

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

TASK 2: ASSESSMENT OF THE WAY SPECIALISED RESEARCH AND INNOVATION CENTRES LIAISE WITH TEXTILE/CLOTHING ENTERPRISES IN 5 REGIONS OF THE EUROPEAN UNION AND THE WAY RESEARCH AND INNOVATION OUTCOMES ARE TRANSFORMED INTO MARKETABLE PRODUCTS/PROCESSES. IDENTIFICATION OF BEST PRACTICES, SUCCESS FACTORS AND DIFFICULTIES. IDENTIFICATION OF POTENTIAL FUTURE DEVELOPMENTS.

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LIST OF ABBREVIATIONS

| | |
|---------|---|
| AiF | Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke" <i>German Federation of Industrial Research Associations "Otto von Guericke"</i> |
| ANR | Agence Nationale de la Recherche <i>National Agency for Research</i> |
| RTOs | <i>Research and Technology organisations</i> |
| AUTEX | Association of Universities for Textiles |
| BG | Berufsgenossenschaft <i>Professional Associations</i> |
| BMBF | Bundesministerium für Bildung und Forschung <i>Federal Minister of Education and Research</i> |
| BMWi | Bundesministerium für Wirtschaft und Technologie <i>Federal Ministry of Economics and Technology</i> |
| BTTG | British textile Technology Group |
| CETI | Centre Européen des Textiles Innovants <i>European Center of Innovative Textiles</i> |
| DFG | Deutsche Forschungs Gemeinschaft <i>German Research Community</i> |
| DTNW | Deutsches Textilforschungszentrum Nord-West e.V. <i>German Textile Research Centrum North-West</i> |
| DWI | Deutsches Wollforschungsinstitut an der RWTH Aachen <i>German Institute for Wool Research affiliated to the RWTH University Aachen</i> |
| ERA-net | European Research Area network |
| ERDF | European Regional Development Fund |

| | |
|--------|---|
| ENSAIT | Ecole Nationale Supérieure des Arts et Industries <i>National School of Arts and Industries</i> |
| ENSCL | Ecole Nationale Supérieure de Chimie de Lille <i>National School of Chemistry of Lille</i> |
| ENSMD | École Nationale Supérieure des Mines de Douai <i>National School of Mines of Douai</i> |
| FATM | Forschungsstelle für allgemeine und textile Marktwirtschaft <i>Center for Research in General and Textile Market Economy</i> |
| FUI | Fond Unique Interministeriel <i>Interministerial Fund</i> |
| IFFTI | International Foundation of Fashion Technology Institutes |
| IFKM | Institut für Konstruktion und Funktionsmaterialien <i>Institute for Structural and Functional Materials</i> |
| IfN | Institut für Nähtechnik <i>Institute for Sewing Technology</i> |
| IFTH | Institut Français du Textile Habillement <i>French Institute of Textile and Clothing</i> |
| ILT | Fraunhofer-Institut für Lasertechnik <i>Fraunhofer Institute for Laser Technology</i> |
| IPT | Fraunhofer-Institut für Produktionstechnologie <i>Fraunhofer Institute for Production Technology</i> |
| IRT | Institut de Recherche Technologique <i>Institute for Technological Research</i> |
| ITA | Lehrstuhl für Textilmaschinenbau und Institut für Textiltechnik der RWTH Aachen <i>Department of Textile Engineering and Institute of Textile Technology of the RWTH University Aachen</i> |
| NPC | Nord-Pas-de-Calais |
| NRW | Nordrhein-Westfalen |

| | |
|-----------|---|
| PPE | Personal Protective Equipment |
| RWTH | Rheinisch-Westfälische Technische Hochschule Aachen <i>Technical University of Rheinisch-Westfalen Aachen</i> |
| SME | Small and Medium Enterprise |
| TBU | Institut für Textil Bau- und Umwelttechnik <i>Institute of Civil and Environmental Engineering</i> |
| TEXTRANET | European Network of Textile Research Organizations |
| TFI | Teppich Forschungsinstitut Institut für Bodensysteme an der RWTH Aachen <i>Textiles and Floorings Institute of the RWTH University Aachen</i> |
| TIM | Lehrstuhl für Technologie- und Innovationsmanagement der RWTH Aachen <i>Technology and Innovation Management Group at the RWTH University Aachen</i> |
| UKA | Universitätsklinikum Aachen der RWTH Aachen <i>University Hospital of the RWTH University Aachen</i> |
| WfK | Cleaning Technology Institute |
| WZL | Werkzeugmaschinenlabor der RWTH Aachen <i>Laboratory for Machine Tools and Production Engineering of the RWTH University Aachen</i> |
| ZiTex | Zukunft Initiative Textil <i>Initiative for the Future of Textiles</i> |

EXECUTIVE SUMMARY

The aim of this task was to analyse in detail how specialised research and innovation centres liaise with textile/clothing enterprises and analyse the process of transforming textile/clothing research innovations into new products/processes available in the market.

In order to identify the best practices that enable good transfer of technology to the market, it was important to identify and map the EU textile centres of Excellence. One of the problems we encountered was due to the lack of transparency in the quality of the research in the networks of technological centres; the 2 major networks for research in textiles AUTEX and Textranet, have not developed formal and structured systems for bench-marking. Moreover, there are regional and national monopolies that prevent competition to express its positive externalities. In general two methods are used (eventually in combination) to assess excellence. One is based on a set of measurable criteria, the other on opinions of selected group of stakeholders. In line with this study the group of stakeholders would be companies. However the surveys in the regions showed that companies are highly selective in their collaboration with research centres. No company in Europe works together with more than 30% of the research centres. Most companies that work with research centres have experience with less than three. A questionnaire approach is unlikely to give good comparable results.

The analysis of objective data is limited to existing data. Most data on output relates to funding (projects funded), publications and patents. In addition some elements can be derived from a systematic analysis of annual reports or websites of research groups/organizations. At times that valorization of research is an important criteria, contribution to marketable results or industrialized processes would be important to disclose. However information here is anecdotal. This is true both in terms of publicly available data or gained in interviews with companies and research organizations. That type of data is not collected and hence we were often limited to the visibility of the person interviewed. This has provided often conflicting data for example a CEO not knowing what happened in the R&D department or differences of valuation of the roles of the company and the university in the contribution to a specific product.

Hence we have mainly used a classic approach to measuring excellence in order to identify excellent research centers while focus on innovation best practices in the regional case studies and company cases. The use of indicators such as publications and impact are widely used indicators to rank and assess the quality of the research of an organization because of their transparency and availability.

We are aware that university ranking systems have limitations. They are often based on indicators such as Nobel Prize winners, publications in journals with very high impact that are not attainable for textiles. In addition most ranking systems favour research with high academic recognition rather than industrially or commercially exploitable results. We are also aware of the fact that rankings take the entire University as a unit of measure rather than a single department. Hence they cover a wide area and that textile is only a part of the research.

Beside excellence in textiles research have been identified other factors that can influence the quality of the collaboration with the industry: co-patenting trends, participation to collaborative projects and funding systems.

Co-patenting is an indicator for the valorisation of public research and occurs when a research centre and a company are jointly mentioned as applicants for patents or as inventors. According to the dataset of selected research centers and companies this only occurred twice, within the context of a European Funded project. Hence Co-patenting was not considered as a consistent indicator of the quality of the collaboration between centres and industry.

Involvement in collaborative projects that benefited from public funding is another indicator of excellence that can be investigated. While information on funded research projects at European level are publicly available through the database Cordis, there is very little transparency in national or regional funding. In general collaborative projects are a good way to foster collaboration between technology centers and companies, while several factors must be considered in order to assess the quality of the collaboration. A project may arise from a clear demand or strategy of a firm or it may be a clear research push. Projects may hence be set up with a clear research leadership with firms as observers and demonstrators, it may also be clearly industry led with research centres focusing on reflection and validation.

The system of funding for technology centers can influence the quantity and the level of the collaboration with the industry. The dynamics of research is related to the systems of funding in place. The members with best public funding are also those with most private research. The quality of funding is determined by the diversity of funding and the reliability of funding. Diversity implies different systems for more fundamental or more applied research, for individual researchers or for large consortia. In Nordrhein-Westfalen and Nord Pas de Calais, the research system has been very apt to absorb the different instruments. It is considered of importance that an element of competition is present. The leading centres prefer funds gained in competition than those earmarked for the sector. Hence framework programmes are preferred over negotiated procedures. In general research firms and companies prefer stable, recurring national programs over incidental and targeted regional programs

Objective of this task was also to carry out an analysis of textile/clothing related patents, designs and trade marks registered. Analysing the database of design cross checking with the list of companies holding patents emerged no correlation with the dynamics of patenting of the industry. In fact registered designs are tools mainly used by large luxury brands for rather recurring patterns. Trade marks are used also by companies active in more innovative sectors but as part of a bigger strategy of IPR protection and communication as showed in the case of TenCate for technical textiles.

The focused analysis of the textile related patents showed that despite the fact that the global number of patent applications in the textile sector is small when compared with other technical fields, there is an interesting growing trend in recent years, which should be connected to the growing importance of technical textiles within the European production, that is more suitable for patent applications. As expected, most of patent applications/inventions in the textile industry are coming from large companies producing chemicals or consumer goods and from larger textile machinery manufacturers while patent activity of small and medium size companies are comparatively small and can be considered marginal. The most trending field for patenting is composed by multi layered products and complex textile structures (fabrics or knitted) with innovative coated solutions, hence technical textiles. Germany is not only the most active country regarding patenting activity but also the only country with a very dynamic activity in several different kinds of classes.

The innovation dynamics of the Industry has been present through the presentation of a number of enterprises that have benefitted from R&D outcomes and have transformed innovation into products. Two extended cases have been presented (Bivolino and TenCate); moreover a bigger selection of short success stories is presented in each regional case. For the extended cases we noticed that EU projects had and are having a significant impact on

the innovation capacity. Another important factor is the important effect of the formation of stable relationships with the centres (dense networks) in fostering trust and reputation; which are important drivers for knowledge exchange and innovation. The relationships have also a more long-term effect on cluster building.

The interviews carried out for the compilation of the five regional cases the factors contributing to the small number of research oriented innovators were discussed. The problems of transferring research results to companies and to the market that emerged were:

- Market dynamics does not reward fundamental innovation. Launching customers are not clearly identified.
- Market dynamics foster short term innovation, while the time to market for fundamental novelties is too long.
- Companies lack in house capacities and skills to engage in medium term innovation. Short term concerns absorb most of research capacity.
- Suppliers often do not offer small volumes of materials to engage into development of new products.
- Internal funding resources are lacking while external funding is too complex.

Thanks to the analysis of the regional cases we isolated the factors that influence the intensity of relation between research centers and companies: Convergence in content of the research, the shape of the institutional system, the cultural distance between companies and research centers, and presence of a clear policy inside the company.

To see the relationship between R&D centres and companies as technology push process does not represent fully the interaction between research and industry. The role of R&D centres can be to initiate fundamental research and innovation, but also to structure knowledge of innovations done in companies, to assist process development, to give a second opinion on new products, to validate and certify (test) results, or to develop training and education programmes. In the best practices we have seen a combination of all of the above. This is however mainly the case when there is strong convergence in content and in human relations.

INTRODUCTION

Although the textile industry as a whole experiences decline in the number of companies and employment, the level of innovation has remained stable as Europe still files close to 50% of world patents in fibres and textiles. Europe still has a considerable research infrastructure in textiles (less so in clothing) with a leading influence and attractiveness for foreign students and researchers. However the evolution of the R&D infrastructure may have been influenced by a focus in funding on projects rather than on capacities, and research is increasing as component for funding compared to education.

Moreover public R&D could be geared to areas with substantial impact factors (nanotechnology, biotechnology) which somehow has greatedened the gap between science and industrialisation or commercialisation. In general fashion (and related textiles) is less oriented to research than technical textiles. Technical textiles has been a growing segment fuelled by substitution of materials towards textiles (e.g. synthetic turf and composites) and encouraged by leading clients (e.g. Airbus). This has also led to new players in the R&D field (e.g. Michelin, Alsthom). However, also in traditional textiles and fashion there is evidence of an increase of patenting.

Since 2004 an increased structuring of Research & Development capacities has occurred under the impetus of the European Technology Platform (ETP) and the European Commission that dedicated specific action lines on textiles and clothing research with an allocated budget yearly of €40-50 Man Under the Sixth and Seventh Framework Programme (FP6 and FP7). This has led to more partnerships between R&D centres and companies, partly in structures of networks like the ETP as well as in projects. Much importance has been given to the involvement of companies in FP7 projects, an element that is pertinent to be evaluated. Leonaviciute (2008) ¹ⁱ has done a thesis on the role of SMEs in FP6 and FP7 projects and this offers a methodology for evaluation (thesis supervised by Scheffer). At the national and regional level, a revival in some regions and a decline in others can be observed, as well as successful clustering compared to fragmentation in others (Saxion, review for Crosstexnet).

Nevertheless the health of the R&D infrastructure in textiles is also debated. An overview made by Saxion/Herriot-Watt for the ETP for the Future of Textiles and Clothing² shows that at large the output of graduates with research graduates is below replacement rate. Institutional factors seem to be at stake here. In addition one has to realise that over the last 18 months, the impact of the economic crisis may have led to retrenchment in R&D.

Over the longer term, innovation has to make a turn from a technology push to a demand pull drive for which the lead markets and challenge based innovation may require new models of organisation. Efforts on research and development are likely to be supported at different political levels (European, national, regional). According to Europe 2020 strategy for smart growth increased focus on large social challenges may for the basis of programmatic funding. On the other side clustering policies foster regional partnerships enhancing recurring

¹ Leonaviciute, G., (2009) *Knowledge spillovers effects and approaches for innovation amongst SMEs involved in EU funded research consortium*, Unpublished Master Thesis, Radboud University Nijmegen, The Netherlands

² Scheffer, M., Wardman, R., (2008) Presentation for the ETP for the Future of Textile and Clothing Conference

connections among Industry, University and Government on the model of the so called Triple Helix. In respect to these two avenues, it is relevant to assess the excellence of research in textiles and to measure the effectiveness of textile research to relate to major challenges and to relate to regional innovation systems. However beyond the regional level this task should also examine European networking with formal networks and within projects between R&D centres.

METHODOLOGICAL ASPECTS

The objective of this task is to analyse in detail how specialized research and innovation centres liaise with textile/clothing enterprises and analyse the process of transforming textile/clothing research innovations into new products/processes available in the market.

The analysis entails the mapping of the R&D infrastructures in Europe at large and a more specific look at the trends in patenting, trade marks and designs as expression of private research; publications and funding of public research and at their interaction. The study will then focus at case studies of selected regions where connections between research centers and industry shall be described. Inside each region will also be presented specific business cases that have benefitted from research policies. The cases to be selected are to be representative of major technology trends such as identified in the Strategic Research Agenda of the European Technology Platform for the future of textile and Clothing or recent technology road-maps developed by Saxion Universities (e.g. Road map for Personal Protective Equipment and US materials research). In addition to regional cases and companies within regions, a limited number of companies with wide European networks in research shall be examined.

In this task we have selected five regions:

- Lombardia-Piemonte
- Nord-Pas-de-Calais
- Nordrhein-Westfalen
- Northwest England
- Lodzkie

And two companies having benefitted from EU funding:

- Koninklijke TenCate NV (NL, Textile - large company)
- Bivolino NV (BE, Clothing - SME)

The requests in the tender document have been organised in a research approach from generic to specific. In addition, in order to segment between tasks 2 and 6, the submitters propose to focus this task to Research and Development which lead to real industry breakthroughs and therefore to patents as a proxy. Task 6 shall focus largely to innovation in a wider sense including incremental innovation and non-technological innovation. Task 2 shall be organised top down, including analysis of accessible project databases (e.g. Cordis), patent databases (e.g. Thomson Scientific Corporation), and publication databases (Web of Science).

The work in this task shall be largely based on databases that are either set up or analysed. It may also benefit of previous road mapping activities as done in Innova projects (by CITEVE) and in Crosstexnet (by Saxion). Beyond this data, interviews shall be conducted to understand patterns and processes of diffusion of R&D results and R&D practices. In particular relations between Textile and Clothing research centres and other research disciplines and with industry have to be assessed. In particular the inception, management and exploitation of results of research

and development projects funded at different levels shall be examined: European (Sixth or Seventh Framework Programme), National (e.g. from French agency Oseo) and regional (e.g. under the funding programme from Regione Lombardia *Metadistretto*). In the regional cases regional authorities shall be interviewed, at the European level project officers but also evaluators and reviewers shall be interviewed as well as companies involved in projects. For some regions round table discussions have been organized to share findings (Nordrrhein Westfalen, North West England and Lombardia).

