite difficult to access due to the very high number of proposals[64]. The Romanian textile sector is present in the ERA-NET project CROSSTEXNET initiative through the presence of the CNMP[65] . So far the practical consequence of that presence in CROSSTEXNET can be

[62] Institutul National de Cercetare-Dezvoltare in Sudura si Incercari de Materiale (ISIM); FI-RI-Vigonia s.a.; Iridex Group Constructii srl; Institutul National de Cercetare-Dezvoltare Pentru Textile si Pielarie (INCDTP)

[63] Institutul National de Cercetare-Dezvoltare Pentru Textile si Pielarie (INCDTP); Gotech srl ; Universitatea de Stiinte Agronomice si Medicina Veterinara Bucurest (USAMV Bucuresti); SC Rodax Impex srl; Institutul de Chimie Macromoleculara Petru Poni (ICMPP); Asociatia Patronilor si Meseriasilor Cluj; Raliant srl; S.C. RO Challenges s.r.l; S.C. Davo Star Impex srl; Technosam srl.

[64] According to INCDTP in this year last call for proposals more than 7.000 proposals were submitted

[65] The National Centre for Programme Management (CNMP) is a legal Romanian public body established by the Government Decision no. 1264/2004 to coordinate research programs under the National Plan(s) for Research, Development & Innovation

translated into 28 proposals submitted within two calls in between 2010-2011, involving 29 Romanian SME's with a result of seven projects being selected for funding.

According to the participants in the round table, a funding program, applied through short term projects, specifically supporting the companies' innovation related activities, with a strong emphasis in supporting the process of bringing new innovative and creative products to market, would probably induce a new attitude of the companies before innovation.

An interesting finding from the Romanian cases discussed on both round tables, was to perceive that there is an interesting learning process, even for those companies working on the CMT model, that helps to create an important knowledge base to face the challenge of moving into its own product development strategy or into a less risky business model that combines the private label system with production to its own brands.

However, the priority for most of the Romanian companies still is to provide a competent production capacity to the market, in which they try to incorporate a service component in order to differentiate their offers from other low cost countries.

3.5.3. SUCCESS STORIES, KEY INFLUENCING FACTORS AND TRENDS

The following individual interviews allow to high light some interesting cases and to confirm some of the findings and perspectives gathered during round tables and workshops. In the case of Romania three different cases were selected: A big company of Italian and Romanian capital producing acrylic yarns (RIFIL). A textile fabric producer SME which was involved in a European R&D funded project in FP6 (FI-RI VIGONIA). A textile producer SME producing velvet fabrics (TESATORIILE REUNITE).

RIFIL is an acrylic yarn producer company for the knitting industry, with Italian and Romanian capital, located in the northwest region of Romania in the village of Neamt, 375 km from Bucharest. Raw material (acrylic fibre) is obtained locally and production goes almost completely for exports within the EU markets. RIFIL has a global annual turnover of approximately 55 Million Euros and employs 560 people.

The company has another facility which produces wool yarns located in the North. We tried to understand how the company differentiates from the competition which according to the General Manager, comes from Turkey: The Company states that its differentiation factor is quality and service, claiming that this is a very standard product where innovation is quite difficult to incorporate. Most of innovation performed by the company in the last years is incremental and is mostly focused in process innovation towards productivity increase and cost reduction, namely energy costs reductions, which for a spinning process represents an important slice of the cost structure.

When we asked about R&D and innovation practices within the company, the company underlines that no R&D is performed inside the company, and most of the innovations introduced in the process were "supplied" by its machinery or chemical products providers directly and is of course available for other companies too.

No particular strategy for technological appropriation was identified and most of the incremental developments performed in the product are in the field of colour development or fibre blend, but in both cases in very standard product ranges. When trying the understand why the company has never chosen a path more oriented to innovation or at least on having a short term strategy development based on it, the following barriers were pointed out: "Innovation is difficult, risky and costly and it should be developed with complementary fields of knowledge".

The company has a recent failure story regarding a significant amount invested in a new technology, an innovative spinning, ply and twist process, but at the end the machinery constructor has abandoned that technology development line and the company ended without any kind of support or further development for the technology.

After this failed experience towards leading the adoption of a new technology, the company has adopted a "follower position" and more than presenting "new things" to its clients tries to answer to the client needs and demands, positioning its products through a competitive price and service (commercial).

When questioned about exploiting the entrance in new application markets, namely for technical applications and how these markets (technical textiles) could open new possibilities for RIFIL's product portfolio, the company refers to that those markets have high barriers to the entrance of new players and demands a complete change in the company business which he does not see as a viable strategy, taking into account the specific production profile of the company (Acrylic yarns).

FI-RI VIGONIA is a Romanian SME that has participated in the INTELTEX project (Intelligent multi-reactive textiles integrating nano-filler based CPC-fibre) developed under FP6 between 2006 and 2010. FI-RI VIGONIA S.A is a manufacturer of yarns, woven and non-woven fabrics with a global turnover of EUR 100.000 and employing 50 people. It's a company that usually produces non-woven for different applications including protective clothing which has industrial lines for producing needle punched and stitch bonded non-woven.

The R&D manager subcontracted by FI-RI VIGONIA to manage the INTELTEX project within the company and whom still collaborates with FI-RI VIGONIA was interviewed during the study. This manager is very sceptical about European R&D projects impact in the market, mostly as a result of the INTELTEX project experience for FI-RI VIGONIA's original objectives when jointing the consortium. While the objective of the company was to end the project with some new products oriented to the automotive sector, according to the Company, the best they achieved was to perform some tests on a very small scale.

The company understands the risk of R&D activities, particularly in new product development, namely in the sense that very often projects results do not achieve the appropriate stage of development required for the market launch of the product.

When trying to understand which factors would reduce such a risk, allowing a higher rate of innovative products being introduced in the market as a result of collaborative consortia projects, the project manager highlights the importance of preliminary studies and preliminary pilot testing that could outwit projects ideas with lower changes of success. If the existent project evaluation schemes and proposal submission systems, would demand more substantial preliminary results, testing and evidence regarding the viability of the project, most probably success rate would increase. According to the company a project proposal should prove with more substantial results, based in pilot scale testing, that the project has a considerable probability of success in evolving to industrial and commercial scale.

This kind of exploratory activity before moving into a more structured and complex project proposal have been somehow the concept behind the exploratory awards funding scheme available within FP5[66] in the past.

[66] FP5 – Fifth Framework Programe 1998-2002

Regarding the relation of the company within the innovation system, it was stated that for a SME is quite complex to follow up scientific development or to implement knowledge management strategies as well as ideas' generation activities. Is clear that the company relies on Universities' offer and proposals regarding the development of R&D and innovation and these kinds of organizations should challenge and influence the companies, towards innovative processes and products.

TESATORIILE REUNITE

When trying to identify a marketable success story resulting from an R&D and innovation process, no immediate identifiable result was pointed out by the participants in both round tables, regarding any innovative product or process developed or launched by a Romanian company. After some discussion an interesting example was given by one of the present companies, however is not immediately identifiable since is a process innovation case. TESATORIILE REUNITE is a technical fabrics producer, namely velvet by double face technologies for interior designs, automotive and railway upholstery.

The company which dates back to 1930 is an SME and employs 50 people, is mostly producing for the internal market, but also exporting 20% to the Italian and Belgian market. The General Manager of the company, clarifies that in the more technical segment, railway and automotive applications, the legislation and the specific product certification standards are the relevant drivers for development.

Through an innovative approach to the double face velvet fabric technology the company managed to develop and produce a long pile carpet for bathrooms, through an extremely competitive production concept and with accomplishing extreme high quality standards.

This result coming from the innovative use of the technology, allowed the company to enter a completely new market and even to attract important new clients that were being supplied by very recognized and consolidated players in the market.

The company manager was asked to identify the critical factors and drivers regarding innovation taking not only his experience but what he considered to be relevant for an SME. According to the company, client's information and involvement plus internal technical and development team are extremely important factors. In a second level of importance come suppliers and other companies with complementary knowledge as well as testing services. He considers that Universities and Institutes are not that important while consultants are not relevant at all.

This is a good example of process innovation through a technology appropriation strategy, that was used by the company to developed a new product (regarding the company's portfolio) to a new market, at a very competitive set up (price x quality). When asking the company about the key factors behind the success of this strategy, he stated that yarn suppliers were relevant but the more important factor was the internal capacity to adapt the technology. The machinery constructor support in terms of information was also important as well as the first clients feedback on the product performance.

3.5.4. CONCLUSIONS

Despite a moderate positive trend in terms of R&D intensity within the last decade, Romania still scores as one of the lowest R&D intensity countries in the European Union[67]. According to the same source, the 2007-2013 strategy for R&D and innovation has foreseen a gradual increase of the R&D public budget but the increase did not take place, due to the economic crisis, resulting in lowering the R&D budget to 0,48% in 2009. Still on innovation funding, it was stressed by several interviewed organizations that the national research program, which funds national projects was closed within the last three years and they are now quite difficult to access due to the very high number of proposals[68]. This situation can be pointed out as a barrier for boosting innovation.

Looking into the European Innovation Scoreboard chart on EU member states innovation performance presented in the introduction of this task, Romania ranks by far in the worst position when comparing the five different countries/regions which were assessed within Task 6, innovation: Germany, Italy, Portugal/Spain and Slovenia. This very same relative position can be assumed when comparing the specific innovation performance of the Romanian textile & clothing sector.

Among the member states, Romania and Italy have the largest clothing manufacturing workforces. In terms of value added generated by the clothing sector, Italy is one of the largest, accounting for almost one third (32.0 %) of the total across the EU27. By comparison, the value added generated in Romania accounted for only 4.0 % of the total. This is in accordance with the fact that Romania production is concentrated more on the labour-intensive stages of clothing production and mass-market products (according to Eurostat Figures).

Most of the Romanian companies are still working on CMT system, which means that basically they are workforce suppliers, without a significant contribution to product design or to the technological content of the product. Patterns provided by the customer are the main basis for the development of apparel sector, despite the identification of a few cases where product design is already being provided.

Innovation practices in companies are almost an exclusive of product incremental innovation cases, with a few cases stated here (like Fi-RI VIGONIA or TESATORIILE REUNITE) where innovation practices were identified as more evolve, but it should be stress that these cases are still not representative from the general performance of the sector. However It's positive for them to be highlighted as a positive sign regarding the further development of the sector.

Regarding the type of innovation performed by the companies itself and the relevant players within that process, it was possible to identify those machinery suppliers, raw material suppliers (yarns and fibres) and chemical product suppliers (for the finishing process) are considered to be important sources for the companies' innovation processes. However, those processes are informal and still they are not systematically adopted by companies as part of their standard managing strategy. It was also pointed out by most of the interviewed, that within the product development stage (both, for textiles and clothing), more frequent and stronger interaction with the clients is taking place, mostly driven by a shift movement from a pure CMT model to a model which is closer to a production partnership model, which is now beginning to develop.

[67] The 2011 Innovation Union Scoreboard

[68] According to INCDTP in 2011 last cal for proposals, more than 7.000 proposals were submitted

Regarding the entrance in new application and thus producing more technical articles for different and high added value markets, this is not in the present agenda and most of the companies believe that the future relies on the fashion market and that the shift for those technical products is only achievable by a very limited number of companies. However, looking into the thematic research topics addressed within European projects where Romanian organizations are engaged, all the projects are within the field of technical textiles or materials or even within the scope of very innovative technologies like nanotechnologies or bio-based composites. Taking into account the average reality of the Romanian sector, there seems to be a gap between the needs and the general innovation maturity of the sector and the different thematic addressed by the European R&D projects.

The Romanian case can be characterized by a strong focus in production capacity and its associated supporting services. The strong presence of foreign companies which have installed their production centres in the country, due to a competitive labour cost offer, is still important when it comes to build the present sector's profile. Innovation mind-set and practices are not present in the Romanian cases like in other regions. It's fair to say that innovation is not yet attached to the companies' mind-set or even present in the agenda priorities, like in other regions. However the few success stories already identified should be interpreted as a positive sign and a good practice example that could be followed by other companies.

Innovation is indeed seen as important for the future, but is still far from being in the top of companies agenda today. Non technological innovation will soon have more importance for the clothing manufacturing companies, which are beginning to develop a shifting and evolving process away from a pure CMT model. For such kind of strategic development, design and creativity will become more important assets. Supporting services and R&D infrastructure are not as developed and well equipped as they are in Slovenia or in North Portugal and Galicia. This situation that can represent a barrier for addressing ambitious innovation challenges in the near future.

Romanian innovation practices are still a few degrees below average looking to the regions assessed within task 6, innovation. Production oriented strategies are the dominant cases, with companies looking into production capacity and service performance as the more critical competitive values for the present and for the near future.

The link between players within the innovation pipeline is being boosted in part by formal cluster managing structures, like ASTRICO for example, and the institute INDCP. However the quality and strength of those links, it doesn't seem to be yet traduced in a critical mass building process for the companies itself, regarding innovation practices and performance. However, the will of developing the formal cluster managing approach is present and it's a positive sign which can have a midterm impact in the companies if the developing process is well conducted and really tackles the innovation related issues instead of working mostly as a commercial promotion agency.