1.1 RESEARCH CONTEXT

The research infrastructure is undergoing substantial transformation in Europe. In general Universities and Research Centres are granted greater autonomy with the aim to enhance competition between them, more differentiation and specialization. These ambitions are also associated with a quest for excellence. Excellence becomes a criterion for funding, either in basic funding or as a top up. Excellence often requires good scores in rankings, and indeed transparency in output and quality is increasing. Universities are held accountable for the taxpayers, the prospective student and industry. In the same time it is expected that Universities become less dependant of public funding and attract more revenues from industry. This also implies more involvement of industry in governance. This in turn reduces the autonomy of research, but puts also more focus on relevance and valorisation.

These tendencies have first appeared in the UK in the 1980s, followed by the Netherlands, Scandinavia and Switzerland in the 1990s. Over the last ten years Germany and Belgium have become more exposed to transparency and differentiation, and also France entered recently in University reform. Southern Europe and the new member states are still to engage in this reform and restructuring. Currently, the University landscape is in full change, and these changes are quite independent from the changes in industry. These reforms tend to reduce the dependency of funding from student intake (and uptake from industry) and shift it to research programming. Hence, the ability to attract funding from public and private sources is the most important qualification criterion. The participation to cooperative research projects becomes an important unit of measure of success.

These dynamics of reform of University and Technological centers systems is supposed to have impact at different levels:

Firstly is that performance becomes transparent, hence mechanisms of emulation, competition, specialization and cooperation appear. Within textiles, transparency has not yet occurred: the 2 major networks for research in textiles AUTEX and Textranet have not developed formal and structured systems for bench-marking. Moreover, there are regional and national monopolies that prevent competition to express its positive externalities. The substantial risk is that overlaps in specialization will occur or that downsizing will happen for lack of critical mass. It is thus likely that currently no mechanism (funding, governance) leads to concerted action. The European networks lack the will, the power and the instruments to engage in that mechanism.

Secondly the dynamic of change increase the need for critical mass. In order to survive departments must have a minimum size in terms of staff and students. Critical mass can be obtained by merging (e.g. textiles and paper at the University of Manchester), by reorienting courses towards subjects with more student intake (e.g. fashion or aerospace materials). Critical mass can also be obtained by diverting to areas with more research demand, like cosmetics, medical implants and composites. However, cross-border mergers of or cross border specialization has not yet occurred.

Thirdly is the process leading university departments to behave like a business, although a specific type of business. This is not always understood by industry that considers universities as a public good. An element in the declining understanding between research and industry is the lack of mutual understanding of where each business goes. If textile research follows money, it is in the current state unlikely that the textile industry has much buying power. Research will orient itself to sectors with more substantial and stable funding. We are arguing that currently such a shift is occurring.

Finally is that the management of a department is becoming a business. Hence a chair or department head requires substantial financial management skills, management of human resources, of course the ability to have a focused research strategy and strive for high quality and, while having authority also a sensibility for industrial needs. The department head or chair needs to attract funding from several sources and need engage in necessary alliances to obtain this funding. At this moment not all department heads or chairs have as yet the profile to engage in this context. This is often the consequence of a specific socialization in another management regime and constrained by statute of staff.

1.2 ORIENTATION OF RESEARCH

In order to understand the dynamics of the research in textiles it is important to point out that textiles is not a discipline in itself but an aggregation of knowledge from different areas in a technology platform based on specific ways to structure and process materials for specific end uses. Research in textiles comes from different historical backgrounds.

The first attempt for research dedicated to textiles has been rooted in textile schools mostly established in the period 1850-1920 to train engineers. In fact textile schools were early movers and federated a range of technical competences with management and design disciplines. While most surviving textile schools did so by promoting design and marketing, a minority developed into engineering research and became part of broader universities. This is the case for ENSAIT in France.

Then schools established between 1920s and 1950s were mainly focused on mechanical engineering; a need that sprang from the increased complexity of functionality, configuration and control of textile machines. These schools are still firmly connected to mechanical and electronic engineering and to process engineering. This is the case for the institute ITA in Aachen, Germany. In the same period the development of organic chemistry and more specifically of polymer sciences and fibre technology led to the set up textile research closely connected to the development of chemical engineering; this is the case for example for the University of Manchester.

Far more recent is the trend of research connected to specific end users such as composites, geotextiles, medical and biomaterials. Composite research has indeed led to research in textiles disciplines (in the frame of Continuous Fibre reinforced Plastics), but knowledge on this field is often localized in advanced materials aerospace departments rather than textile department. Medical materials and more largely biomaterials are important drivers for research. Also the integration of electronics and materials has led to new paths in textile related research. This theme is often connected to military or to security oriented research or to broader research in occupational health and human physiology.

We can then distinguish four types of orientation of textile related research:

- Fundamental research in materials
- Fundamental research in textiles
- Research towards applied textile materials
- Oriented towards end uses of textiles

In addition there is a much less structured orientation of research towards, management, marketing, arts and design, cultural studies, sociology of work, regional development and development studies. These disciplines are sometimes attached to textile schools, to design schools or it may concern individuals within a department in economics, geography, anthropology or history of art. This is a very mixed bag of disciplines with few federative efforts often concentrated on regional events. Main hubs currently existing is the Copenhagen Business School with a Scandinavian network, Arnhem Research Centre on Creative Industries (Netherlands) within the Organza network (an Interreg IVC project), and the research group in Global Commodity Chains at Duke University (North Carolina, USA) but with an important European network. Attempts have been made to structure research on creative industry, globalization and territorial development, e.g. under the FP7 Socio-economic sciences and Humanities program, under the ERA-NET project Hera-Net (Humanities in the European Research Area), but currently still without a considerable impact. This means that more recent conceptual approaches and findings in economics and management are barely translated to the industry.

1.3 RESEARCH INFRASTRUCTURE IN TEXTILES

Europe still has the most comprehensive and well funded textile research infrastructure in the world with over 40 Universities engaged on a sustained basis in textiles and associated. In addition it has some 50 applied research centres organized in Textranet or outside of this network. At some distance but of relevance is the Coronet network on composites. Furthermore the fashion and clothing technology schools are associated in IFFTI and/or in Cumulus. Other networks concern the textile research group of the International Geographical Union and some networks on cultural studies and fashion organized within the HERA-Net (in fact an ERA-NET project). Then some schools and research groups are not associated to networks, such as the biggest textile and clothing technology school in Europe in terms of students: the Hochschule Niederrhein in Krefeld, Germany. Altogether the system counts some over 150 institutes loosely organized in four networks. This is substantially more than in the United States of America where eight research groups on textiles in Universities can be identified with an additional 20 fashion schools and less than 10 technical centres.

1.3.1 AUTEX

The tangible institutional expression of textile research in Europe is in the organization AUTEX, the Association of Universities for Textiles. It is a global network but Europe is its origin and core. The byword “for” is of relevance since they entail departments within Universities dedicated to textiles. This implies that independent Textile Schools at University level rarely exist while ENSAIT in France is the exception. Textile research groups are now departments at best or disciplines within larger Universities. The key criteria for AUTEX membership is the right to grant PhD and to effectively carry out research at PhD level. Most but not all AUTEX members grant PhD themselves, some do this in association with another University. However not all “schools” having an association are recognized as members. Indeed membership is subject to balloting with some discretionary judgment. The

practice is that some Universities that qualify for AUTEX do not apply, have been refused or have chosen to join Textranet, the other textile research network. The latter case is true for the University of Stuttgart in Germany (that is directly eligible for membership) or Saxion Universities in the Netherlands (that has an association with the Universities of Twente and Nijmegen).

Autex plays an important role in networking of textile research in Europe. Their annual conference has a wide audience with 200 to 300 participants (mainly from academic research); moreover it publishes a research journal and a networked masters (E-Team). The network plays an important role in (informal) brokerage for research projects. AUTEX members do also play an important role in the conceptually complex and labour intensive work of preparing research proposals for the Framework Programme. It is also a labour exchange for researchers as it provides a platform to present research. It is less manifest as a platform for bench-marking for research, but it is an informal arena for academic adaptation and coordination but it is not an active voice in modernization of research infrastructure and policies. Albeit it active in the European Technology Platform for textiles (one member in the governing council) it lacks internal resources to be active in industrial outreach. It has nevertheless become over the last ten years an important rallying point with in principle a potential for further consolidation of research.

1.3.2 TEXTTRANET

Textranet is the network of applied textile research and technology centres. Its objectives are to “provide technical and commercial benefit by participation for all of its members; to promote the exchange of information between its members; to facilitate the establishment of trans-national projects, with particular emphasis on those receiving European funding; to develop and maintain co-operative links with professional and textile associations, particularly those having a pan-European activity; to provide a forum for the promotion of technical progress within the European textile industry”.

Textranet has 32 members in the European Union. Germany and Spain have each four members, Italy has three members, the Czech Republic two and all other EU members, if any, have one member. In fact 20 member states have at least one Textranet member. Not all applied research institutes are member of Textranet: for example in Nordrhein-Westfalen, the textile institutes TBU and TFI and in Italy Stazione Sperimentale per la Seta (SSS) are not associated, although they are well established applied research centers.

Membership is also restricted to centres having the majority of their income deriving from commercial activities. All the Textranet members, except three (TNO in the Netherlands, VTT in Finland, Swerea in Sweden) are specialized in textiles or adjacent sectors.

The main commercial activity performed by the centers is testing. It is followed by engineering services, technological advice and dissemination including training. Over the last years a number of Textranet members have enhanced their manufacturing facilities hence they can engage in pilot production or small scale manufacturing. However besides the commercial activities they engage in collaborative research, and indeed are highly active in European funded research. In fact for a long period of time they had clear leadership in coordination of projects, while over the last five years they have lost market share to Universities.

Some institutes are partly funded by a generic endowment from public resources, but in general this fixed revenue is under pressure for public budget reasons or for the potential of the industry to support specific levies.

Their formal nature differs since they are either closely linked to the industry as associations or foundations (e.g. Centexbel in Belgium) have a public status (e.g. TNO in the Netherlands or IFTH in France) or a private status (research institute Hohenstein in Germany). Hence the governance differs from centre to centre, but in general industry is closely associated with the governance of the centres. Of relevance is that five Textranet members have also the status of University department, three of them are in Germany.

Their nature often limits them to work mainly inside a member state or even a region. Although the national and regional funding mechanisms do foster such a bias, activities of the centres are rarely limited to the region, while the majority of their income often comes from the region. That has much to do with their implantation in regions with a high representation of textile industry.

Some centres have engaged in policies of internationalization. Centexbel is active selling services in Northern France and Belgium. Citeve and Hohenstein have set up subsidiaries abroad. Internationalisation is a prevalent trend for the institutes when it comes to commodity services such as tests.

Despite the reduction in size of the industry and internationalization strategies, there has as yet not been a clear specialization of centres. If any, it is often related to the specialization of the sector in the region. In fact there are few mechanisms fostering specialization and complementarity. This means that except for the largest companies, there is little transparency in the offer of the centres. Two exceptions are cooperation amongst the Scandinavian institutes and intensive cross border cooperation in the North of France with Flanders and (less so) in the Triangle Saxony- Poland – Czech Republic. One of the objectives of Crosstexnet is to foster bench marking and cooperation amongst the centres.

1.4 ANALYSIS OF THE CURRENT SITUATION IN TEXTILE EDUCATION

The main purpose of universities active in textiles is education although research is rapidly becoming the primary activity. In order to understand trends in research, some background in trends in education is needed. Education is than no longer a self standing objective, being to train graduates for employment in industry, but becomes a necessary condition to train future researchers. A worrying trend, which has been subject of a survey carried out by the author in 2008, is the decline of student enrolment in textile education.

AUTEX and the French School for High Studies in Engineering (HEI) are currently assessing the structure, strengths and weaknesses of the educational system. Current knowledge puts forward the unevenness of the educational system in quantitative and qualitative terms. Overall estimates point out that the current student population in textiles, fashion and design is around 10.000 to 12.000 students. However in the fields of textile and clothing technology the population seems to be of the order of 1680 undergraduate, 385 Masters student and 45 PhD students. This is in comparison with an industry of approximately 2.5 million workers, with an estimated 10% employed with a higher education degree. (ca. 250.000 employees). While most studies done over the last 15 years point towards a stable or increasing need for higher educated staff (IFM 1994, IFM 2003, IFM, 2007), the quantitative output of qualified textile technology graduates has declined.

The ability to transform the industry from a resourced-based to a knowledge-based industry is also threatened, as total PhD enrolment in textile research is below 100 students. This means that the PhD training is below even the replacement rate for higher education needs, let alone the requirement for textile researchers for industry. This

means also that if FP7 funding is calculated in PhD equivalents the current level of funding (ca. 10 Millions for RTOs a year) cannot be properly absorbed by the industry.

There are however important geographical imbalances: three countries in Europe account for the majority of total student enrolment: Germany, the UK and the Netherlands; each with more than 1500 students. Germany has maintained a substantial industry, while UK and the Netherlands have a limited industrial basis. It is worrying that student enrolment in countries with still a sizeable industry is far below replacement rate (e.g. Italy, Belgium, Spain, and Portugal). Exact figures are not available for all the centers but the examples of the Politecnico of Torino (textile department in Biella) and the University of Gent with an enrolment below 50 students for an industry with more than 20.000 employees in their catchment area is concerning.

There are also imbalances in terms of content and specialization. Schools with a focus on design and management record good enrolments while schools with a strong technical focus have painful figures in entry and graduation. Although the shift away from technical degrees is a general trend in education, there is evidence that many technical schools have not adapted their course curricula and teaching methods to the changing demands of students and of industry. Some university departments have adapted their curricula to fashion and management skills, but their large student intakes allows them to maintain technical specializations (either at undergraduate or postgraduate levels) with sufficient critical mass. However the schools with a good overall student intake are at risk of losing technical quality and have a gender balance skewed towards an extreme high representation of women (over 80%). Fashion attracts, but not always with a realistic view on the labour market.

There are however also examples in rebranding such as done at the Technical University of Delft. While the material engineering department is declining, the aerospace engineering department is thriving and is now one the main education and competence centres in Europe on composite materials. This example is not illustrative for a general remedy for the industry. Especially in technical competences other technical degrees cannot and will not cover for deficiencies in textile education. Chemical engineering is an entry for fibre and finishing industries, and mechanical engineering for spinning and weaving. However enrolment in these studies is declining. Moreover in the competition for graduates, the textile industry offers generally lower salaries than other industries, and more limited carrier paths because of the dominance of family companies.

1.5 ANALYSIS OF EXCELLENCE

An important objective of the study is to identify centres of excellence and their impact on the industry. Our approach was to carry out an assessment to identify with objective parameters centres of excellence. Such an exercise has not been carried out before, neither by the research community in textiles nor by other stakeholders; hence there is little transparence in the quality of research. We could have been satisfied with the assumption that all AUTEX or Textranet centres are excellent, but that assumption would assume the unlikely possibility that they are equal. An interview round at the AUTEX conference in 2010 showed that there is wide consensus in the textile research community about differences in excellence of research groups.

Two methods are used (eventually in combination) to assess excellence. One is based on a set of measurable criteria, the other on opinions of a selected group of stakeholders. In line with this study the group of stakeholders would be companies. However the surveys in the regions showed that companies are highly selective in their collaboration with research centres. No company in Europe works together with more than 30% of the research

centres. Most companies that work with research centres have experience with less than three. A questionnaire approach is unlikely to give good comparable results.

The analysis of objective data is limited to existing data. Most data on output relates to funding (projects funded), publications and patents. In addition some elements can be derived from a systematic analysis of annual reports or websites of research groups/organizations. At times that valorization of research is an important criterion, contribution to marketable results or industrialized processes would be important to disclose. However information here is anecdotal. This is true both in terms of publicly available data or gained in interviews with companies and research organizations. That type of data is not collected and hence we were often limited to the visibility of the person interviewed. This has provided often conflicting data for example a CEO not knowing what happened in the R&D department or differences of valuation of the roles of the company and the university in the contribution to a specific product.

Hence we have mainly used a classic approach to measuring excellence in order to identify excellent research centers while focus on innovation best practices in the regional case studies and company cases. The use of indicators such as publications and impact are widely used indicators to rank and assess the quality of the research of an organization because of their transparency and availability.

Ranking systems are mainly used at the international level and mainly involve universities as a whole. Research assessment is mainly carried out at a national level and at the level of departments. Although ranking and assessment systems have limitations, they have nevertheless impact since they drive the governance of research organizations.