4. TASK CONCLUSIONS

For the European textile & clothing sector, product Innovations strategies based in product differentiation, mostly through a path of incremental innovative product development, are relatively more common than process innovation, and is considered to be more important towards the future development of the sector. This is confirmed by the Task 1 survey results, where the majority of the companies (49%) considered the development of new products to be very important. The importance of this preference in shown in a different way depending on being a textile or a clothing company and having or not a role in the final product creativity and concept. In countries playing an important role in manufacturing (Portugal, Italy, Romania or Bulgaria) and particularly in those companies where the competitive production capacity is one of the key differentiating factors, either through CMT models or through hybrid models that combines CMT with own brands production, process innovation is more relevant, as a way of achieving higher competitive standards through productivity improvements. The dominance of incremental innovation over more radical innovation strategies is another finding that is also supported by the fact of "new to firm" product's sales shares being higher than "new to market" product's sales share. This trend remains the same from CIS4 to CIS 2008.

Regarding process innovation strategies it is interesting to see that in the 90s most of the innovations were addressing general processes, not influencing specifically the product characteristics or performance, but mainly looking into production tracking, monitoring, control, process efficiency and process management. In more recent years, several process innovation addressed very specific phases within the production value chain, which can contribute to the product differentiation itself, either through product functionalization, or towards the introduction of additional innovative properties to the product. Process innovation seems to be driven by the need of having a wide variety of options regarding the product properties within the same technological line and not so often by the need of improving process performance *per se*. This is connected to the fact that flexibility is proven to be the key success for many of the interviewed companies in the report on restructuring (Task 4). Within the key lessons the report on restructuring, one can see that several companies are unable to compete with the Far East on price, but with strategies addressing just-in time production methods, investments in production efficiency and also using the flexibility resulting from networking and collaborative value chain management.

Marketing innovation is growing in importance and is more commonly adopted than organizational innovation. Task 1 survey question about the most important area of innovation, places market development as the area where the extremely important option reaches the higher quota. Particularly for those companies acting in the fashion business and controlling the distribution channel and/or the retail management, marketing innovation is very often considered as strategic for the commercial performance as the release of new products. Besides the marketing strategy itself, the importance of communication practices within the innovation performance, is present in several cases in North Portugal and in Slovenia. A good example of the interest of such innovation line are the companies in the Galicia region, which considered being extremely important all the innovative technologies in the field of client empowerment, product and brand communication within the retail shop floor (see the PAZ RODRIGUES case). Marketing innovation effectively linked and integrated within product innovation strategies, was also identified as a key factor regarding the success of innovative products launching into the market in several cases, which are using the internet as an alternative marketing channel (North Portugal cases or Lombardia/Piemonte cases). This finding

is very much in line with the growing importance of e-commerce and internet sales for the fashion value chain. By 2010, Internet sales have become a visible feature with a market share above 10% in at least Germany, the UK, France and the Netherlands. Annual growth rates are above 20% even in years of crisis. Online sales are developed by brands and large retailers. It has been observed that SMEs (both retail and manufacturers) have not invested in the IT backbone to be able to get on that band-wagon. The ICT innovations are presented in the Baden-Württemberg case.

Suppliers, clients and companies within the same group are the more relevant cooperation links engaged during the innovation pipeline, in general and also in particular for big companies, which are driving and leading their innovation processes. These links have been identified in almost every regional case, particularly in the company study cases of North of Portugal and Slovenia. Also for these kinds of companies, the corporate "customer" or the final client itself are important sources of the innovation strategy. Yarn and fibre suppliers as well as chemical products suppliers are particularly relevant in the case of the textile companies, while fabric suppliers are more relevant for the clothing manufacturing companies. Technology suppliers (machinery) are often engaged within the innovation process, in both textile and clothing companies, but in a more secondary role. Larger companies tend to do the bulk of the work inside using its own resources and they are more frequently in charge of leading the process, while in the case of SMEs the bulk of the work is done by institutes, either through project based activities, either in subcontracting relations, but in this case the lead is very often taken by R&D institutes. Institutes are more relevant in the innovation pipeline as the process tends to get closer to scale up or to pilot production stages. Within this specific timeline frame, pilot plants available within R&D Institutes are considered an important asset towards the final result, as it was found particularly in the Slovenian case. Most of the identified success stories (in all regional cases) have in common that the companies were driving the innovation process and therefore deeply engaged from the very beginning. This happens more often in the case of bigger companies or at least is easier for bigger companies than for SME's to perform that leading role.

Looking at the more relevant external sources of innovation, statistic figures shows that clients and customers are considered by the higher share of the innovative companies (36%) as the more relevant source for innovation. This benchmark does not change from CIS4 to CIS 2008. According to the field findings, companies which have direct access to the final consumer tend to profit in a more effective way from such contact, exploring continuous information feed from shop to the creative process. Even in those companies with no direct interaction with the final client, as we found in North of Portugal and in Slovenia cases, alternative ways or methodologies are being explored, in order to bring customer preferences and expectation into the innovation process, therefore trying to increase the success rate of new products in the market. Despite not ranking as a relevant source for innovation within the statistics figures, product exhibitions and fairs are often referred by companies, particularly by SME's in those regional cases, as a very important source for innovation.

We did not see R&D funding as an essential factor of incremental process or product innovation in textiles and clothing. R&D Funding was mentioned by several companies as being much more oriented to scientific activities. In Lombardia companies appreciated the Metadistretto funding programme for collaborative research. They saw it as an example of discontinuity in regional innovation funding, since it was not available in 2010 and 2011. For (innovation) activities closer to the market, including non-technological innovation, companies in all regions mentioned the lack of a financial framework. Most European schemes do not fit the specific needs of textiles and clothing companies, but they mentioned innovation vouchers (North Portugal) or tax relief (France) as alternatives. An alternative model identified if innovation activities do not fit into the existing European programmes, is that companies do it at their own expenses or through national smaller scale projects that only fund part of the innovation pipeline activities. This situation was identified in the case of companies with product innovation in

North of Portugal or Romania. Their innovation ideas would certainly not succeed in any European call for proposals, despite being sufficiently interesting (novelty) for the market, such as new to firm or new to market innovations. Several companies in different cases (Portugal, Slovenia and Romania) pointed out the absence of a funding scheme addressing close to market innovation related activities within the European framework.