There is no existing ranking system for research in textiles at Universities. In order to prepare a ranking system we have examined the presence of Universities with textile research in overall university ranking systems: ARWU, CWTS and QS and we have carried out a small survey at AUTEX 2010 in the preparation of the proposal.

We are aware that university ranking systems have limitations³. They are often based on indicators such as Nobel prize winners, publications in journals with very high impact that are not attainable for textiles. In addition most ranking systems favour research with high academic recognition rather than industrially or commercially exploitable results. We are also aware of the fact that rankings take the entire University as a unit of measure rather than a single department. Hence they cover a wide area and textiles are only a part of the research.

However the rankings give an indication of four possible impacts.

- In the first place textile research may benefit from a challenging research climate and internal transfer of knowledge.
- In the second place it may lead to peer pressure or to explicit pressure to publish high quality research in journals with high impact.
- In the third place a department may benefit of internal resources for e.g. European funding.
- In the fourth it makes a university more attractive to the brightest students and researchers.

The ranking exercise is based on four ranking systems: ARWU/Shanghai, QS/Times, Webometrics and CWTS/Leiden. All four are considered references in the academic world, although they have their limitations. In the first place

³ Saxion University is ranked 3175 in the World, definitely third tier.

they favour English speaking universities. In the second place they favour larger Universities and Universities with high impact science. However at a European scale, only UK Universities have a clear advantage. The impact of disciplines may be neutralized by examining only engineering disciplines, which we took as a proxy.

The examination of overall rankings of 23 AUTEX members and one Textranet member (the only one with the status of University) show that out of 24 Universities, 15 do not appear in any ranking. This means that these Universities as a whole are not ranked in any top 250 of European Universities or Top 500 worldwide Hence they can be considered in the third tier or lower. This status concerns almost all new member states but one and also the major Southern European textile manufacturing countries.

The table below shows how the Universities form the two mains research networks ranks according to different lists.

Table I: AUTEX/TEXTRANET University list

| | | <i>ARWU</i> | <i>QS</i> | <i>Webometrics</i> | <i>Leiden EU Rank</i> | <i>Leiden World</i> |
|------------------------|-----------|-------------|-----------|--------------------|---------------------------|-------------------------|
| Uni.Manchester, GB | AUTEX | 44 | 25 | 273 | 8 | 41 |
| Uni.Gent, BE | AUTEX | 90 | 192 | 211 | 29 | 81 |
| RWTH Aachen, DE | AUTEX | 250 | 34 | 210 | 61 | 170 |
| Uni.Stuttgart, DE | Textranet | 250 | 84 | 180 | 140 | 84 |
| Dresden TU, DE | AUTEX | 350 | 103 | 217 | 93 | 214 |
| Uni.Twente, NL | AUTEX | 350 | 138 | 162 | 186 | 138 |
| Tampere TU, IT | AUTEX | | | 264 | 208 | n.r. |
| Politecnico Torino, IT | AUTEX | 450 | 100 | 629 | 216 | n.r. |
| Uni. Ljubljana, SI | AUTEX | 450 | | 151 | 109 | n.r. |

Eight Universities act in the second tier European top (amongst the 250 best in Europe): Ghent, Aachen, Dresden, Stuttgart, Torino, Tampere, Twente and Ljubljana. The latter one is the only institution in the new member states. Only one University operate overall at world level (top 100): Manchester, hence it is in the first tier. Europe compares well with USA Universities with textile research (2 world class and three second tier). Chinese and Indian Universities are at best in the second tier.

The Delphi method – a study in which a great variety of experts are asked to comment and contribute their opinions - carried amongst Professors at AUTEX Universities shows a clear top position for Gent, RWTH, Dresden and Ensait (Roubaix) and runner up positions for Tampere, Torino and Twente. The British Universities were mentioned as having lost their pre-eminent position. Hence we see some correlation between Universities in their overall ranking and with respect of the position attributed by their peers. It is thus likely that there is a correlation between the quality of textile research and the quality of overall research.

In order to identify more precisely centers of excellence, we have analyzed a number of databases. The analysis is not yet complete, since not all research centers are included. The analysis is only done for Universities with specific textile departments. We have only attempted to identify the best centres as well as the centres in the regional case studies. It is thus likely that centres are missing in the second and third tier. More applied technology centres do not fit in this methodology, since publications are of less relevance for them.

1.5.1 METHODOLOGY

We have examined the Textile departments in European Universities in terms of publications using the database of Web of Science. Three criteria can be used: impact factor, citations and references. With regard to impact factor we only examined the publications of members of a department with regard to the impact of the journal published. For each department we examined the sum of all publications and the average. The cumulative is the result of number of publications and the sum of their individual impact. It is somehow a reflection of size of department and the publication pressure on researchers. The average is rather the reflection of the individual quality of publications.

We took the years 2008-2010 to measure the current impact factor, and considered the period 2000-2007 as legacy for a possible correction if the score over recent years would deviate significantly. It is advised to use an average of a number of years since some departments are too small to deliver significant results over one year. The impact factor is not a measurement of the impact of the article, in fact a method to assess the impact of the article itself is based on the number of citations but this method does only work with more time lags. Therefore for examining the citation impact we took a longer time scale of five years. (2006-2010). The use of the ratio “references” is more an indicator of scientific hygiene and possibly awareness of state of the art.

There are limitations to the use of impact factors. The first one is that impact factors are largely based on effect within the scientific community. It is a reflection of scientific novelty and recognition, not of industrial application. Nevertheless it is widely accepted as a mark of scientific excellence, and it has been for some time now, hence the scientific community has started behaving in accordance with this indicator. Moreover since high impact journals have almost always an Anglo-Saxon base and accept only articles in English it is an indication of international excellence.

A closer analysis of impact factors of publications shows that textile journals themselves score not higher than 1,096. In order to achieve an average higher impact it is required to orient research towards areas with higher impacts such as composites or biotechnology (impact factor between 2 and 3). Medical applications deliver high impact, while applications in construction do not. Many Eastern European universities publish in *Fibres and Textiles in Eastern Europe* which, albeit peer reviewed and, is a journal published by the Universities of Lodz (PL) and Kaunas (LT). The ranking of this journal is increasing, but as national textile journals in Germany and France its impact is far below 1. Therefore high impact can be achieved by publishing in English and in Journals outside of textiles.

The search string was based on terms as textiles, fibres, and other textile terms. In total we identified almost 600 articles of direct relevance and some 500 articles of possible relevance. The review was based on abstracts of the articles. The test was to approximate as much as possible the publication lists of textile departments within Universities. However since some textile departments are also active in other fields (for example the German institute for Wool –DWI- in hair) these publications do not appear. For DWI we excluded one publication in Nature that has an impact close to 30. On the other hand publications relating to composites may appear, although these may be of researchers not in textile departments. However as in some universities (Dresden) composites is associated with textile research while in others not (Twente) we have maintained coherence in search terms. We did make a comparable dataset for all centres below based on a search string with textiles, and applied a correction factor to take into account the corpus of publications not directly related to textiles, but relevant for textiles.

CO-PATENTING

For measuring excellence in relation to impact we considered looking at co-patenting. An indicator used for assessing valorisation of public research is co-patenting⁴. This means that a research centre and a company are jointly mentioned as applicants for a patent or as inventors. In the former case, except for recognition, this gives public research centres a financial stake in the costs and revenues of a patent.

We made a sample of 250 patents over the period 2008 / 2010, simply by examining the 250 first listed patents with a search with the term “textile”. The sample was made to assess the frequency of co-patenting of universities with firms. This did only occur twice, in both instances in the case of the same two partners and within the context of an FP6 project. We noticed also other patents in the same sample that emerged from an FP7 project but without co-patenting. This makes the indicator of co-patenting not a highly relevant indicator in the textile industry for co-operation between research and industry.

COLLABORATIVE PROJECTS

Involvement in collaborative projects that benefited from public funding is another indicator of excellence that can be investigated. While information on funded research projects at European level are publicly available through the database Cordis, there is very little transparency in national or regional funding. We have been able to receive some listings (e.g. from German Federation of Industrial Research Associations a list projects in Germany, including the budget but without mentioning industrial partners) and some databases are public (e.g. the database of the

⁴ Ponds, R., (2008), *Regional Innovation and the Geography of Research Collaboration in Science-based Industries*, University of Utrecht

German Research Community DFG, but without budget mentioned). The compilation of a single database and its analysis for the entire EU-27, encompassing probably more than 1000 projects was not feasible in the scope of this study. We have only evidence by case study.

Joint involvement in projects is another indicator of valorisation of knowledge. Indeed European research funding as well as many national and regional innovation funding is based on consortia of industrial partners and research partners. This is certainly the case in European instruments in Cooperative research within FP6 and FP7, and also in many national (e.g. *Pieken in de Delta* in the Netherlands) or regional funding (*Metadistretto* in Italy). These instruments have become important sources of funding for public research and also important tools to link industry to research.

Joint involvement is formally an indicator of valorisation, but as Leonaviciute (2008) has assessed in her research on SME involvement in FP6 and FP7, the details should be taken into account properly. A project may arise from a clear demand or strategy of a firm or it may be a clear research push. Projects may hence be set up with a clear research leadership with firms as observers and demonstrators, it may also be clearly industry led with research centres focusing on reflection and validation. However a consortium may choose to bring forward an SME as lead-partner although in effect a research centre may be the real leader. In order to have a clear assessment of the depth of partnership Leonaviciute has found the key indicators: were companies involved from the beginning of the development of the project idea, do they have significant budgets and real use of these budgets, and do they have a leading role in research work. These indicators are not publicly available (e.g. through Cordis) hence demand additional survey or interviews.

EXCELLENCE AND MARKETABLE RESULTS

The terms of references demands to analyze the occurrence of marketable results coming out of public research. The concept of marketable results was considered as fundamentally and methodologically difficult for the research centers and companies involved. Fundamentally most expressed that the objective of research centers is not primarily to develop marketable results. Especially German firms did not want research and technology centers (RTOs) to develop results close to market. However in Poland firms expressed that the research interests from RTOs were too far from marketable results.

There are also methodological problems. The concept of "marketable results" describes a form of technology push, where fundamental inventions are ultimately translated to industrial processes and indeed commercial products. The pattern is often not linear and often iterative, takes a long time and transcends borders of institutions. We have from the interviews two examples.

In the first instance the initial research of a new industrial process was developed at RTO1 with two industrial partners in the region. The concept was researched but the industrial validation failed. Five years later a neighbouring RTO took over the research with a new team and three new industrial partners, of which one is in the region and two in another region (also studied in this task). The industrial validation was successful, however the chemical auxiliary partner changed strategy and the RTO reverted to another firm (in another region studied in task 6) to pick up the results for further commercial development.

In the second example research on new concepts of textile functionalities was transferred through the contracting of the PhD having done the research for a company. However of the three marketable results only one was developed immediately after employment, the second about five years after employment and the third was not further developed. The RTO was not aware of the situation.

Companies mentioned in addition that in some instances RTOs would be involved in validating or testing marketable products of processes of companies; especially small contract for research comes at the end of a development process. Moreover for those research centers having substantial pilot production facilities, their function is often to assist in the solving of problems in industrialization of the process.

Another problem is that research centers have not kept track over a longer period of the trickle down effect of their results. Patents are known but IPR developed without patents and further applied are not well documented. Hence evidence we have received (from RTOs and from industry) is rather anecdotal. This is enhanced by the high labour turnover of researchers at RTOs: this makes it hard to trace transferable knowledge. None of the research centers were able to give a structured overview.

Also the long time lag between invention and application, as shall be shown in task 6, makes it difficult to assess the marketability of research results. Commercial exploitation in the period 2005-2010 is then the result of research done in the period 1990-1995 (e.g. in mass-customization, enzymatic processes, digital printing, lamination, phase changing materials, anti-ballistic materials, biopolymers). However the long time lag between research and innovation also shows that the marketability of research results is low, at least in the short or medium term.

We have instead given a composite indication of industry involvement of research centers. The composite indicator is made of the involvement of industry in the governance of the centre, the intensity of project work with industry, the appreciation of technical facilities, and the perception of the industrial relevance of the centre by industrial interviewees.

OFFICIAL EVALUATIONS

In most European countries universities are evaluated by national evaluation or accreditation bodies. Evaluation can be for education and research separately or combined. Evaluation is often based on a system of self evaluation, followed by an external assessment and a discussion between external evaluators and an internal team.

We have attempted to structure the evaluation reports; however in many countries we could not easily find evaluation reports. In many cases they were written in a language not accessible and often the textile departments are examined within a broader evaluation scope of a faculty for engineering. Finally the evaluations do sometimes enable a national comparison, but in most countries this is meaningless since there is only one textile school. It is impossible to make international comparisons unless (in rare occasions) there is an international bench-mark done.

1.5.2 RESULTS

Since the indicators have a margin of error, we propose to work with a classification in three groups: High Impact (A more than 2 average or/and more than 20 cumulative), Medium Impact (between 1 and 2 average and between 10-20 cumulative) Low impact (below 1 average and 10 cumulative). The overall number of citations is ranked at more than 200 (A), between 100 and 200 (B) and below 100 (C). The three indicators determine the score of research excellence.

We also examined a number of other indicators:

In the first place we looked at student enrolment, structuring in three categories. The mark “A” refers to an enrolment that is covering the needs of the industry and providing substantial critical mass and funding. The mark “B” refers to sufficient enrolment to service the research needs of the institute and to provide specialized employment (these schools often offer only a masters course). The mark “C” means that enrolment is below subsistence levels (calculated by Dutch standards), hence a centre is at risk of being closed.

In the second place we examined the technical facilities. Centres ranked with the mark “A” have state of the art laboratory facilities as well as pilot equipment. Centres marked with B have excellent lab equipment but little pilot lines. Centres marked with “C” have good laboratory facilities and no state of art pilot production.

The third indicator is the share of funding attained through industry funding (tertiary funding). The bench mark is more than 30% for mark “A”, “B” stands for 10 to 30% and “C” less than 10%.

The fourth indicator is a measure of impact of dissemination events measured in size and geographical origin of the audience. Mark “A” stands for events standing events with international recognition and audience that form a landmark in the calendar. Mark “B” stands for more focused or regional events. Mark “C” stands for occasional events.

We have weighted the overall indicators, whereas publications count for 60% of the overall score, as best comparable measurement of excellence. The other indicators count altogether for 40%.

Table II : Evaluation Universities

| Results and Score | | | Impact of Publications | | | Student Enrolment | Technical Facilities | Industrial Funding | Dissemination Conferences | |
|-----------------------------|----|-----------|------------------------|---------|-----------|-------------------|----------------------|--------------------|---------------------------|---|
| | | | Total | Average | Citations | | | | | |
| RWTH Aachen | DE | AUTEX | A | A | A | B | A | A | A | A |
| Dresden TU | DE | AUTEX | A | A | A | B | A | A | A | A |
| ENSAIT | FR | AUTEX | A | B | A | A | B | A | A | A |
| Uni.Stuttgart | DE | Textranet | B | A | B | B | A | A | A | A |
| Uni.Manchester | UK | AUTEX | A | B | A | B | A | A | B | A |
| Uni.Gent | BE | AUTEX | A | B | A | B | B | B | A | A |
| | | | | | | | | | | |
| Uni.Minho | PT | AUTEX | A | B | B | B | A | B | B | B |
| Tampere TU | SF | AUTEX | B | A | B | B | B | B | B | B |
| Uni. Duisburg-Essen/DTNW | DE | Textranet | B | B | B | B | B | A | B | B |
| UPC/Intexter | SP | AUTEX | B | B | A | C | B | C | C | B |
| Uni.Twente | NL | AUTEX | B | B | B | C | C | B | C | B |
| Hochschule Niederrhein | DE | None | C | C | C | A | A | B | B | B |
| Hogeschool Gent/Centexbel | BE | Textranet | B | C | C | B | A | B | A | B |
| | | | | | | | | | | |
| Poli.Torino | IT | AUTEX | C | B | C | C | B | B | C | C |
| Uni.Ljubljana | SI | AUTEX | C | C | C | C | C | C | C | C |
| HWU | UK | AUTEX | C | C | C | B | C | C | C | C |
| Politeknika Lodzkie | PL | AUTEX | B | C | B | B | C | C | C | C |
| Kaunas Technical University | LT | AUTEX | C | C | C | B | C | C | C | C |
| University Maribor | SI | AUTEX | B | B | C | C | C | C | C | C |

In the overall ranking, six universities score in the A category, of which three German Universities: Aachen and Dresden are at some clear distance of the others because of an excellent score in publications combined with

excellent technical facilities. The two Universities organize the bi-annual Aachen-Dresden conference which is the main international conference for research and industry. ENSAIT can be considered as a runner up, having improved its publications score significantly in the last three years. ENSAIT is also the only institute having significantly improved its student enrolment, without sacrificing its technology profile. Manchester scores lower than the overall score of the University would predict. It has probably lost the leadership position it had 10 years ago. Gent is an important centre in overall impact, with increased relative impact over the last three years especially in smart textiles and in biotechnology and textiles. However its moderate student enrolment and limited pilot plant reduces the score. It has been active in using its good EU funding position to set up a number of international events and conferences.

The second group is made up of niche players and some schools with more practical research. University of Minho is the leader in this group, with overall good research and high rankings for publications at the crossroads of biotechnology. It achieves a good score without having a science oriented industry in the vicinity, but by having the ability to attract various sources of funding and being well related to other groups in Europe: Duisburg-Essen, UPC Twente and clear niche players with a good score in chemically oriented research. In fact all three form with Minho and Gent a close network around biotechnology and textiles. Student enrolment is lower and other industrial indicators create a lower score for these institutes. Hochschule Niederrhein is the third institute in Nordrhein-Westfalen, making it the region in Europe with the highest concentration of centres of excellence. Its score is partly based on the highest enrolment figure of students, which makes the school an important seed bed for researchers at other universities. Hogeschool Gent combined with Centexbel scores moderately in impact of publications, but ranks higher because of industrial impact.

The third tier, which is not exhaustive in this analysis, regroups many research centres in South and Eastern Europe. Of them Torino has a good quality of output, it has even one of the most cited articles, but its scientific production is small. The Politecnico di Torino is the only textile centre in Italy that is listed. Nor of the other textile groups reaches level B. The Technical University of Lodz has a large output but of moderate quality. As other centres in Eastern Europe it suffers from a lack of connection with industry. Moreover all universities in South and Eastern Europe suffer from declining student enrolment.

1.5.3 EXCELLENCE IN THE RESEARCH CENTER

According to opinion of stakeholders and interviews at the research centers we could identify three ways research centers can be considered excellent:

- Professional
- Commercial
- Programmatic

This characterization shapes the orientation of the centres, their internal governance and their relations with stakeholders.

PROFESSIONAL EXCELLENCE

In the professional excellence the focus of activities is on the education of professionals. The majority of funding comes from education and hence is related to the number of entrants or degrees granted. The funding may take into account the specific infrastructure needed for engineering (in the best case) or is equal for all students (in the worst case). In this model higher degrees are funded mostly from internal resources and PhD candidates are treated as students. In the course of their studies students may have to do in-company traineeship or thesis work. Full time paid staff will do research as a side issue, for which they have less than 20% of their time available for. Students may be engaged in professorial research in a master-fellow relation. Research often reflects personal scientific interests of the professors but can often derive from personal contacts of the professors.

Centres with this characterization have rarely more than 30 full time staff. The technical facilities are to show the proof of concept so equipment is made of laboratories with good equipment to characterize materials. However these centres are rarely equipped to perform tests. Relations with industry are often based on (informal) alumni networks and personal contacts of the chairs. There is no structured dialogue with industry. Events have a social character. Mostly clothing companies and apparel textile companies appreciate this kind of centres.

| | |
|-----------|---|
| Examples: | Politecnico di Torino, IT; Technical University Lodz, PL; Hochschule Niederrhein, DE; |
|-----------|---|

COMMERCIAL EXCELLENCE

Centres characterized by commercial excellence focus their activities on short cycle standardized activities where a solid knowledge basis provides economies of scale and cost advantages. The main commercial activity is testing and certification. Most other activities can be supportive to this task. Training, seminars, engineering support is often oriented towards production for markets in which norms and tests are important; engineering support is the most important sometimes with the involvement of pilot manufacturing lines to assist product or process development. Commercial activities represent more than 50% of budget. The size of commercial activities depend very much of an industry in the region, but also give a strong regional bias to activities.

The testing service is often funded exclusively by commercial revenues, but in some instances normalization activities are funded by a state/regional subvention or a specific levy. This levy does also cover activities such as dissemination of research, technology watch and reference point to industry. These centres suffer from a dual position, partly commercial partly public. The governance is often also blended with industry and public authorities represented. Many centres have besides commercial activities some research activities. Nature and funding of project differs. It can be sometimes fundamental in nature it is most often of a more applied character. Some centres have a formal mission to do collective research for which they are funded through a levy, in other instances they may bid for project funding. Their mission may then be to involve SME's in research.

| |
|---|
| Examples: Centrocot, IT; IFTH, FR; TFI, DE; |
|---|

PROGRAMMATIC EXCELLENCE

Centres with programmatic excellence put their focus on long term research. This research is often embedded in multiannual programmes involving teams of researchers. Programmatic research fits in an ambition to be leader in a theme. The output of research is fundamental knowledge (to be published in peer reviewed articles), trained researchers (doctoral thesis's) and exploitable results fitting in the technology road-map of key strategic partners. Centres of this type may also be inclined to engage in collective research for SME's or have SME's benefitting from research results, but preferably only if it fits in the research strategy of the centre. Relations with a select group of

SMEs are also relevant for application for European funds. Because of the nature of research structure strategic partners are likely to be large companies or organizations with a long term research agenda such as defence industries, aerospace, infrastructure, transport and medical. In addition chemical multinationals are connected to these centres. When non-textile companies are important clients/partners centres have developed large in-house pilot plant facilities.

Centres have often a large degree of autonomy much is compounded by a variety of funding sources. In addition to programmatic funding, these research groups may have some educational activities, such as bachelor and masters courses. Others focus on PhD and recruit candidates for doctorates in Europe (using the AUTEX network) or in Asia. Since PhD is employed with salaries, working conditions are rather attractive especially if the University is well positioned in the international rankings. They have also some outreach activities, and some are hosting major conferences in the industry. Autonomy is reflected in the governance structure wherein management has much independence provided that research excellence is aimed at and funding is evolving positively. Almost all of these centres have a form of advisory council in which major partners have an influence on strategy.

| |
|--|
| Examples: ENSAIT, FR; RWTH, DE; University Manchester, UK; |
|--|

1.6 EU FRAMEWORK FOR FUNDING RESEARCH AND INNOVATION

In this paragraph we will deal with the funding conditions for research and innovation in textiles in Europe. Collective funding is an ever important element since the private research carried out by large chemical companies and specifically fibre companies has declined over the last twenty years.

Funding is an important condition for research, and possibly for innovation. Funding can be for research and education institutes or for **industry**.

Research funding can be divided into three forms:

Basic, institutional or lump-sum funding can be based on student numbers, with possibly an allowance for research or institutional funding for research alone; eventually there can be a bonus for performance and evaluation.

Research funding can consist of grants for individual researchers or for projects or programmes allocated in an open competition at regional, national or international level. Grant funding may require co-funding (hence requiring matching from basic or funding form contracts).

Research funded can be also funded with contracts with public or private partners, usually in a competition and with 100% funding. A specific form of contract funding is research for government procurement or specifically public procurement. This type of funding from companies may also be for non research activities such as testing, certification and trainings.

1.6.1 BASIC FUNDING

Basic funding is traditionally based on the number of students or on a structural model. The structural model implies a plan at government or at institution level about the number of chairs or staff available for a department; this is typically the case in Italy. As supply is managed so is demand curtailed, since the number of chairs determine the size of staff and hence the number of students (although student/staff ration differs still widely inside the EU). In most countries demand determines the size of funding, hence a student intake or a combination of intake and diploma determine funding. The allowance by student may be equal across disciplines, but more often differs by discipline (science and engineering being more expensive than arts). Increasingly higher education shifts to be funded by a mix of criteria including quality. The primary allowance may also include an allocation for research which ranges from 0% to 30% but is generally declining.

Technical research centres are also funded through a mix of basic funding, grants and contracts. Basic funding can come from a diversity of systems; a common one is through a levy or specific tax (France, Italy) on a range of relevant products or industries; another system is through a yearly endowment based on historic data with regular adjustment according to size of industry and quality assessments. In this endowment the volume of public services (e.g. participation in normalization) is also taken into account. A general trend, whatever the system is that primary funding is under pressure for technical centres.

A general trend in Europe, also valid for textile research, is the decline of primary funding of education in research. In many countries this is compensated by some growth in alternative ways of funding. However these general trends should be examined in the light of declining student enrolment in textile education. A survey carried out in 2008 shows a dramatic decline in student numbers across textile universities since 2000. Hence the potential to fund research through education has declined considerably. This is all the more the case that the education establishment having maintained student enrolment at a reasonable level are those with a curriculum focused on fashion and design, and in these instances those schools are often those with a weak research tradition.

1.6.2 GRANT FUNDING

The decreasing trend of basic funding contributes considerably to the importance of grants as stable source of income for research. National funding through grants has remained stable at least in France, Belgium, Germany and the Netherlands over the years 2008-2009. In some countries like Germany and the Netherlands additional crisis packages were put in place to maintain research capacities in companies and centres. It has been decreased at least in the UK, Italy, Spain, Portugal and Greece. At the regional level the map is complex to read. We have noticed that regional funding for innovation has remained important in the regions of Piemonte, Toscana, Valencia, Baden Württemberg and Bavaria, Flanders Nord Pas de Calais and East Netherlands. It has declined or even has been absent in East Midlands, North West England, Nordrhein-Westfalen and Lombardia.

In almost all countries grants are not addressing specific sectors; in fact projects are usually funded in broad competitive calls. Hence there is rarely a textile program at national level while it may happen that regions have a specific textile programme, that it is often a mini-program within a generic funding line. A trend in some countries and in some regions is to focus research funding to top-sectors. Although the selection of top-sectors is done at country level, and are supposed to be distinctive compared to other countries and regions, high-tech materials and creative industries are very often amongst them. This does not mean that textiles (as part of high-tech materials) or

fashion (as a creative industry) are included in the top-sectors. A bottom approach prevails. If the sector has lobbied themselves in the top-sectors they are in. If not they are not included. However also inside the top-sectors, funding is with competitive calls.

Grants can be oriented towards fundamental research or applied research. It can entail funding for an individual researcher, a research group or for consortia. Fundamental research is more often for research groups, whereas applied research always requires consortia with industry or end users. In interviews industry have a clear appreciation for applied research, since they can be involved in it. A minority of companies (the interviewed often himself held a PhD) also appreciate the use of fundamental research, since they have in-house abilities to apply to often a very specific business case.

It appears from the interviews that for national or regional funding, companies and less competitive research centres prefer very narrow thematic programs, calls that are focused or funding allocated in a negotiated procedure. The benefit is that although funding is smaller, it is less competitive and success rates are higher. Moreover since the absorption ability is smaller, the size of funding is sufficient. The more competitive centres prefer more open calls and less negotiated procedures. The benefit is that the programs are larger and regular, hence it provides for a recurrent source of funding. Moreover it stimulates quality of research. However, as reported by interviews, the national and regional funding system – by focusing on technological excellence and economic potential bias in the evaluation process towards biotechnology, and nanotechnology in the scientific domains and towards technical textiles in areas of application with special interest for constructive application and medical applications.

CONTRACTS AND SERVICES

The evolution of funding coming from contracts and services is hard to assess. The evidence from questionnaires and interviews is hard to amalgamate or translate to numeric trends. Much information was confidential and often lacking monetary figures. The evidence we have shows the following possible evolutions.

1. Generic funding by industry wide levies is declining or has been stopped altogether. This is partly due to the declining size of the industry and the lack of consensus between the two largest sections of the industry: fashion and technical textiles. Where fashion wins levies are abolished, trimmed down or focused on promotional activities.
2. It is impossible to generalize about private research funding. It is increasing mainly from non-textile companies such as end users of materials, chemical companies or in materials research outside the industry (e.g. cosmetics). It is however declining from fibre companies and textile companies (or in that instance more dependent on public funding for consortium based research). This is all the more the case that larger companies tend to give grants for longer term research while SMEs rather contract short term assignments.
3. Research funding from government agencies. Most research in textiles is demanded for the ministry of defence, civil protection, civil engineering and health. Over the last ten years demand from all disciplines was reasonably positive. It is expected, from the interviews we had, that with budget cuts this type of research shall be cut.
4. Revenues from commercial activities such as testing, engineering services and training are on the increase although they are related to the economic cycle. In general testing is a growing business for research centres, but this trend benefits those centres having certified testing facilities. Centres have, because of decline of other sources of funding to charge all overheads on the costs of tests hence companies complain about the increasing costs for them. Training activities are also on the increase but are cyclical.

This kind of funding consists in a diverse set of revenues. It is increasing in importance, but with a clear shift from rather predictable sources of income to cyclical sources of income. In addition there is a shift from the more classic textiles to textiles requiring some form of certification, which is generally home textiles and more often technical textiles.

1.7 EVALUATING THE FUNDING STRUCTURE

When it comes to funding of research the main issue for companies and certainly for research centres, is to combine the different sources of funding. Although the segmentation between the three funding streams is universally applicable, diversity in Europe prevails. This is mainly related to different division of responsibility between the member states and with relations between government and industry. Finally it depends on the budgets available which differ between member states.

The figures obtained from the research are not always precise but based on seven regions⁵, and in line with data collected by Crosstexnet.

Table III: Types of Funding

| Type | Source | Average | Trend | Deviations |
|------------------|----------|---------|--------|-----------------------------|
| Basic | National | 15-25% | Down | Higher in New Member States |
| | Regional | | | |
| | European | | | |
| Grants | National | 30-40 | Up | Higher in Germany, France |
| | Regional | 10-20% | Stable | Higher in Italy, Spain |
| | European | 5-10% | Up | Higher in Southern Europe |
| Contracts | N.s. | 20-25% | Up | Lower in New Member States |

⁵ Lodzkie, Lombardia, Nord-Pas de Calais, Nordrhein-Westfalen, North-West England, Oost-Nederland, Piemonte, Comm. Valenciana, West Sweden, Flanders

In general basic funding is no longer the largest funding source, and if it is the largest source of funding, as is the case in southern and new member states it is not to a level that enables to support a vibrant research infrastructure. Grants are by far the largest source of funding in all old member states. National funding is the most important source for fundamental research (which is less relevant for this study) and it is in many countries also the most relevant for applied research. Even in federal states like Germany national funding is the most important; however in Belgium industrial research is the domain of the Communities. In Spain the regions give out most of applied research funding. In Italy, although not a federal state, the regions are the main purveyors of funding for applied research in textiles instead. European funding for projects is essentially the framework programs.

Contracts funding is most developed in older member states, and is marginal in new member states; moreover within old member states it is of higher relevance in Northern Europe than in Southern Europe. Its share is also higher for more applied activities and for services than for longer term research. In that instance funding from companies is in kind, and this is not traceable in this research.

2.1 TRADEMARKS AND DESIGNS

The terms of reference of this study demands to examine trade marks and designs as a signal of commercialization of results of research and development. We have done a feasibility analysis of this approach by examining the databases of trade marks and of designs both hosted by the Office for the Harmonization in the Internal Market (OHIM). The initial query was to examine whether there is possibly a correlation between the number of patents held by companies and the number of trade marks and designs held by them. The concept is to see whether research projects lead to visible results either in patents or later in trade marks or designs.

Since the number of trade marks and designs is substantial as the number of companies with patents or participating in EU funded projects, we have only tested a sample of matched pairs companies that had at least one of the three features.

According to Nice Classification, textile related trade marks fall under 2592 entries while clothing falls under 692 categories. These categories contain final products, intermediate products, components such as buttons, chemical auxiliaries to obtain properties, processes to obtain properties and (pieces of) machines to obtain a product.

In October 2011 (revised calculation from an initial assessment in February 2011) the database of trade marks reported 120.913 trade marks for clothing and 33.023 trade marks for textiles. According to our investigation around 400 trade marks are held by textile firms holding patents whereas less than 100 are held by clothing firms having patents. The average number of trade marks by textile companies having patents is three whereas for clothing companies (that have far less patents on average) are 11. At the level of individual company we have examined Freudenberg (more than 10000 patents) that has 6 trade marks, Lenzing with more than 2000 patents has 10 trade marks and Teijin Aramid with more than 1000 patents has 4 trade marks. As counter examples Louis Vuitton has 8 trade marks for some 120 patents (mainly for watches) and Hermes 44 trade marks and no hits on patents. The same for Hugo Boss that has 188 trade marks but no patents. TenCate and Heimbach have a comparable number of patents (ca. 400) in technical textiles. Heimbach has registered three trade marks (each been the successor in graphic outlook of the other). TenCate has registered around 30 trade marks. In the latter case we are not sure that we are comprehensive since new trade marks are registered by the holding, whereas trade marks before 2009 are registered by business units, and it is hard to assess which trade marks were disposed off or acquired.