In the case of Baden Württemberg, public funded R&D is of marginal relevance to the core R&D processes. The processes could be described as a constant iterative process between several actors, either based on formal or informal road-maps or on a project oriented approach. This type of innovation does not combine easily with public funding in terms of project management. The region finds itself very much self-supporting and national funding (possibly with bridges to Austria and Switzerland) is preferred over large EU consortia. The latter are only sought after for more exploratory research on long term challenges. The presence of local research centres is however important for engineering support and testing. Competition between centres is a more dominant logic than cooperation, and relations with research in Dresden and Aachen are as relevant as those with regional centres.

Regarding the awareness of European funding, the European Framework Program (FP6 and FP7) comes first on the list and only after the CIP program appears, no matter in which regional case this issue in presented. Within FP6 North Portugal leads the number of project participations with 13 project participations involving ten different organizations, while Romania have participated in four projects with four different organizations and Slovenia appearing in only one project. Regarding FP 7, the participation is quite more balanced between countries/regions: North of Portugal (seven projects, 12 organizations), Romania (eight projects, 11 organizations) and Slovenia (eight projects, 12 organizations). The improved balance among the regions is due to the fact the FP6 program was partly before the accession of the new member states.

The position of Baden Wurttemberg is very modest with only two participations in FP6 and three in FP7. In all instances ITV Denkendorf is the coordinator and there are no industrial partners from the region. In Lombardia and Piemonte the combined score is three projects in FP6 (of which Leapfrog) and four under FP7. Participants are mainly suppliers to the textile and clothing industry.

No spontaneous reference or comment in particular was made in any interview about the “Community Framework for State Aid for Research, Development & Innovation” in any of the regions addressed by Task 6, innovation. State aid aspects are covered by the existing funding schemes. In the case of Interreg projects state aid is subject to a specific declaration to be signed, but this rather considered an administrative procedure and not a strategic aspect. Only in the Romanian workshops, the subject was brought indirectly to discussion but without any specific concern. This is a possible sign for a lack of awareness among the companies regarding this subject. This debate has been probably kept at a more political level. Since a number of regions have developed a innovation funding system, and since companies perceive a lack of transparency about national and regional scheme, an uneven playing field was mentioned. However companies present in regions with a good aid framework often complained that it obliges them to work with companies and centres in the region, while this is sometimes second best.

A funding model where companies fund with its own resources all the innovation related activities, at closer to market stages can sometimes show up linked to an European funded project. In these cases the European project is mostly used as a source of knowledge and funding, which is somehow strategically interesting for the business, despite very often being too much precompetitive and disconnected from the market short term needs or from the short term needs of the company (see the case of FIRI VIGONIA in Romania). European funded projects seem to have a long lead time between project results impacts in the market and its formal ending. The predominance of scientific research within the European funding schemes has been recently highlighted within an international benchmark on the share of basic, applied and development activities funded by the US, China, South Korea, Japan,

and the EU[69]: Korean, Chinese and US federal R&D funds mainly go to applied "Development" where Europe has the highest share of basic research funding. Still in what funding schemes is concerned, it was interesting to notice the proposal of an interviewed company (Romania case) towards a system of exploratory studies to be performed before submitting a project proposal, with the aim of improving the proposal's consistency and thus increasing the success probability rate of the project.

Innovation strategies following more a problem solving approach rather than an innovative product or process development are very often guaranteed by fibre supplier's laboratories or by chemical products supplier's laboratories, which are driven by the identification of new market opportunities. Both the Baden-Württemberg and Lombardia-Piemonte cases support those findings. Joint approaches between both machinery suppliers and chemical stuff suppliers, towards a more effective implementation of innovative processes is becoming a common trend, particularly in processes like scouring or washing, where the crossed linked effect of machine technology and the detergency or auxiliary products formulation plays a critical role.

IPR is still a complex issue for companies to manage within the innovation pipeline, even for those with a relatively high qualified internal R&D staff. Task 1 survey about how companies protect their intellectual property supports this finding, since the higher number of answers indicated "no IPR protection", followed by "trademarks registration". This difficulty is more critical for SMEs. IPR registering is still considered to be expensive and complex, but there is a lack of knowledge even regarding simple and cheap procedures, that can at least provide some protection in early stages of product development. Germany is by far the more active country regarding patenting, position that is in line with the dominance of this country regarding two kind of business which are more suitable for patenting activity: technical textiles and textile machinery construction. Textile companies are patenting more often than clothing companies, which usually tend to use trademarks and designs. The patenting cases are often connected to more developed companies, in most cases not SMEs, either with a strong qualified internal R&D staff or with a strong cooperation link with Universities or other R&D supplier, like in the case presented in the North of Portugal region. A patenting strategy seems to be more applied in highly regulated markets, with a tendency of oligopoly because of barriers of entry created by strict standards and certifications; in particular companies make more use of patents when textile products are used in the medical and healthcare market, personal protective equipment and composites.

There is a gap between European strategic R&D topics or thematic addressed by European projects and companies strategies, particularly in the case of those companies which strategy is completely focused in the fashion business. As we found for example in the North Portugal and Galicia or in the Romanian cases, this gap is even accentuated in the particular case of clothing manufacturing companies, with or without retail managing competences, which found it difficult to fit their innovation strategies into the European framework programmes guidelines. The agendas and roadmaps are very much oriented to the western European reality and are much more focused on textiles than on clothing.

The Lombardia-Piemonte case show a good dynamic of innovation in the market sector, with limited public involvement. In both subcases the dynamics are portent of further incremental step by step improvement and further diffusion of innovation. What both subcases also show that next challenges may need more intensive involvement of public research and public funding. Moreover initial public research, sometimes funded by the E.U. has been instrumental to set a dynamic in motion. It then also shows that the lead times between proof of concept

[69] Source: Science & Engineering Indicators, National Science Board, 2010 Digest, NSF, OECD Research

and implementation is long, between 10 and 15 years. It may furthermore be the case that competing smaller projects are more successful in delivering results (in which one can shop), than large integrated projects. But considering the time lag, it may be too soon to say.

The Lombardia-Piemonte subcases do also demonstrate that the innovation logic goes beyond the regional and national borders. We have taken two cases where a critical mass is present in the region, however key inputs are provided from outside the region and also companies somewhere else benefit from the results. The uptake of critical challenges such using digital technologies to functionalize materials, and to integrate mass-customization with digital technologies is such a challenge requiring a European approach and possibly public research and funding. The two cases also demonstrate the power of technology to keep production in Europe. This comes through the importance of time (short lead times), high quality, complexity of technology and logistics; however it goes too far to state that it may leads to a return of manufacturing of production to Europe. There is ample evidence that made-to-measure production is also being set up in new member states, Northern-Africa and Turkey. It is more a matter of strategy and organization than of geography.