An additional problem in analysing the database of trade marks and designs is that the description of each of them rarely traces back to a patent or even a technical invention or result of research and development. Hence a generic analysis of correlation is impossible without in depth knowledge of each case. Finally the database of trade marks makes possible to trace back trade marks to the nationality of the holder, but a linkage to a region requires a complex convergence via postcodes. In some instances patents are held by a holding company situated in another member state or region than where the research was carried or the production takes place.

We have also analysed a sample of designs, as with other tests we examined first companies with a substantial number of patents. In general companies with more than 100 patents had few designs registered. Most of designs registered concerned logo's linked to trade marks. Very few of them concerned configurations of products. A sample of firms was examined in terms of content of patents. Few of them had features that could lead to designs. Most patents were related to processes and often clearly connected to functionalities of products obtained by chemical auxiliaries. Similarly we examined the companies with most designs registered in connection to textiles. These firms were not the large printers (such as Ratti or Mantero in Italy) – who had no design registered). It were mainly the large luxury brands and in view of the age of designs, for rather stable designs such as the monogram of Louis Vuitton. Hence design is not a reliable indication of innovation or of fruits of research.

2.1.1 ANALYSIS OF DESIGN, TRADEMARKS AND PATENTS

It should be said that we have found in the course of the regional case studies several of the cases described as examples. Of the situations above the most frequent instance is that patents would be exploited under a generic trade mark of the firm. In general this is a single trade mark of the firm. In a limited number of firms several trade marks were developed to cover different products with different functionalities or for different markets. In all these cases a brand is progressively enriched with the results of patents. In some cases patents are process oriented hence substantially all products benefit for a number of years of the patents developed. In general the ratio of utilization of patents is high. Around 85% of patents are exploited in industrialized processes or commercialized products. This percentage is slightly higher in Germany than in France and in Italy lower than in France. In the Italian case not exploited patents concerned applications for new markets for which the barriers of entry were too high. The German firms were almost always using patents to defend and develop existing market positions. There is no general rule of the time lag between the application of a patent and its exploitation.

In general, knowledge derived from cooperation with public research is not exploited in patents. There are several reasons given for this. The first one is that results of research is being published, hence patenting is no longer seen as possible. This may seem problematic but often innovations find their secret in the implementation of the process (combinations of chemicals, choices of processes and process factors). In the second place many results of research are of generic nature – especially when they concern processes – and since the project has been carried out in collective funding schemes, the knowledge is available (under conditions) to all stakeholders. In the third place nor universities nor most companies have a systematic IPR policy and structured approach to patenting.

Nevertheless a substantial number of projects lead to patents. In the case of EU funded projects and national/regional funded projects the ratio is 1 to 1, one patent for each project. It is substantially higher for European funded projects, but since the number of EU funded projects in which the centres examined have participated is a small share of all projects examined, the higher number of patents in EU funded projects is not reflected in the average. An explanation is the need to implement IPR procedures in EU project and the obligation to patent exploitable results. This obligation is monitored by the EU Commission.

This obligation is less well defined in national or regional funding schemes, and is almost never monitored by funding agencies. However since universities are increasingly evaluated by performance, the filing of patents has become more important, since a patent is seen as an exploitable result. The major research centres we have interviewed have a complex relation with patenting. They clearly prefer patents to be taken up by firms, since they can industrialise and commercialise the findings. However they also desire that a claim is put on knowledge, hence

they will patent if not done by industry. This approach can not be too regular since patenting has its costs and licensing of patents is for most universities not fully developed. Universities also mention that patenting by them puts a barrier to cooperation with companies. In Poland instead universities are willing to patent since the patenting activity reflects in their performance indicators for the sake of external. Companies mentioned this as a barrier for working with universities.

Notwithstanding this analysis the majority of patents filed after research between Universities and companies were filed by companies. The majority of patents filed were not filed by textile firms but by machine manufacturers or by manufacturers of chemicals, either fibres or auxiliaries. The fibre manufacturers were the leaders in patenting but have been supplanted since 2000 by chemical auxiliary manufacturers. In the comparison on the five regions, German firms were the most active in patenting, followed by far by the French and British firms. Italian and Polish firms had hardly patented technology flowing out of research projects.

PATENTS AND TRADE MARKS A CASE STUDY

The complexity of relations between research, patents and trade marks can be exemplified by several cases in Royal TenCate in the Netherlands, a leader textile company further analysed in an extended industrial case in this task. TenCate has since 2004 an active policy of filing registering trade marks, as it fits in a strategy to control the value chain and to avoid dominant positions by other players. The growth in trade marks registered in the period 2004-2010 reflects the increased investment in R&D but also as a backlog of trade marks already in use from 1990 but not yet registered. This means that the timing of invention, commercialization and filing of trade mark is not linear and stable.

The TenCate portfolio shows several interesting cases that may be significant for the industry as a whole:

1. A trade mark covers a range of products. The *CETEX* trade mark for composites covers a wide range of combinations of fibres and resins. The *Thiolon* trade mark for artificial grass depicts a family of products (more than 60 varieties of yarns). The Thiolon family led to some sub-brands which are not registered. In addition the trade mark covers all steps of the process (from polymer granulates till complete field systems).
2. A trade mark covers a range of patents. In both examples mentioned before but also for products in geotextiles, the trade mark covers patents pertaining to a system, to components to blends of materials, to processes obtaining products or parts thereof. In some instance the same trade mark covers the original products or renewed products with or without a patent.
3. A trade mark covers products for which no patent has been filed, simply as a patent requires disclosure of knowledge. In some instance part of the process may be patented (e.g. with the *Tecapro* brand). In other instance the trade mark covers a product which is the application of patented product of a supplier (often a fibre), for which TenCate has developed a non-patented confidential process (e.g. *Tecasafe*).
4. For several fabrics (e.g. *Defender M* or *Tecashield*) the core of the product consists of a fibre patented and branded with a trade mark by a supplier. This is the case for Lenzing *FR Viscose* in the latter case or *Nomex*, which is an aramide fibre from Dupont. TenCate applies its own branding to magnify market position and valorise additional features on the product. However in some instances clients of TenCate do not refer in their branding to TenCate brands but revert to the original *Nomex* brand.
5. In some of the above mentioned instances the relationship between trade marks is explicit. On the website of TenCate there is an explicit reference in the specifications that *Tecashield* is made of *Nomex*.

However in the case of *Tecapro* there is no reference to the use of *Proban* (a phosphine based flame retardant from Rhodia).

6. We found one instance whereas a trade mark refers to a technology, that has led to a range of patents, and that was partly developed by publicly funded research. TenCate *Itex* has been filed two weeks before submitting the FP6 project Digitex for funding at the European Commission. The trade mark intends to cover all products emerging from digital finishing of textiles, and although the project Digitex has led to more than 10 patents yet, it has not led to any commercial product. Of interest is that the description of the trade mark only mentions categories of products, without any reference to the technology supposed to be used to make those products.
7. *TenCate* is itself a trade mark covering all sub brands of the business units of the group. The full name of each brand should read as "*TenCate Tecasafe*" with guidelines indicated in an internal style book. The company TenCate was established in 1704. The trade mark TenCate itself was filed on the 3d of May 2010!

TenCate is possibly with some fibre manufacturers the company with the most sophisticated IPR policy in textiles outside the fashion sector. In developing a strategy it has inspired itself from Dupont and from Gore, and it required the services of a Danish consultant, a Dutch Patent attorney and an American Law firm. It internalized the coordination of IPR policy by recruiting in 2004 one of the few people in Europe combining a textile engineering degree and a masters in intellectual property law. The branding strategy is explicit in its objectives and operational execution. In addition it has become a source of revenue for the holding that demands a branding fee of the business units. The branding policy fits in a pro-active Public Relations strategy and an active public affairs policy.

2.2 PATENTS ANALYSIS ON TEXTILE AND CLOTHING

The database research was done through Thomson Innovation, based on the following key words and concepts: textile, clothing, fabric, wool, cotton, silk, fiber / thread / knitting e technical textile. The analytic period considered was from 2006 until 12th July 2011. The analysis was limited to patent applications filled in by European Countries.

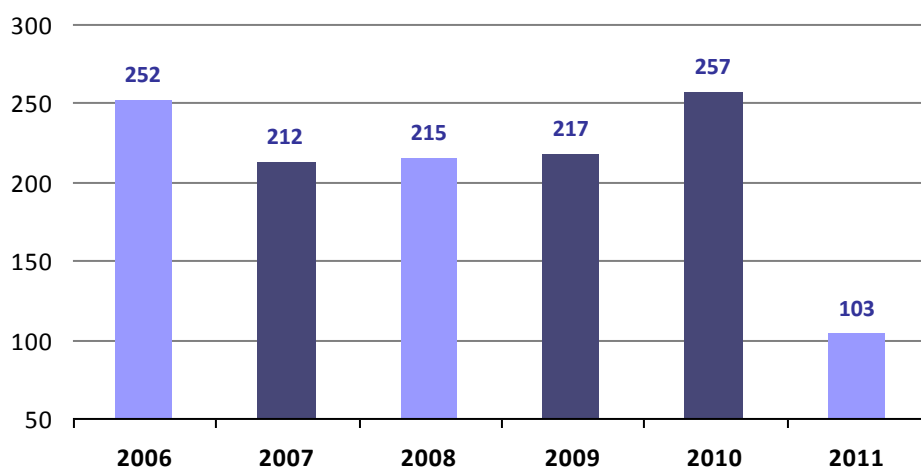


Chart I: Patent applications evolution 2006-2011

Source: Direct output from Thomson Scientific Corporation database

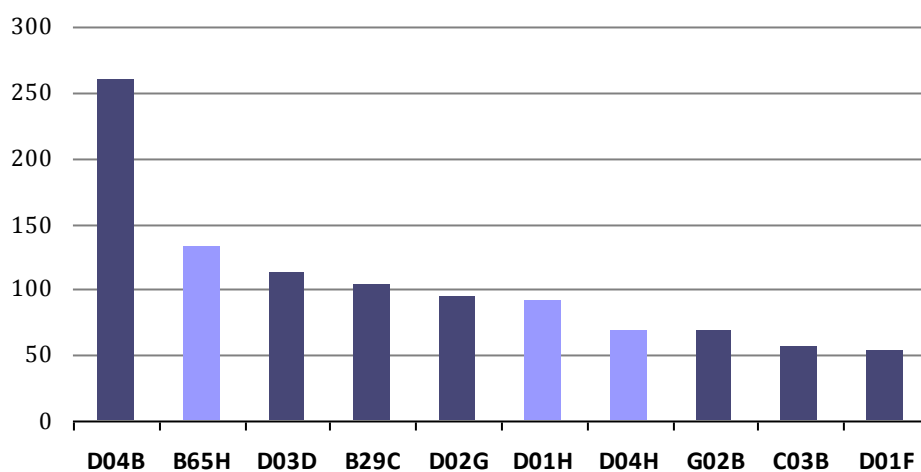


Chart II: Main International Classifications

Source: Direct output from Thomson Scientific Corporation database

Table IV: Description of IPC codes

| IPC | Description |
|------|---|
| D04B | Knitted products, i.e. fabrics, articles, are classified in this subclass only if they have constructional features which are of interest from the knitting aspect. |

| | |
|------|--|
| B65H | HANDLING THIN OR FILAMENTARY MATERIAL |
| D03D | WOVEN FABRICS; METHODS OF WEAVING, LOOMS |
| B29C | SHAPING OR JOINING OF PLASTICS; SHAPING OF SUBSTANCES IN A PLASTIC STATE, IN GENERAL |
| D02G | CRIMPING OR CURLING FIBRES, FILAMENTS, YARNS, OR THREADS; YARNS OR THREADS |
| D01H | SPINNING OR TWISTING (unwinding, paying-out, forwarding, winding, or coiling filamentary material, not intimately associated with spinning or twisting, B65H; cores, formers, supports, or holders for coiled or wound material, e.g. bobbins, B65H; twisting oakum D01G 35/00; crimping or curling of fibres, filaments, or yarns D02G 1/00; making chenille D03D, D04D 3/00; testing yarns, rovings, slivers, fibres, or fibre webs G01) |

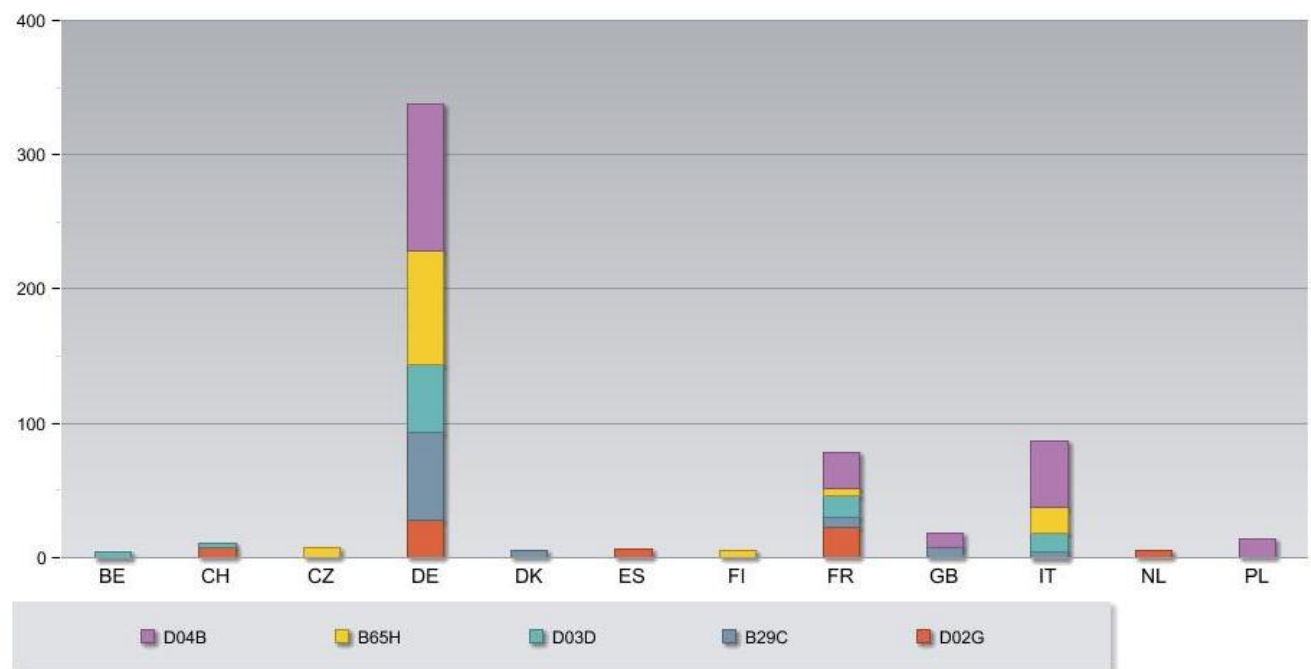


Chart III: Main IPC used by the most active patenting European countries

Source: Direct output from Thomson Scientific Corporation database

Looking into recent patenting activity for the last 5 years and browsing EPO patents for textiles and clothing, the following major remarks should be highlighted:

Despite the fact that the global number of patent applications in the textile sector is small when compared with other technical fields, there is an interesting growing trend in recent years, which should be connected to the growing importance of technical textiles within the European production, that is more suitable for patent applications;

As expected, most of patent applications/inventions in the textile industry are coming from large companies producing chemicals or consumer goods and from larger textile machinery manufacturers

Patent activity of small and medium size companies are comparatively small and can be considered marginal;

Multi layered products and complex textile structures (fabrics or knitted) with innovative coated solutions are becoming important in terms of recent patenting activity;

Germany is not only the most active country regarding patenting activity but also the only country with a very dynamic activity in several different kinds of classes. This confirms that in this country, three relevant factors with a strong influence in patenting activity are present together and with a relevant crossed influence in the industry development: 1) A significant number of very representative textile machinery constructors; 2) Germans textile manufacturers have been the most successful in the last 10 years in what concerns the production increase of high added value technical textiles; 3) A very significant number (36) of textile related research and development institutes (the higher in Europe).

In addition we also carried out a different analysis starting from innovative companies in Europe and checking their patenting activities. Disruptive innovators are a very small minority in the European industry. They are the pioneers in the development and application of very strong fibres such as aramides and high tenacity polyester (Akzo and DSM), developers of thermoplastic composites and synthetic grass (TenCate), starters in making tufted carpets (Lano and Depoortere) pioneers in the development of constructive textiles (Ferrari, Verseidag and Mehler), leaders in filtration (Heimbach), early users of textiles for cars (Michel Thierry), inventors of artificial suede (D'Alcantara) or of the Velcro strip (Aplix), the first users of jacquardtronic knitting machines (Desseilles) or of digital printing (KBC) or of plasma technology (Verosol and Mascioni) or in made to measure shirts on-line (Bivolino). Most of these companies are based in the Netherlands, Belgium, France and Italy. Some of the companies do not exist anymore, but some master the art of launching every twenty years a disruptive technology (e.g. TenCate). Nevertheless the number of companies able to engage in long term investment in new technologies and liaise in a long term development relation with suppliers and research centres. In the list of patent holders (235 firms) this is a minority of 20-30 firms.

In this part of the patents analysis we have only looked sample wise to specific companies and technologies to gain some deeper insights. All figures given are orders of magnitude and relative trends.

The world patenting stock in textiles stands currently at around 50.000 patents, a stock that is growing with around 5000 patents a year. This is a modest number, since Philips and BASF have on their own a comparable stock and production. Europe is still the global leader with a share of 55% of all patents and a share of 40% of new patents. The number of patents held by the United States has reached in 2011 a mark below 20% with less than 10% of new patents. Asia is moving up fast with a share of 30% of all patents and close to 50% of all new patents. Europe's position is still leading but eroding.

The overall majority of innovation oriented firms patent technologies in a continuous developing line and combine patenting to create a protected island with the nurturing of tacit knowledge and in-house re-engineering of recipes and processes. The majority of firms holding more than 10 patents are of this type. Adaptive innovators and

reflective innovators often have a limited number of patents, all below 10 per company. Around 60% of patents are held by textile companies. Around 10% are held by Universities and Research Centres, while 30% are held by chemical suppliers (not being fibres) and machine suppliers). The share of textile firms holding patents is increasing (reflecting the shift in innovation from fibres to downstream); the share of patents held by RTOs is declining. The share of patents held by fibre manufacturers is declining.

Within Europe Germany is the clear leader with around 55% of all patents. It is followed by France, Italy, and the UK. The Netherlands and Spain hold each around 7-10% of patents. Belgium, Finland and Sweden are in a band between 3 and 5%. Patenting in UK has dropped dramatically whereas Italy is increasing a little. Belgium, Finland and Sweden are also improving their position. All other countries are in decline.

By region, the leading regions are as follows:

Table 5 Ranks of patents per region

| | |
|--------------------------------|------------------------|
| Baden-Württemberg, DE | More than 5000 patents |
| Nordrhein-Westfalen, DE | More than 2000 patents |
| Oberösterreich, AT | More than 2000 patents |
| Oost-Nederland, NL | More than 1000 patents |
| Rhone Alpes, FR | More than 1000 patents |
| North-West UK, GB | More than 1000 patents |
| Flanders, BE | More than 500 patents |
| Lombardia, IT | More than 500 patents |
| Nord-Pas de Calais, FR | More than 500 patents |

Hence 10 European regions hold almost 50% of all textile related patents. The score is highly influenced by the performance of single companies. Freudenberg (non-wovens) determines largely the score of Baden-Wurttemberg, Lenzing that of Oberösterreich, and the former Akzo fibre daughters Oost-Nederland. Also Rhone Alpes (Rhone-Poulenc) and North West (ICI) have their leading position thanks to the fibre industry. In the other regions the patents are wider spread over larger companies. At a regional level regions in Southern Europe and the new member states have a marginal position.

Patents are mainly held by companies controlling the value chain and hence mainly by larger companies. There is a clear correlation between company size and the number of patents, with around one patent per 5 Mln turnover at the top of the curve. At the bottom of the curve, the ratio is one patent per 15 Mln turnover. Patent activity of small and medium size companies are comparatively small and can be considered marginal; it should be underlined the arrival of players like luxury fashion companies like Luis Vuitton or Hermés, in this kind of activity. However one sees a minor but significant trend that companies active in the luxury segments have started after 2005 to defend their intellectual property by patenting. This is the case for luxury suppliers such as Loro Piana (cashmere), Ratti and Mantero (silk) and Mascioni (printing). Also Falke, Lacoste, Adidas and Zucchi in the higher end of the market are starting to patent parts of their product development.

A general trend is that the share of patent held by fibre companies is declining. Only Lenzing and Teijin Aramid (ex AKZO) are keeping up their leading positions. The runners up are manufacturers of non-wovens that form the leading sector in number of patents. This is a sector dominated by large companies, with an oligopolistic market structure. The other runners up are technical textiles. This is also a sector with large players, oligopolistic markets. Despite the fact that the global number of patent applications in the textile sector is small when compared with other technical fields, there is an interesting growing trend in recent years, which should be connected to the growing importance of technical textiles within the European production that is more suitable for patent applications.

Indeed the leading companies in number of patents held that can be classified as textiles are active in technical textiles:

Table 6 Patents per Company

| Company | Area | Subject | Patents |
|----------------------|--------------------------|--------------------|---------------|
| Paul Hartmann | Baden- Württemberg | Medical textiles | More than 500 |
| TenCate | Oost-Nederland | Technical textiles | More than 400 |
| Heimbach | Nordrhein-Westfalen | Technical textiles | More than 300 |
| Tamfelt | Finland | Technical textiles | More than 300 |
| Schmitz Werke | from Nordrhein-Westfalen | Home textiles | more than 200 |

The last firm is an exception in a range of technical textiles, but it is the global market leader in (inside and outside) sun awnings and drapes.

All these markets are relatively oligopolistic, and patenting is possibly rather part of a commercial strategy to limit access to newcomers and to protect market positions. A remainder of 15% of patents are held by companies not active in technical textiles. In classic activities such as spinning and weaving of natural fibres, and more general active in fabrics for interior and fashion, the patent stock is rapidly ageing.

2.3.1 COMPANY PROFILE

Bivolino is an innovative textile company in the Hasselt Area, Belgium. It has been selected as a case for the Study since it has been involved in two European projects. It is fact one of the few clothing manufacturers consistently engaged in the European Research Arena. It is an example of a transformation of a traditional SME into a modern business.

The core business of Bivolino is the production and sales of customized shirts on the Internet and the development of internet interfaces for customization to retailers and brands. The firm is currently lead by the 3rd generation of the Byvoet family. It started originally in the 1930s by offering labour intensive, customized shirts. Subsequently, the 2nd generation took part in the “mass”ization (the standardization of tailored products and the industrialization of the tailoring techniques). The 3rd generation has been able to combine the two techniques. Currently, Bivolino produces tailor made products *and* has them largely made by automated machinery.

For their products, they predominantly target the European and – to a smaller extent – the US market. Bivolino works at 4 locations with a total of approximately 250 employees. The headquarters, sales and R&D department (12 fte⁶) is located at the science park of Diepenbeek, and a small software firm (4fte) is located in Belgium as well. Additionally, there are two production facilities in Romania and in Tunisia, where the majority of the employees work. Until 1990 production used to be located in Belgium. However, due to past industry dynamics, it was moved to low-wage countries.

Currently, Bivolino markets three core business models. The first one is more traditional. In this business model, Bivolino provides end-users directly through a web-store, customized shirts. The offering is built around a software application to customize the shirts in four steps. Online, consumers pick one of 200 fabrics. Next, they are able to design the shirt and see the result immediately. At this point, they have the opportunity to add embroidery, and finally, they ensure that the shirt will fit by using Bivolino’s patented biometric sizing technology. This technology replaces the traditional measuring lint method, which was found to cause too many mistakes in the pattern if executed by consumers. The men’s shirt size is based on three biometric parameters: age, height, and weight. For women’ shirts, they ask an additional parameter, cup size. Given this, it is clear that Information Technology currently plays a central role in the customized shirt offerings of Bivolino.

Leveraging from the first business model, the second model is to offer retailers (e.g. De Bijenkorf, Otto), with men’s and women’s shirts, under their own label. It also produces customized shirts under a contract label (e.g. WE fashion or M&S fashion). The offer is simplified compared to the first model with a smaller selection of fabrics and a more focused choice in models and details. The price is also lower than Bivolino’s own range. This business model is the continuation of the major business model of contract production. Besides the customized line, Byvoet also produces small orders for retailers.

The last business model is the most innovative. It consists of a software package to manage the complete supply chain for companies in the fashion industry. The IT-package includes visualization and consumer design software at the front-end, programs to manage and optimize textile cutting in manufacturing, and track and trace applications

⁶Fte is full time equivalent

for e-fulfilment at the back-end. Bivolino markets this software package as a platform, which is interactive, configurable, modular, scalable and generic. In other words, the software package covers the entire fashion supply chain, involves consumer input for design, targets the business-to-business market, and can be purchased as a kit or piece by piece.

From the description of the two product lines, we can see that Bivolino has become much more than a traditional textile fashion company. In particular, its use of the Internet since 2000, several software applications and their participation in two EU funded projects, first “Leapfrog” and later “Open garment”.

2.3.2 EU PROJECT: LEAPFROG

The objective of Leapfrog⁷ was to achieve a positive change in the productivity and competitiveness of Europe’s clothing industry, given the industry’s great dependence on labour costs. The project ran from 2004 until 2009. It consisted of 35 partners from 11 European countries and is a part of the FP6 program. Leapfrog was coordinated by Euratex, which is the apex organization of the European Textile industry. Leapfrog’s aims were to achieve technological breakthrough in the clothing industry by conducting research on new materials, technologies, and processes to enable innovative fabric preparation, automated garment manufacturing, and 3D virtual garment prototyping in the setting of an embedded network of partnerships.

2.3.3 EU PROJECT: OPEN GARMENT

The Open Garment project is still running. The objective of Open Garment is to enable the textile manufacturer with a new business model to sell individualized garments. This model will generate inventive means for the design, production and sales of consumer designed and configured garments, based on the provision of individualized services and products to customers and partners. This new business model will generate much more value and will lead to new product designs, to higher degrees of customer satisfaction and, subsequently, to an increased competitive position of the manufacturing textile SME. Applying this to the European Textile and Clothing Industry, it will be possible to create and provide individual garments with high degrees of customization in terms of fit, fashion, and function at a comparable price, typically within 72 hours. In other words, the core idea is to empower the consumer as the designer, producer, and retailer for individual garments.

2.3.4 BIVOLINO DYNAMICS

At the beginning of the 1990s, Mr. Byvoet was facing a constant struggle: he was beating the industry’s commodity magnet. This means that many firms were offering similar and basic products, which was making it very difficult to generate distinctive value. Value is important because the more value a product delivers, the more customers are willing to pay. Firms in commodity markets face intense competition because customers perceive the value of

⁷Leadership for European Apparel Production From Research along Original Guidelines.

products as being equal and makes sales price as the main determinant to buy the product. Subsequently, cutting costs is business as usual, profit margins are squeezed, and often, many firms go bankrupt. "In that time, I had to produce a shirt for 7 to 8 Euros and could only earn a couple of cents margin, and the thing that frightened me most was that in the near future I had to produce [the shirts] even cheaper", Byvoet said. Moreover, in a mass market, stocks are hard to manage, and in Fashion, some products sell very well and become sold out, whereas others sell too little. This so-called "slack" of stock exercises an important negative effect on a company's profitability as well. Thus, Bivolino was searching how to raise the margins again. The only way to achieve a greater margin in this business seemed to be to relocate the manufacturing plant to the Far East, to make use of the cheap labour force, and to produce the same products for less money. But this is not what Byvoet wanted: "I do not see the solution in relocating the manufacturing plant to the Far East, in terms of managerial issues, but also in terms of speed of delivery and sustainability issues. Personally, I believe in the European Union -I call myself European- that's why that the future of Bivolino has to be in Europe." Subsequently, Byvoet had to find another solution, besides cutting costs, for Bivolino.

The remaining option was to give the shirts more value in order to make customers pay more. Bivolino did this by conducting some experiments. In 1997, an intranet connection was started to offer at first a retailer in Brussels an automated solution to sell customized shirts. The idea was that customized shirts create more customer value and, subsequently, higher prices. Another year later, Bivolino ran its own www-application to sell its shirts online and directly to consumers. By selling directly to customers, Bivolino was able to by-pass the retailer and generate more margin as well.

The next idea to generate more efficiency and ease of use was derived by Mr. Byvoet and the CTO, Mr. Ratajczak, together. They wanted to solve the problem of "non fitting" shirts. Since they had started to provide consumers directly with customized shirts, this problem happened much more often than before. "When customers are using measuring tape, somehow mistakes happen much too often. We thought we could reduce this amount by asking for standard and robust body measures to indicate their sizes," Mr. Ratajczak said. This idea was so unique and innovative that they went into close cooperation with the Open University of Brussels to file a patent on it. The result was the Biometric Linosoft patent, an important milestone of Bivolino's transformation.

Although these experiments were promising, by 2003 Bivolino had generated only a couple of percentages of total turnover with the new business. The bulk of turnover was still generated by the old-fashioned way (big batches of standardized shirts at a low margin). About this time, their traditional business was not profitable at all, but Mr. Byvoet became confident that their innovation would become a great substitute. This made Byvoet decide to cut down the entire traditional business and dedicate all resources to their new (e-) business: the provision of end-users as well as retailers with customized men's and women's shirts created online only. Byvoet: "For us this was a huge leap, it was very hard to find parties to invest. We have got almost no assets [e.g. buildings or manufacturing equipment that could stand surety were outside the EU] and others think you are throwing your business away. Anyway, the die is cast and from now on all efforts are needed to make the e-business work." This strategy was a major overcoming of lock ins. The cognitive leap had already been taken, but the functional lock in, in terms of reallocation of assets was a major risk to take.

At this point, the first EU funded project, Leapfrog, came along. Bivolino had experimented sufficiently with their applications to know how they could benefit from the project to increase their turnover. They wanted to apply the patent more extensively in their offerings but had some difficult technicalities to deal with. For example, the rendering, which is the process of generating images of a model by means of a computer program, was a complicated task to apply to shirts. They could not have done this without help from outside. Bivolino also needed

a lot of statistical knowledge to improve the connection between the patented biometric measures and a perfectly fitted shirt. Through the Leapfrog program, the e-business became more and more attractive, but still, improvements towards the applications could be made.

Although Bivolino experienced long travelling distances and time-consuming introduction meetings to get to know each other really well, these problems were of insignificant matter. That's why Bivolino initiated the next project, Open Garment. This program is smaller in terms of participants but much more focused around their new e-business. For Bivolino, the main deliverables were/are to further optimize the supply chain software for fashion and to diversify into customized women's shirts as well. Again, many developments were made in close collaboration with the project partners, now resulting in more concrete applications.

2.3.5 LOCK-INS AND NETWORK DEVELOPMENT

In the case of Bivolino, it is worth noting that they were held hostage by the dynamics of the industry. As shown before, this phenomenon can be labelled as the commoditization of fashion textiles: customers demand lower prices, so suppliers must offer lower prices. This typical cognitive lock-in made it hard for Bivolino to change and to escape a downward spiral. Especially since a lock in into larger retailers and large volume production leads to a functional lock in into specialized, automated high productivity production lines with little flexibility. Bivolino was profoundly coupled with big and renowned customers who were accountable for a lot of turnover.

Although it was a lot of money, making the business profitable was another challenge. It is common practice for firms to look for solutions in the business they're currently running. This is because they already know all the ins and outs and feel most connected with it. In the case of Bivolino, its external investors thought the same and did not really want to invest in this new innovation. The saying "Let the cobbler stick to his last" is inaccurate expression that captures this behaviour perfectly.

From our point of view, there are some things that helped Bivolino to get out of this lock-in. First, Bivolino started looking and dedicating resources to new solutions at an early stage. The company noticed quickly that in order to survive, they had to create more customer value instead of continuously cutting costs. Subsequently, Bivolino was one of the first to combine modern IT with traditional customized fashion to architect their new e-business. Being the first means that you have a lot of benefits, including a head start, although there are a substantial number of theories that argue that the "first mover advantage", particularly for an SME, may not always be beneficial. Mr. Ratajczak, however, is convinced that in their case, being the first mover, helped them to file a patent and become a front-runner in Fashion Textile and sophisticated IT.

Next, the two EU funded projects made it possible to develop patented technology to working applications, which played a central role for Bivolino's convergence. "I really owe the EU for that; otherwise, we would still be sewing shirts and competing on costs," Byvoet mentions. The EU and the US patent are very valuable for them because they have made it easier now to defend their position on the market. Another benefit of the participation in the project is to benchmark one's strategy and to raise visibility for the firm. Bivolino is a reference in Europe especially in the textile R&D Community.