Innovation in North Portugal and Galicia is following different patterns, mainly due to the stronger presence of textile companies in North Portugal, which makes the sector more diversified in that part of the region than in Galicia. In North Portugal technical textiles and other product oriented innovations, towards specialized applications and markets are more important, as well as process innovation leading to product differentiation (new finishing, new fibre blends and new functionalities). In Galicia, the stronger presence of clothing manufacturing companies working in the fashion business is mostly due to the Spanish market (with the exception of INDITEX that represents 90% of the region exports), under a model which is strongly influenced by the INDITEX phenomenon, drives innovation through a path which is more focused on organizational innovation. Due to the presence of clothing companies there is also a focus on organizational aspect, in particular logistics, retail management or marketing innovation. Non technological and organizational innovation practices, namely through design and creativity, are strongly adopted by all clothing manufacturing companies within the region of North Portugal and Galicia, disregarding their business models, which in this region is mostly assuming an hybrid model that combines private label with own brand production.

Looking at the common factors from the case study on North Portugal & Galicia, it would be fair to state that in general, those companies working for INDITEX have developed their skills and have improved their capacity in three major fields: 1) Product development (independently from the degree of trend interpretation and from the audacity of the style and design proposals incorporated in the product); 2) lead-time management – having the reliability and self-assurance security to assume compromises for very short lead-times, without having the risk of systematic failure; 3) Product control – having implemented routines and systems for product and production monitoring, inspection and testing in order to have reliable information about product quality and delivery time accomplishment. According to most of the statements, it is possible to say that while factor 1 is not the reality for every single company working with INDITEX, most probably factors 2) and 3) are present in almost every company.

When trying to frame the above skills and competences within the innovations categories, it is clear that the INDITEX effect is much more felt in the organizational innovation field than in the product innovation category, despite the fact of incremental product innovation cases being normally present within any of the mentioned cases in the North of Portugal region.

The Slovenian case supports the idea that innovation is clearly in the agenda of companies as an important competitive factor towards international markets. Clothing manufacturing is not representative within the Slovenian sector therefore most of innovation paths that are followed by the companies are in line with fibre and

textile related fields of development, with similar drivers to the ones found in North Portugal. Eco-innovation and process innovation strategies towards more efficient use of resources are very often adopted by companies which find a well-developed R&D capacity available in that particular field at university level. The link between universities and companies towards more significant innovation impacts within the market has a good margin to evolve, since there is no strong institute playing an effective interface role as an a innovation facilitator within the sector.

The Romanian case can be characterized by a strong focus in production capacity and its associated supporting services. The strong presence of foreign companies which have installed their production centres in the country, due to a competitive labour cost offer, it is still important when it comes to build the present sector's profile. Innovation is seen as something important for the future, but is still far from being in the top of companies agenda today. Non technological innovation will have an important role for the clothing manufacturing companies, which are starting to develop a shifting and evolving process from a pure CMT model. In these cases, the perception of design and creativity as very important assets for that process is clearly perceived. Supporting services and R&D infrastructure are not as developed and well equipped as they are in Slovenia or in North Portugal and Galicia, situation that can be a barrier for addressing ambitious innovation challenges in the near future.

Looking into the regional performance of the sector regarding innovation, specifically on the regions that were addressed in this chapter it is possible to categorize three levels of maturity and performance. Baden Württemberg is clearly in a leading position, with more advanced practices regarding innovation performance, which benchmarks this region in accordance with the best ranking position of Germany regarding relevant indicators such as: share of T&C enterprises engaged in innovation activities, share of innovators introducing product and process development and innovation expenditure. A second group composed by Lombardia-Piemonte, Slovenia and North Portugal-Galicia, which are closer to each other both regarding the practices identified in the field, and in terms of most relevant CIS 2008 benchmarks, like the share of enterprises engaged in innovation or the innovation expenditure. In any of these three regions a positive dynamic is identified regarding innovation performance and its importance is clearly recognised by the companies together with creativity and internationalization as absolutely crucial factor for the future of their business. The third level is occupied by Romania which is still a few degrees below the average and where production based strategies are the dominant cases, with companies looking into production capacity and service performance as the more critical competitive values. Regarding most of the CIS 2008 benchmarks, Romania is ranked clear below average in most of the relevant indicators. However it should be highlighted that despite this situation, both regional clusters identified in Romania, considered innovation as an important issue in their road mapping documents.

Regulation in application markets is an important driver for innovation. This is especially the case in protective textiles within the PPE directive (89/686/EEC) and norms derived from it, as it was found in several cases of companies working on technical products in the North of Portugal and in Germany. In automotive industries, car safety, lower fuel consumption, recycling of cars drives innovation are innovation trends derived from market regulation that influenced also textile suppliers. However for ICT domain a regulatory power is absent. Hence this leads large players to set their own standards. Despite the role of DTB, as an industry group, the industry has not been able to organize a single voice towards the ICT or retail industry. This is not a failure at German level. Similar initiatives in France, UK and Netherlands have failed.

Technical textiles are seen by the vast majority of the companies as an opportunity for setting the business up to higher value standards but at the same time is recognised to be a very difficult market to enter, requiring deep knowledge of regulatory standards and legislation, besides high technical skills. This was particularly found in more than one case in North of Portugal, for the case of medical and healthcare products. In fact those markets are

characterized by barriers of entry that create a competitive advantage for the incumbent . This is especially evident in highly regulated markets, like the automotive sector or the aeronautic sector, where only few competitors dominate the scenery. There is a second type of technical textiles markets, with relatively lower barriers of entry such as sportech, clothtech or hometech[70] However in some cases those markets present an high degree of fragmentation, which follow a product/project approach, without leading to a consistent critical mass building within a specific application sector. In this case companies tends to end in a combined product portfolio between traditional and technical textiles, developing too many different things and in several cases referred to this development process as being more "fun" experiments than real business.

Market innovation creates barriers of entry into markets and even oligopolies. In the clothing industry with low capital intensity, the ICT investments in the back-office and for e-commerce are substantial and foster brand recognition of large companies. In technical textiles the regulatory context, the permanent effort in innovation, the demanding requirements of clients demand a very high level of professionalism that is hard to reach when a company comes from a fashion background. However large SMEs (typically between 20 and 50 Million Euros turnover) can develop a good niche in technical textiles. For companies having attained these standards, the high barriers of entry supports survival and profitability. However this is equally important in an industry with low entry barriers. For companies not yet at this level, the costs of transition to niches or a controlling position in a value chain is a risky and expensive venture.