Finally, we believe that a more macro factor – "the rise of the Internet" – caused a tail wind that should not be underestimated: IT technology progresses exponentially, the sales market has become global, the number of Internet users is still growing, and consumers are less resistant to order products online.

If we look at how the convergence of Bivolino allowed it to other partners, we see that Bivolino and the EU projects helped other organizations as well. For example, TNO Soesterberg, a Dutch semi government applied research institute, was very fond of working in the project: Mr. Daanen, principal scientist at TNO: “I am sorry, I am trying very hard to come up with critique or remarks on the project, but I just cannot.” He was so fond because he could comply with all his deliverables. TNO was able to apply and further develop their knowledge, they have published a refereed publication, and they have strengthened their relationship with Bivolino and other partners for more fruitful and future collaborations. The most positive derivate of the project is that TNO was able to launch a spin-off that consults other textile companies in the textile fashion industry on sizing problems. The company is called “Sizing science” and is going well.

Another example is Fratelli Piacenza. Piacenza is an Italian company that produces high-end cashmere fashion. They currently deal with the same industry dynamic as Bivolino. The Open Garment project is the fourth European project that they have been participating in. In the Leapfrog project, which is their third, they were not directly collaborating with Bivolino but were on a different track. In contrast to the Open Garment project they were trying to convert their traditional business model, just like Bivolino, with customized products at the front-end and an integrated supply chain for their manufacturing process. Hence smaller projects (typically FP7) create more synergies than the larger Integrated projects under FP6.

Mr. Canepa, business development manager at Piacenza, had no complaints about the EU projects. “Some partners complain about high levels of bureaucracy, in Italy the local/national government is much slower and once did not pay us at all for a project.” At the beginning of their first project (part of FP5), they perceived the research project as too far away from feasible applications; however, this has much improved over time. The last Open Garment project has clear deliverables that will help them gain experience for adapting their traditional business model to the new market needs of customized fashion textiles, and to develop instruments to automate and optimize their manufacturing process. According to Mr. Canepa, these major steps, which are a great opportunity, could not be done by themselves alone and have to be seized now.

2.3.6 DISCUSSION AND CONCLUDING REMARKS

Bivolino and its partners have certainly improved their innovation performance by means of participating in the EU funded projects. Currently, Bivolino is looking towards a bright future: they’re experiencing exponential growth of their business. However, Bivolino could not have done this alone. As this case study has shown, Bivolino needed partners with specific resources (e.g. knowledge, technology, and financial) to help them develop the new business models. The EU funded projects played a central role in making this work.

The projects offered a fruitful setting, in which Bivolino could access this diverse set of resources. Subsequently, Bivolino was able to finance its development costs, better market its patents, benchmark its strategy against other companies, and build up an array of sustainable relationships. These strong relationships and the consequent awareness of the various parties’ needs and resources have helped to make the follow-up project “Open Garment” possible. The project was smaller in terms of participants, more targeted on market ready applications and, therefore, perceived as more valuable.

Bivolino’s remarks on the EU projects are of relatively less significant organizational issues in that they include a lot of travelling time, time consuming meetings (at the beginning) and a complex granting procedure. Another more significant issue is that it looks like bigger projects are more interesting for the science partners than for the SME’s.

In these projects, the emphasis is put on developing a more fundamental knowledge about technologies instead of developing market ready applications. Nevertheless, Byvoet relates his current business success to the company's participation in both EU projects.

2.4 TENCATE

2.4.1 COMPANY PROFILE

Royal TenCate is a multinational enterprise that supplies advanced materials based on textile technology. It consists of about 4700 employees working in 25 different countries, is quoted on the stock exchange, and has a turnover of almost a billion Euros⁸. TenCate has been (and still is) participating in many European projects. With an involvement in nine projects it is one of the most involved companies in EU projects. Nevertheless the budget involved in its participation represents less than 10% of its total R&D budget, but close to 20% of its European R&D budget. R&D in America is less based on public funding although defence research procurement is of relevance. TenCate also works closely with research centers in national or regional projects or on a tertiary funding model. This extensive experience makes TenCate an interesting company to include in the case studies.

Until a decade ago, TenCate was a traditional textile company. It mainly sold highly commoditized products on the consumer market and its competition was predominantly based on sales price. Today, TenCate has transformed its business into a set of (relatively) small market niches in which business to business customers are seeking innovative and high-tech textile products to solve complex problems. This transformation was tough, but it helped TenCate to generate highly desired added value for customers, become profitable again, and generate company growth and continuity.

TenCate's mission statement, "Materials that make a difference," stands central in everything it does. TenCate lives up to this mission by stating that their materials are at the cutting edge of textile-, chemical-, and material technology. This message is sent out from the headquarters in Almelo in the Netherlands to all its subsidiaries, which are arranged within three main sectors: Advanced textiles & composites sector, Geosynthetics & grass sector and sectors with other activity.

To give a brief impression: the advanced textile & composite sector is responsible for 45% percent of the total revenue of TenCate. The sector is known for its products used in bullet proof vests, heat/chemical/electricity resistant fabrics to protect fire fighters or other professional workers, or composite materials used in the aircraft industry by Boeing or Airbus. Next, the geosynthetics & grass sector has an equal share in revenues as the advanced textiles & composite sector, and is known for its products like the artificial grass applied in the Olympic rugby and hockey pitches at Beijing, or the geo-materials used to isolate poisoned soil and lightweight artificial foundation materials. The last and smallest sector consists of a subsidiary, TenCate Enbi that produces rollers and components particularly used for printers, copiers and fax machines, and, in addition to the holding company, the recently acquired company Xennia. This company develops inkjet technology for industrial production processes.

⁸ TenCate's annual report 2010

2.4.2 TENCATE & INNOVATION

As can be noticed from the description above, many of the company's products are quite innovative and are the result of TenCate's high levels of Research and Development (R&D). R&D's main goal is to improve the firm's innovation performance, which in return enables a firm to ensure its future business. However, R&D is a difficult process to manage. Besides working with technology road maps to frame the project portfolio, stage gating is an important step in the R&D process. At TenCate, about 80% of the fundamental R&D projects are cut prematurely, according to R&D manager Olde-Weghuis. In addition, those R&D projects that ultimately become important innovations take a long time to market (the successful Cetex composite applied in airplanes took around 20 years to develop). Subsequently, there are many innovation challenges that need to be taken into account in order to successfully carry out innovations.

Hence stages of disruptive innovation are followed by long periods of sustained innovation. Of relevance is to keep options open, since the current business strives on disruptive changes such as synthetic turf in the 1980s and thermoplastic composites in the 1990s. Sometimes disruptive innovations are not sustained, such as with windsurfing in the 1970s. The business growth then goes to the second movers. TenCate is also now involved in disruptive product innovations (e.g. in geosynthetics) and disruptive process innovations (e.g. Digital Finishing).

TenCate predominantly organizes its R&D along the "open Innovation" paradigm of Chesbrough,⁹ which assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. In other words, firms cannot afford to rely entirely on their own research, but should instead buy or license processes or inventions (i.e. patents) from other companies. In some instances TenCate takes share in crucial technology providers, or assures preferential access to technology. TenCate has currently a number of associated companies. TenCate used to develop as much as possible in house with their employees. Currently, management limits its task to more of a coordinating role. They set up the main boundaries, like strategic directions and knowledge areas, and help their R&D departments to provide access to required knowledge (either self-, co-developed, or acquired). The creative process that happens next is given much more room; it is decentralized among the several R&D departments, a more evolutionary approach is taken here.

According to Frank Spaan, TenCate's director of corporate development and investor relations, TenCate recognizes four cornerstones of its main business model, two of which deal with R&D. One involves the development of new technologies; TenCate calls it the INNOVATION cornerstone. Here the emphasis is put on developing boundary-breaking technologies. The research is much more fundamental and experimental, and the time horizon is more long-term. This is the stage where Open Innovation is really possible, where the partners need to be diverse, and where they want to discover more radical innovations. This cornerstone entails about 10 projects that can be aggregated into two main research lines: 3d-stitching and digital textile finishing (which will be elaborated on in the coming DIGITEX section). Spaan believes that if these two technologies become operational, they will have a strong effect on their business.

At the DIFFERENTIATION cornerstone, a more incremental innovation takes place. This stage is focused on improving TenCate's applications for existing market demands with existing technologies. The time to market is

⁹Chesbrough, H. W. (2003). Open innovation: the new imperative for creating and profiting from technology. Boston, Harvard Business School Press.

much shorter in this cornerstone, and more and smaller projects are run (around 50), usually in close collaboration with customers.

Spaan says that TenCate tries to keep the R&D portfolio balanced, although currently they are putting more focus on the DIFFERENTIATION cornerstone. Recently they had some proof of concepts for new technologies, but now it is the case to transform them into a clear business case. “We cannot afford to innovate just to innovate,” Spaan said. “We are a commercial party that also needs return on investment.”

The open innovation policy can be very well applied at the INNOVATION cornerstone, as here it is also possible to innovate with competitors to set joint standards or industry requirements. The closer you get to the DIFFERENTIATION cornerstone, the more the open innovation is limited to the value chain partners. Here, TenCate also tries to create a defensible business by claiming patents or have a major market share.

The open innovation policy puts a strong emphasis on the quality of the network. For example, every firm needs customers to precisely list the requirements, suppliers for new boundary breaking materials or technologies, and partners with whom to share development costs or access new knowledge areas. Subsequently, the network provides any firm with all the remaining resources (e.g. knowledge) they will need to innovate. One way to increase the value of the company’s network is to join the subsidized framework programs of the European Union, the EU projects.

2.4.3 TENCATE & COLLABORATIVE PROJECTS

For TenCate, the EU subsidized projects have become an important asset to develop successful innovations for both cornerstones. Not only in financial terms — as Olde-weghuis said, “out of the total amount of TenCate’s R&D project portfolio, about 20% is financed with EU money” — but also in other (e.g. technological, relational, market) aspects. This will be clarified by zooming into some of their EU projects.

ARTIFICIAL TURF PROJECTS

The first example of TenCate’s EU projects is the Sokraturf¹⁰ project, followed by the Multi-turf project.¹¹ These projects were some of the first EU projects that TenCate took part in, and aimed to “upgrade” the technological benefits of artificial turf. The annual report (2010) argues that the TenCate Grass Group has currently obtained a leading market position worldwide (fibres and backing) in synthetic turf systems. The market for artificial turf mainly consists of sport pitches (e.g. hockey, tennis and soccer), and, to a smaller extent, landscaping. The grass groups experience increasing revenues, profits, and market shares, due to some technological advantages and related patents: artificial grass has benefits in contrast to natural grass in terms of a higher number of usable hours, a more constant performance, and more usable in a large variety of climates. TenCate has also formed close relationships with their (up-stream value chain) partners. They conduct joint R&D, licensing, and branding.

The leading position does not come out of the blue: the two EU projects, Sokraturf & Multi-turf, have formed an important contribution, not only in terms of developing technology to produce the artificial grass, but also in

¹⁰SOKRATURF Project (1999-2003), FP5 Contract No : G1ST-CT-2001-50141 & G1ST-CT-1999-00035

¹¹MULTI-TURF Project (2005-2008), FP6 Reference No 16456

helping the TenCate Grass Division to establish very close relationships with its value chain partners. The positive experiences of the Grass group in EU projects, and its consecutive valuable pay-offs, its match with a general open innovation strategy have formed an important motivation for joining in more EU projects.

COMPOSITE PROJECTS

Another example is the Fibrechain¹² and M-Rect¹³ projects. They are both recently begun EU projects in which TenCate is participating with the Space and Aerospace market group. Besides these two projects TenCate is involved in two other projects relevant for composites. TenCate hopes to use the Fibrechain and M-Rect projects to develop a more sophisticated version of their Cetex composite. Cetex is a high-tech composite that is extensively applied in the aircraft industry. TenCate's main competitive advantage does not come not from the fact that it can produce Cetex (according to Wijskamp R&D project leader, it is relatively easy) but more in the high degrees of reliability it can achieve in the manufacturing process. In other words, for the aircraft industry, it is imperative to deliver exact the same quality, time after time. It took TenCate 15 to 20 years and many national grants to pass the certification period.

One of the two EU projects is aimed at improving mechanical specifications (i.e. wear & tear, stiffness, weight), and the other by incorporating nano-tubes into the composite. The nanotubes will enable the composite material to transport electricity. This could lead to a 50% reduction in electric wires, or a better lightning rod function, both are valuable solutions for aircraft manufacturers.

The Aerospace group is relatively inexperienced in carrying out EU projects. The current projects they are working on are usually carried out in close collaboration with some customers, enclose a specific problem, and take half a year to 1 year. In contrast, the EU projects are perceived as "massive" in terms of amount of work and diversity of parties on the table, but also in their time span (4 years). The Aerospace group in Nijverdal is relatively small; the R&D function is, in fact, managed by only one person, Sebastiaan Wijskamp, who deals with many production-related issues as well. The production-related projects, together with the 2 EU projects, make it hard for him to find enough time to carry out the work well. "What happens next is that production comes first. That's where we earn our living; it receives priority over the long-term goals," Wijskamp said. It is, however, a problem from which more medium-sized firms can suffer.

Nevertheless, from the EU projects TenCate Aerospace composites hopes to gain more knowledge that they can use to make their products better. Furthermore, for a company, it is a relatively easy and a cheap way to conduct R&D. Finally, the relational aspect plays an important role as well. "The composite world is a small world; hopefully, the project brings us much closer together, so we can work on projects together more often," Wijskamp said.

In the Fibrechain and M-Rect project, Wijskamp is curious about what will happen when the technology proofs to be valuable. "We're now working very closely with technicians who find their drive in making the technology work. I do not know what happens when the Intellectual property (ownership) discussion will start. The project might explode." Spaan places this more in context and mentions that patents are usually not the bottleneck in a project. He mentions that is relatively easy to find clear agreements on patents. "What we find much more difficult is to go from the INNOVATION cornerstone, where you talk about technologies, to the DIFFERENTIATION cornerstone in

¹²FIBRECHAIN Project (2011-2015), FP7 Reference No 263385.

¹³M-RECT Project(2010-2014), FP7 Reference No 246067

which a concrete business model is needed with a clear product market combination.” In other words, what is needed is the process of transforming a proof of concept into a clear application. An example of such a project is the Digitex project, in which there is a proof of concept, but not yet the application.

THE DIGITEX PROJECT

The Digitex project is an EU funded¹⁴ project that is recently finished (December 2010). It had the aim of conducting joint research on inkjet technologies in the textile finishing industry. Digitex – the Digital Programmed Jetting of Fluids for Multifunctional Protective Textiles – consisted of a consortium of 28 partner organizations occupied in business, as well as science. The applied inkjet research would help the textile industry to generate new production methods and technologies, cleaner and more efficient processes and add more advanced textile functionalities and products. (E.g. Anti-bacterial, chromic functionalities or single-sided hydrophobic functions). In other words the technology has boundary-breaking potential in the textile finishing process. The project delivered a wide range of achievements such as scientific publications, conference papers, lab scale demonstrations and proof of concepts, computer models and tools.

TenCate was already curious about the possibilities of inkjet technology a couple of years before the Digitex project was launched. In 2002, the company started a laboratory and employed some people with support from the Dutch ministry of economic affairs, but quickly saw that the technological complexity was far too big for TenCate to handle alone. On the other hand, the first findings of the research showed very promising (profitable) market prospects. Despite the market potential, in the old “traditional” times, the inkjet technology project for TenCate would have ended here, but the Open Innovation route offered them an alternative.

At this time, TenCate gained a substantial amount of experience in former EU projects (e.g. Sokraturf, Multiturf) and knew that this might provide the solution to the company’s lack of resources to develop a viable inkjet technology for textile finishing. Subsequently, TenCate initiated and led the Digitex project themselves. The preparation of the proposal and the consortium was assisted by a consultant. According to Gerrit Koele, the Digitex project manager, this was quite unique because normally these projects are led and initiated by research institutes. The four and a half years that the program ran were very satisfying for TenCate. “One important advantage is that you make an agreement on a target and dedicate a fixed time to it”, Koele said. He thinks that if the EU project would not have been started, and TenCate had begun to run the research in another way, the financial crisis would probably have killed the project. So EU projects have given the R&D departments a great deal of continuity.

Although the program was reengineered twice, the final deliverables gained more value. “We expected that EU would not be very happy about our changes, but strangely we received EU feedback that mentioned that these changes showed the commitment that partners are putting into the project to get it work. This touches on the essence of why the EU funded projects are started in the first place,” Mr. Koele said. This feeling probably arises from that fact the EU takes a long time to officially grant the proposal. “For companies, the risk is relatively easy to overcome. But a university that employs full time employees on the project receives 100% compensation and might be led into deeper problems if the subsidy is not granted after all,” Koele said.