Formal clustering activities and organizations have been identified in almost every region or country and in some cases innovation is the particular focus of such clusters and organizations. This is the case of the ASTRICO cluster in Rumania, the Portuguese Fashion Cluster or the PTIC initiative in North Portugal or even the EURCLUSTEX initiative (North Portugal and Galicia).The Italian case of Lombardia-Piemonte or the Baden- Württemberg could be considered as evolved clusters even if such clustering activity is rather informal and not institutionalized. Very often formalized clusters are the platforms to adapt European roadmapping documents or strategies into the sectors specificity within those particular regions. There is an evident concern in improving the quality of the cooperation links within the innovation players towards achieving better results in the market, with higher visibility and with stronger induction and positive contamination effect to other companies. At the same time internationalization promotion, as a strategic development vector for all companies (either innovators or followers), is frequently present within the same strategic umbrella of increasing competitiveness.

Looking into the description of chapter 2 (Technology Overview) together with different opinions collected during several field interviews with company experts in almost every regional cases, it is expected that some specific technologies will play a leverage effect on the innovation performance of textile companies. It seems that innovative/specialty fibres (both synthetic and natural based) and special finishing technologies such as coating, laminating or other textiles functionalization techniques, will play a very important role in innovative product development. From the process innovation side, eco-efficiency towards less water, less chemical products and reduced energy consumption will certainly be the drivers of the future. Looking into clothing manufacturing the trend will be to adopt a set of technologies allowing the implementation of more collaborative design strategies between client and supplier (within the value chain), process versatility towards the possibility of assembling wider ranges of different materials, innovative marketing tools and smart retail management technologies, addressing shops and other consumers relation platforms, either under traditional commerce channels or through electronic commerce.

[70] according to the Techtextiel nomenclature presented in subsection 2.2.3 – Technical and Smart Textiles)

Activities related to non technological innovation, are strongly based in processes like creativity, design, logistics, product communication and marketing; they are considered by several companies in every regional case as important innovations per se and as relevant as innovative products or innovative processes. Those kinds of activities are considered by innovators as crucial when it comes to transform R&D results into successfully innovative products in the market. Companies from the North of Portugal & Galicia case, working in the fashion retail business model for groups like INDITEX, support the importance of non technological innovation in this particular kind of textile & clothing business.

No particular signs of relevance or any systematic reference was identified or pointed out by any interviewed company regarding emerging trends or phenomenon like crowd sourcing, the use of social networks as an input for product development and innovation and the adoption of competitive intelligence or technology watch methodologies. Despite not being pointed as such, it is quite certain that social networks are most probably instrumental for catching final consumer information and to improve customer emotional relationship with brands, namely in those companies acting in both production and retail. However, e-commerce strategies have been identified in different cases (North Portugal-Galicia, Baden-Württemberg and Lombardia/Piemonte) are also in-line with interesting growing rates of Internet sales and with importance of that specific marketing channel which is presented in subsection 2.2.4 (commercial Innovations)

Regarding the delocalization of R&D departments from European companies, no special reference or sign of such kind of strategy was identified in any of the cases or in any of the interviewed companies. A phenomenon which can be considered close to this, but at the same time following a completely different purpose, is the contract of local designers in specific international targeted markets. The purpose of such strategy is to use local designers that can better incorporate local trends into the design process, while at the same time they are often engaged in the commercial activity for that specific market, therefore being also responsible for the commercial success of their creations.

Looking through all the success stories and cases that were presented in the different regions is possible to identify common critical factors which are considered relevant when it comes to innovation performance. The strong link with suppliers (raw materials, chemicals and sometimes technologies) is present in every case and particular for SMEs this is a very relevant input for innovation. The engagement of the client (in both business to business and business to consumer cases) through more or less formal methodologies it's also a common factor which is present in every success story, with particular relevance in the case of B2C relationships regarding incremental product innovation or non technological innovation strategies. Interaction with users has been mentioned several times as one of the richest information sources for innovation. The importance given to marketing and communication specificities, when it comes to present an innovative product, within or not the usual markets, has been underlined in almost every case as having a critical influence in the "new product" success. This factor is even more critical when the innovation strategy addresses non-traditional markets, where also specific legislation and regulation issues have been pointed as one of the critical common innovation barriers. The importance of industrial know-how is present with higher or lower intensity in every case, directly or indirectly. The role of innovation centres and R&D centres in the innovation pipeline, beyond the latest stages of the development processes, which is more relevant in the case of SME's, seems to be connected to a role of information providers acting sometimes as hubs to reach less known application sectors from the companies point of view.

The future outlook for innovation is rather positive as many companies are focussed on it. Most of innovation is in incremental product development and processes, much less is in non-technological innovation or in radical innovation. The more radical innovation is rather based on a research push model, as we have analysed in the

Report on Research (Task 2). The outlook is rather positive for innovation when a leading customer takes the lead (e.g. Inditex or BMW) or when a technology push is manifest (e.g. digital printing). Competition between retailers, clients and suppliers also fosters innovation, especially since a cooperative approach is harder to organize. Innovation requiring the organisation of the supply chain such as ICT standards or adoption of biofibres remains fragmented. Fragmentation, also enhanced by institutional barriers such as difficulties to cross-border cooperation or regional funding of innovation enhances this fragmentation.

ANNEXES

ANNEX I: ROUNDTABLES AND INTERVIEWS

For the purpose of this study on-field activities were carried out, namely:

Companies interviewed for the Lombardia case. In some cases only questions to non identified agents during trade fairs were carried out

N.	Name (Person)	Name of Company/Organization
1.	Ludovico Lanza	Arioli (textile machinery producer)
2.	Sig. Cominetti	Achille Pinto (printer)
3.	Sig. Corti	Achille Pinto (printer)
4.	Marco Brenna	Stamperia di Lipomo
5.	Paolo Torricella	Reggiani Macchine
6.	Antonino Tricomi	Reggiani Macchine
7.	Head of digital Dpt.	Stamperia Chiara
8.	Senior operator of digital Dpt.	Stamperia Chiara
9.	Sig. Alberio	Stamperia Ellebi
10.	Ugo Zaroli	For.tex
11.	Cesare Losavio	Ratti
12.	Agent at trade fair	Robustelli
13.	Agent at trade fair	Vitale Barberis Canonico

14.	Luciano Bandi	Loro Piana
15.	Ercole Botto Poala	Reda
16.	Agent at trade fair	Munro
17.	Agent at trade fair	Corneliani
18.	Agent at trade fair	Ermenegildo Zegna
19.	Dutch Agent at trade fair	Caliban

Companies examined/interviewed for Baden-Württemberg. In some cases only questions to non-identified sales agents during trade fairs were reported.

N.	Name (Person)	Name of Company/Organization
1.	Agent at trade fair	Dornier
2.	Stefan Zaman	Groz Beckert
3.	Zees de Baat	A3
4.	Jeorg Seifert	Freudenberg
5.	Agent at trade fair	Paul Hartmann
6.	Agent at trade fair	Rokona
7.	Werner Moser	Mattes und Ammann
8.	Agent at trade fair	Christian Eschler
9.	Jan Hilger	Hugo Boss

10.	Agent at trade fair	SAP
11.	Andreas Schneider	GCS
12.	Agent at trade fair	Modint GmbH
13.	Anna Niess	Dialog Textil-Bekleidung
14.	Christof Riethmueller	ITV Denkendorf
15.	Stefan Mecheels	Hohenstein
16.	Agent at trade fair	BASF
17.	Agent at trade fair	Lohmann and Rausher
18.	Agent at trade fair	Dr Petry GmbH
19.	Oliver Gerlach	Huntsman
20.	Holger Daniels	CHT Beitling
21.	Agent at trade fair	DILO
22.	Stefan Kehry	Benninger

North Portugal and Galicia case

One roundtable in Portugal and one in Galicia (also for the work of task 3) and individual interviews were performed. The individual interviews and the round table participants within Portugal are presented below while for the Galicia case that information has been presented within Task 3 report.

Portugal and Galicia Individual interviews

N.	Name (Person)	Name of Company/Organization
1	Alexandra Ferreira (Product Manager)	SALSAJEANS (Denim wear producer & retailer)
2	Duarte Nuno Pinto (President of Board)	P&R (Sport clothing manufacturer)
3	Manuel Pinheiro (CEO)	TINAMAR (Dyeing & Finishing Company)
4	Carla Pires (R&D Manager)	IMPETUS (Underwear producer)
5	Claudio Carvalheira (CEO)	NEW TEXTILES
6	Rui Teixeira (CEO)	GULBENA
7	Joaquim Moreira (CEO)	TETRIBÉRICA
8	Asdrúbal Azevedo (CEO)	A2
9	Álvaro Rodríguez Toubes (MD)	PAZ RODRIGUEZ
10	Fernando Trebolle (MD)	FAT OLD SON
11	Alberto Guisande	COINTEGA
12	Fernanda Valente (CEO)	Fernando Valente

Portugal Round Table, 24-11-2011

N.	Name (Person)	Name of Company/Organization
1	Gonzaga Oliveira (CEO)	Artefita, Lda. (Narrow technical fabrics producer)
2	José Pinto (R&D Dep.)	Artefita, Lda. (Narrow technical fabrics producer)
3	Artur Belém (CEO)	Crispim Abreu (Knitted Clothing manufacturing)
4	Carla Freitas (CEO)	F.D.G. – Fiação da Graça, S. A. (Yarn Producer)
5	Fernando Eblagon (R&D Manager)	Lankhorst Indutech Cerfil, S. A. (Ropes and nets producer)

6	Hernâni Gouveia (CEO)	Moda21- Tinturaria e Acabamentos Têxteis, S. A. (Dyeing and Finishing Company)
7	Vanessa Coelho (R&D Dep.)	New Textiles, Lda. (Healthcare/Medical Textiles)
8	João Batista (Innovation Manager)	Riopele – Têxteis S. A. (Fabric Producer)
9	Sandra Ventura (R&D Manager)	Têxteis Penedo S. A. (Home textiles producer)
10	Manuel Pinheiro (CEO)	Tinamar – Tinturaria Têxtil, S. A. (Dyeing and Finishing Company)
11	Fernando Nunes Ferreira	Minho University
12	Rui Miguel	Beira Interior University
13	Maria José Machado (Researcher)	CENTI (R&D Centre)
14	António Sousa Correia	IMATEC (Portuguese Textile Innovation Club Manager)
15	José Morgado	CITEVE (Technological Centre)

(Galicia's round table and interviews are presented in Task 3)

Slovenia case

Roundtable at the Chamber of Commerce and Industry of Slovenia, attended by entrepreneurs of local T/C companies, representatives of Ministry of Economy and Ministry of Education and Science and Universities. Meetings with individual companies, with the University of Maribor and with the Director of the Textile, Clothing and Leather Processing Association.

Ljubljana Roundtable 11-10-2011

N.	Name (Person)	Name of Company/Organization
	Alenka Majcen	University of Maribor
	Majda Smole	University of Maribor
	Daniela Pavlinic	BIOMED (Consultant and Service)
	Barbara Ulcnik	INPLET (Knitting Fabrics)
	Jozica Weissbacher	GZS ZTOUPI (Textile, Clothing and Leather

		Processing Association)
	Lucija Kobal	TEKSTINA (Fabric producer)
	Aleksandra Lobnik	IOS (Technology Provider)
	Denis Jamic	AQUAFIL (Fibre Producer)
	Andrej Demsat	University of Ljubljana
	Petra Forte	University of Ljubljana
	Natasa Persu	University of Ljubljana
	Ulban Kronkav	Ministry of Science and Education
	France Debelak	PREDILNICA LITISA (Yarn Producer)
	Matej Novak	Ministry of Economy
	Verica Zlabravec	IRSPIN (Technology Platform)

Individual Interviews, Slovenia

N.	Name (Person)	Name of Company/Organization
	Alenka Majcen	University of Maribor
	Edi Kraus (GM)	AQUAFIL (Fibre Producer)
	Simeon Spruk (GM)	TEKSTINA (Fabric Producer)
	Joze Smole (GM)	GZS ZTOUPI (Textile, Clothing and Leather Processing Association)
	Daniela Pavlinic (CEO)	BIOMED (Consultant and Service)

Romania case

Two roundtables, one in Neamnt at the ASTRICO Cluster head office and one in Bucharest at INCDTP, both attended by entrepreneurs of local T/C SMEs, as well as by representatives of Employers Associations, of Textile and Clothing Industries and Technical University.

Neamt Roundtable, 10-11-2011

N.	Name (Person)	Name of Company/Organization
1	Manuela Mihailiasa (CEO)	SOFIAMAN (Knitted clothing manufacturer)
2	Maadalina Tanasa (Secretariat)	Astrico Nord EST (Textile Cluster)
3	Serban Stratila (General Manager)	Astrico Nord EST (Textile Cluster)
4	Ion Stratila (Managing Director)	RIFIL (Yarn producer)
5	Luigi Bodo (President of Board)	RIFIL (Yarn producer)
6	Sorin Chiriac (CEO)	SMIRODAVA (Knitted clothing manufacturer)
7	Emilia Visileanu	INCDTP (Research Institute)
8	Carmen Loghin (Dean)	Faculty of Textiles Leather and Industrial Management
9	Mariana Ursache (Professor)	Faculty of Textiles Leather and Industrial Management
10	Mr. Alexandru Arosoaie (General Manager)	JATEX (Knitted clothing manufacturer)

Bucharest roundtable 11-11-2011

N.	Name (Person)	Name of Company/Organization
1	Aurel Hofman	TESATORIILE REUNITE (Fabric Producer)
2	Emilia Visileanu	INCDTP (Research Institute)
3	Adrian Taras	TRANSILANA (Yarn Producer)
4	Sara Wechsler	DATSA (Knitted clothing manufacturer)
5	Siddhant Sharma	UCO RAYMOND (Denim producer)

6	Chivu Minela	TANEX (Clothing manufacturer)
7	Carmen Ghituleasa	INCDTP (Research Institute)

Romania Individual interviews

N.	Name (Person)	Name of Company/Organization
1	Manuela Mihailiasa	SOFIAMAN (Knitted clothing manufacturer)
2	Emilia Visileanu	INCDTP (Research Institute)
3	Ion Stratila	RIFIL (Yarn producer)
4	Paulo Meireles	TRIMSOL ROMANIA (Seat Cover Manufacturer)
5	Aurel Hofmann	TESATORIILE REUNITE (Fabric Producer)

ANNEX II: BIBLIOGRAPHIC REFERENCES

[1] John Provost, "Dynamic Response in Textile Printing", Textile Chemist & Colorist, Vol 27, No. 6, pg.11, June 1995.

[2] John Provost, Mike Freche, Elrike Hees, Michael Klug, Juergen Weiser, "Ink-Textile Interactions in ink Jet Printing" – "The Role of Pretreatments", BASF Aktiengesellschaft, Ludwigshafen, Germany.

[3] H. Ujiie, "Digital Printing of Textiles", Woodhead Publishing Limited in Association with The Textile Institute Woodhead, Cambridge England, 2006.

[4] John Provost, "Print Heads for Digital Textile Printing – Current Market Situation", Provost Ink Jet Consulting Ltd. (www.provost-inkjet.com), 2010.

[5] John Provost, "The Name of The Game is Speed", Digital Textile, Issue 5 2011, pg.21-35, 2011.

[6]. L. Thompson, IMI / IT Strategies Digital Printing of Textiles Conference, 3rd Annual, pg. Thompson, 1999.

[7] Brooks G. Tippett, "The Evolution and Progression Of Digital Textile Printing", Digital Printing Systems, Orangeburg, New York, USA

[8] http://textileandfashions.blogspot.com/2011/04/production-digital-textile-printing.html

[9]http://www.wideformatonline.com/index.php/home/553-dupont-imaging-technologies-previews-new-digital-textile-printing-system-at-itma

[10] John Scrimshaw, "Digital Textile Has a Long Way to Grow", FESPA Digital Conference, Conference Report, Digital Textile, Issue 3 2011, pg.30-32, Hamburg, May 2011.

[11] John Scrimshaw, "Fast Printers Make First Appearance", Digital Textile, Issue 3 2011, pg. 22-29, Fespa Digital, Hamburg, May 2011.

[12] CIRFS, "World markets for technical textiles to 2012", International Newsletters Ltd, 2007

[13] David Rigby Associates, "Technical Textiles and Nonwovens: World Market Forecasts to 2010", Manchester UK

[14] http://techtextil.messefrankfurt.com

[15] Chemical Fibres International – Textile Techology, "Fiber Polymers, Fibers, Texturing and Spunbonds", September 2011, D 2027 E

[16] Textiles Intelligence Limited, "Technical Textile Markets: Business and market analysis for the world´s technical textiles industry", No 86 3rd quarter 2011

[17] EURATEX, ETP, *Strategic Research Agenda",* 2006

[18] European Foundation for the Improvement of Living and Working Conditions, “Trends and drivers of change in the European textiles and clothing sector: Mapping report”, 2008

[19] M. Kolybaba, L.G. Tabil, S. Panigrahi1, W.J. Crerar, T. Powell, B. Wang -Biodegradable Polymers: Past, Present, and Future; presentation at the 2003 CSAE/ASAE Annual Intersectional Meeting, Fargo, North Dakota, USA

[20] Chakraborty, A., Sain, M., & Kortschot, M. In K. Oksman, & M. Sain - Cellulose microfibers as reinforcing agents for structural materials; Cellulose nanocomposites: Processing, characterization, and properties ACS Symposium Series, 2006,(169–186)

[21] Majeti N.V. Ravi Kumar- A review of chitin and chitosan applications; Reactive & Functional Polymers 46 (2000) 1–27

[22] Lenz RW, Marchessault RH - Bacterial polyesters: biosynthesis, biodegradable plastics and biotechnology; Biomacromol 2005, 1–8.

[23] Imam, S. H., Cinelli, P., Gordon, S. H., & Chiellini, E. - Characterization of biodegradable composite films prepared from blends of poly(vinyl alcohol), cornstarch, and lignocellulosic fiber; Journal of Polymers and the Environment, 2005. 13, 47–55.

[24] Hunealt MA, Li H, Chapleau N, Favis BD - Processing and properties of poly (lactic acid)/plasticized starch blends; In: World Polymer Congress and 41st International Symposium on Macromolecules. 2006

[25] European Bioplastics – a vision for bioplastics for nearly two decades

[26] http://www.textileworld.com/Articles/2011/June/Outlast_Polyester_Fiber_Wins_Innovation_Prize_At_2011_Techtextil.html

[27] http://www.nap.edu/openbook.php?record_id=11268&page=6

[28] Wiliam C. Smith, ITA, Greer, SA – High performance and High Temperature Resistant Fibres

[29] Sectoral Innovation Systems in Europe: Monitoring, Analysing trends and identifying challenges – Textiles Final Report – Boheim, M. – Austrian Institute of Economic Research (WIFO), May 2008

[30] Euroclustex – Análise da Indústria Têxtil e Vestuário no Norte de Portugal e Galiza, CENIT, 2009

[31] European Innovation Scoreboard 2006 – Comparative Analysis of Innovation Performance, PRO INNO EUROPE (INNO METRICS)

[32] European Business – Facts and Figures – EUROSTAT, 2009 Edition

[33] Measuring Innovation, Hollanders, Hugo. - Maastricht University,

[34] Directory of technical textiles from Portugal - CITEVE, 4th edition 2010

[35] Sergiu-Valentin PARVAN Statistics in Focus – Science and Technology 116/2007

[36] - Chemical Fibres International, Nº3 September 2011

[37] - http://www.cirfs.org/

[38] - Melliand International, Nº 3 August 2011

[39] - LENZING “A vision to the world of Cellulosic Fibers in 2020”, 50th Man-made fibers congress, Austria 14 September 2011

[40] – NANO textile – Questions and answers on all aspects of using nanotechnologies with reference to the German textile industry. , 1st Edition 2011 – Gesamtverband