This is one of the major complaints of Warmoeskerken as well. Warmoeskerken is Full Professor at the University of Twente, and his research group joined the Digitex project in the role of science partner. Warmoeskerken once

¹⁴FP6 contract no. IP 026740-2

calculated that the costs for having a proposal granted may outweigh the benefits it will deliver. In other words he argues that the investment costs are sometimes higher than the returns, especially if the 5% chance of getting a proposal granted nowadays is included.

The Digitex project had clear deliverables; however, in the role of a project manager, Gerrit Koele finds it hard to align expectations between all the partners. TenCate is much more experienced, and is aware of the time and effort needed to get an innovation to the market. “SMEs hope to obtain an “implementation ready” innovation, but often face a rude awakening. The projects are usually much more research-based, which makes the science partners much more happy of course, but this does not mean that the outcome is an application (which the SME’s want so desperately),” Koele said.

At the end he concludes that for most SME’s it is a relatively cheap and valuable lesson to experience the necessities of innovation. What remains is a tight set of relationships, and future projects will go more smoothly because of the experience. To stay at the expectation level of SME’s, Warmoeskerken likes to distinguish between Eastern and Western SME’s. He questions the true contribution of Eastern European SME’s in the project. It is not that he does not grant them the new EU project knowledge to innovate their business. The eastern partners are definitely very motivated and have equal rights compared to the Western SME’s. However, he thinks that these companies could make a much more significant progression by bringing them to the current level of their Western European sisters (an in-between step) than by taking them to the top levels of European innovation (a step too far). “The technological diversity is too large to effectively absorb knowledge, less diversity would make the collaboration in EU projects much more efficient”, Warmoeskerken said.

The Digitex partners contributed in many different ways to the project outcomes. Most participating SME’s were customers of TenCate who buy their raw textile products and process it into end-customer ready applications. Their main role is to discover the potential use and subsequent customer requirements. Furthermore, a substantial number of universities took part, often possessing fundamental knowledge; they are an important pillar of the R component in R&D. Finally some engineering partners have specific knowledge regarding how to design (the D of R&D) and manufacture applications for use. For example, Reggiani Macchine, an Italian manufacturer of textile machinery equipment, was able to release a newly developed digital textile printer in mid-2010 with Xennia. Xennia played a central role in the development of inks and coating fluids and the related operating software. Their leading knowledge levels and the shared patent position with TenCate is of such a strategic importance that TenCate obtained a 75% controlling interest in Xennia.

The University of Twente was also very satisfied about the Digitex project outcomes: They could employ a PhD researcher and produce some publications. For science institutes publications are the main performance indicator of the knowledge they have gained. This knowledge delivered new insights but also raised new and relevant questions, regarding which the University of Twente was able to receive an EU Marie Curie project grant. However, Warmoeskerken wanted to remark that he expected from the industry partners more concrete applications. “You know that the Digitex project was coordinated by a partner from the industry, and not a science partner, as usual. If I compare my experience to former projects, I think TenCate may be more successful. We showed them so much that the technologies really worked. I do not know why management was not more persistent and that more digital finishing applications have been launched. In terms of acquiring Xennia and launching a digital textile finishing machine with Reggiani Macchine, TenCate has achieved some quality performances, but this is not their core business.”

As mentioned before, transforming a technology into an application was found to be difficult by SMEs as well as by TenCate. Obviously, a link is missing between the development of fundamental knowledge and the technologies of

science partners, and the applications needed by the industry partners. Frank Spaan is of the opinion that project follow-up could play an important role in bridging this gap. He subsequently hopes that the follow-up of Digitex will go beyond the experimentation stage and generate some concrete applications.

However, Warmoeskerken is of another opinion. He thinks that other parties can and should deal with these transformation issues during the project. Parties like the Saxion University of Applied Sciences have already shown good results with relevant and practically-oriented PhD research.¹⁵ TNO is also an organization that should fulfil this role; however, as regards the Digitex project, TenCate and the University of Twente had unanimous opinion about them. They were not found working with TNO (=The Netherlands Organization for Applied Scientific Research) at all. Warmoeskerken, Koele and Spaan found TNO much too aggressive in terms of their patent strategy: It does not match the open character of EU projects, and secondly, by claiming the patents, they deprive companies like TenCate of a defendable business model.

2.4.4 EXPLOITABLE RESULTS

TenCate has a long history of involvement in innovation and thus research, often together with Universities; it had an important role in boosting the Textile School in Enschede (predecessor of the Saxion Hogeschool) to develop a chemical engineering and a mechanical engineering school. Moreover it was instrumental in setting up the Technical University in Twente (by offering the land for the campus). Since 1958 TenCate and the University have intensive relations. The former rector of the University of Twente sits on the Board of Directors of TenCate while a former CEO of TenCate sits on the Board of Trustees of the University.

TenCate sponsors a research group on sport materials and has also intensive relation with the composite research department: in fact it has recently set up the TRC, a dedicated research centre. Finally TenCate has set up with Saxion and University Twente OICAM, the Open Innovation Centre on Advanced Materials. The center is active in three subjects: protective textiles, synthetic turf and composites; the partnership has created families of new products as well as related testing methods. The collaboration often generated spin offs: an estimate counted over 10 spin off companies with over 100 people employed.

The relation with the Universities is not exclusive. Composites and geotextiles are also subject of research and development projects with the University of Delft. The American subsidiaries have connections to US Universities (Georgia Institute of Technology). More recently, since 2005 TenCate has spread out its linkages wider with projects with the Universities of Dresden, Aachen and ENSAIT. Relations with more applied research have become less intensive; TenCate has increasingly integrated development activities, hence the connections are more related to testing, considered to be more tactical and operational.

TenCate also works substantially together with machine suppliers and chemical suppliers. Projects are then often confidential and exclusive in order to develop proprietary technologies; this reinforces IPR positions defended in patents. A step further is performed acquiring strategic stakes in companies with essential technologies.

Examples of development of new products and processes:

¹⁵G.H. Bouwhuis, *"The design of a novel, environmentally improved, industrial cotton pre-treatment process"*, Phd thesis University of Twente, ISBN 978-90-365-3153-5, 2011

CETEX thermoplastic composites Carbon/PPS R&D done by TenCate with University of Delft 1985-1995. Product introduction around 1995, full uptake after 2005. National Funding. Lead clients Boeing and Airbus

Thiolon: Development of artificial grass fibers, artificial grass field systems and validation of sport functionalities. R&D done by TenCate with TNO, University of Twente and spin-offs from 1980 onwards. Product introduction around 1990, full uptake after 2000. Regional, National and European Funding. Lead clients Netherlands Hockey Federation, UEFA.

Defender M: Development of light weight flame retardant fabrics for military and security forces. Research & Development done by TenCate with Lenzing (AT) and validation at Georgia Institute of Technology between 2000-2005. Full uptake from 2008. Only internal funding. Lead client US Army.

Geotubes: Development of geotextiles systems with water filtration, also with sensors. R&D done with the University of Delft and TNO between 1995-2000. Product introduction in 2000, full uptake after 2005. Mainly internal funding, some national funding. Lead clients Rijkswaterstaat (Dutch authority for public water), Airport Authority of Hong Kong.

Low temperature cotton scouring and bleaching. R&D funded and validated at University Twente with industrial partners (CHT and Benninger) since 1995. Process not yet implemented because of problems of up scaling the process.

Digital finishing. Development of digital technologies applied to textile printing and finishing. R&D developed with High Tech SMEs, Reggiani (IT) and some involvement of University Twente and Manchester from 2002 onwards. Not yet introduction of process/product, because of difficulties in up scaling process. Uptake expected in 2013. Regional and European funding.

Biopolymers in grass and geosynthetics. R&D done with regional consortium and with Universities of Twente and Delft from 2003 onwards. No product or process introduction because of poor performance in relation to market demands. A new regional consortium studies possibilities from 2011 onwards.

2.4.5 DISCUSSION AND CONCLUSIONS

From the description above, it can be noted that EU projects had and are having a significant impact on the innovation performance of TenCate, as well as its network. These projects made it possible for TenCate to transform itself from a company that competes mainly on production costs in a commoditized mass market into a company that competes with high-end solutions in niche markets. TenCate could definitely not have achieved this without its close relationships (e.g. customers, suppliers, universities, etc) and their valuable contributions (technological, market resources). However, a substantial set of these innovation processes have been extensively triggered by EU projects:

First, we see that some projects (like Fibrechain) draw on key fundamental knowledge (usually available at universities) to create new and innovative applications (needed by the industry). We like to call these first stage projects, or similar to TenCate's INNOVATION cornerstone projects. In contrast to SME's, even companies like TenCate are much more business oriented and cannot afford to step into R&D trajectories that take more than 15 years (for instance, in the case of Cetex). Especially in the first stage of fundamental research there are no pay-offs for a company, in contrast to their science partners. They can attract PhD researchers and publish interesting

articles. EU funding plays an important role in investment for these projects; it is also believed that this funding brings stability to R&D departments in times of crises. However, the problem for the industry partners is that these first stage projects usually end up with a proof of concept, and seldom deliver market-ready applications.

Sometimes these projects are followed up by second stage projects (Multi-turf) or projects aimed at improving existing products (M-Rect). In TenCate terms, these projects are at their DIFFERENTIATION cornerstone. These projects will not deliver radical innovations, are smaller in terms of participants and are thus aimed at translating the technology or proof of concept into a market-ready application. Industry partners usually find projects in these stages to be more valuable, but radical improvements are hard to carry out here. Subsequently, both types of projects are important for the competitive position of the industry, as well as the progress of science. The first stage projects are important to gain fundamental knowledge, and to ensure continuity in the future and second stage projects to make improvements.

Besides the technological and funding aspect of the projects, there is also a very strong relational aspect that EU projects nurture perfectly. The Multiturf and Sokraturf projects had a great effect on current tight relationships over the entire artificial turf value chain. The Digitex project strengthened its relationship with Xennia, and the M-Rect / Fibrechain projects are hoped to create strong relationships as well. After every project, the partners got to know each other very well, and started to form dense networks. These networks have an important effect on social mechanisms like trust and reputation, which in return are important drivers for knowledge exchange and innovation. Knowledge exchange and the strength of ties are also increased by researchers who first carry out their PhD in an EU project, and who then begin to work with one of the industry partners of an EU project. For example, TenCate employs several such researchers.

Next to the relational aspect of innovation performance, the relationships have also a more long-term effect on cluster building. According to Spaan, TenCate and its artificial turf value chain partners have become the world's leading suppliers, and they jointly dominate the market. Furthermore, TenCate supports in the Twente area (The Netherlands), a newly founded "open innovation centers on smart textiles¹⁶," and a textile research chair at the University of Twente (EFSM chair of Warmoeskerken). Finally, knowledge intensive spin-offs¹⁷ employing former PhD students on textile topics have also come into existence. All these new developments have led to a more modern and healthy textile cluster which is well-protected against the lock-in of old textile mass market dynamics.

Remarks on the EU-projects that have emerged from the case study are usually based on the same findings. On the part of the industry partners, there is a greater desire to run smaller projects that are better focused on market-ready applications. It can be argued that market-ready application projects should be preceded by more fundamental projects. Furthermore, the bureaucratic fuss that companies go through to hire consultants when applying for an EU project, and the non-transparent granting procedure, often makes the partners frustrated. The pre-investments necessary to get a project granted may create financial problems for science partners.

Another remark arises from the effect of the subsidies on the entire industry. Gerrit Koele thinks that the effects of an EU subsidy can certainly help to improve the innovation performance of a group of companies. Whether the interest of the entire industry is served, however, is questionable. Koele argues that the group of companies that takes part in EU projects is already the innovative element. What happens next is that it leads to an increased

¹⁶Open Innovation Center Advanced Materials (OICAM), Nijverdal, the Netherlands

¹⁷AgrawalEcolabs - Innovation in Fibrous & Smart Materials, Enschede, the Netherlands, Reden BV, Hengelo.

¹¹Schumpeter, J. A. (1934). *The Theory of Economic Development*. Cambridge, Harvard University Press.

performance difference between the frontrunners and the laggards. In other words, the EU projects will speed up the evolutionary process of natural selection, or the Schumpeterian Creative Destruction¹⁸, meaning that the low-performing companies (the laggards) are leaving the scene much more quickly. If this is not the case, and this is Spaan's complaint about granting subsidies to companies that have a questionable right to existence, it will slow down the process of creative destruction. "If a company is essentially unhealthy, you will not heal the company with grants, you will only postpone bankruptcy, and in the role of EU you will face a much lower return on investment in terms of tax on profits and salaries," Spaan said. This will eventually have a much more negative impact on the economy. It is important to keep a watchful eye on this possibility.

Nevertheless, the framework program projects of the European Union certainly have a positive effect on the innovation performance of TenCate and its partners. The projects are the perfect glue to hold this wide variety of partners together. Warmoeskerken proclaims that the industry can no longer do without it.

TenCate is the best example of a well deployed internal and external strategy. However it should be seen as a structuring and formalization of a mind set that has been in the company at least since 1945: a constant awareness of changing competition, an inherent technological curiosity, a attitude to seek differentiation and to protect its market position, a strong drive to reduce costs, a sensitivity to its environment and a strong institutional presence and a strong competition for leadership inside the company. Now TenCate presents a more structured approach embodied in a vision, a technology road map, procedures to select promising projects, structured laboratoria, an IPR policy and a strong end user marketing. However TenCate is in fact a collection of four business units in Europe each having its own networks and methods.

The TenCate case is particular but not unique. More focused companies also develop technology road maps, have structured procedures to engage into projects, have internal project management skills, are able to translate novel concepts in products and in processes and have the ability to defend their IPR. However when companies are more focused the strategy is less formalized and the networks of relations are not as broad. Relations are predominantly regional or very focused with specialized centres in a wider geographical zone.

We would like to focus on two key success factors in a company. One is to be able to share a common vision, the other to defend the progress

To see the relationship between R&D centres and companies as technology push process does not represent fully the interaction between research and industry. The role of R&D centres can be to initiate fundamental research and innovation, but also to structure knowledge of innovations done in companies, to assist process development, to give a second opinion on new products, to validate and certify (test) results, or to develop training and education programmes. In the best practices we have seen a combination of all of the above. This is however mainly the case when there is strong convergence in content and in human relations.

By and large we see three patterns:

- Firms with Universities interact mainly on fundamental concepts and on validation of results
- Firms with Applied Universities (e.g. Aachen, ENSAIT, Manchester) but also Citeve offer a technology platform to industrialise products and processes

- Firms with Applied technology centres focus on technology watch testing and training.

3.1 NORD-PAS-DE-CALAIS, FRANCE

3.1.1 RATIONALE OF THE CASE

Nord-Pas-de-Calais (NPC) has been selected as a case because of the active policies engaged by the industry and the region over the last five years, under the umbrella of the *Pôles de Compétitivité* (competitive clusters) policy. NPC is thus a region, that albeit in restructuring for the last 40 years has found a new textile identity at the crossroads of materials and applications. The region hosts one of the best education and research centres in Europe, which is also one of the few with increasing student enrolment. Finally the region has taken a spot in the sectorial ERANET project called Crosstexnet.

In the methodology the focus lays on face to face interviews (in the region and during Techtextil) and telephone interviews. The research team also benefitted from 10 years practical experience with innovation projects in the region, hence confidential information has enriched the analysis of main findings.

3.1.2 PROFILE OF THE REGION

The case study covers mainly the region of Nord-Pas-de-Calais. However, the textile cluster and the impact of the research centre is wider and covers the entire Northern part of France including the regions of Picardie, Haute Normandie and Champagne-Ardenne and to some extent the Ile de France. In textile terms the Lille area is the second textile hub in France after Lyon (Rhône Alpes). In addition, the North of France is closely related to adjacent Flanders. Unlike in the case study on SMEs, in this task we shall only examine Flanders in connection to Northern France.

Of relevance for textile research are three segments of the industry technical textiles (extending into plastics); lace (case addressed in Task 3) and the linen industry (with a major agricultural component). Beyond the case description in Task 3, the technical textiles and the linen industry shall be addressed in more depth in this case. In addition we shall make a point on retailers.

In 2010 the Northern French textile and clothing industry represented around 600 companies with an employment of around 13.000 people. The region is the third cluster within the French system after Paris (fashion) and Rhône-Alpes (textiles). Since the demise of the larger textile groups (VEV-Prouvost, Chargeurs) the region's industry is essentially made up of SME's. Moreover, the region was dominated by the wool industry in the agglomeration of Roubaix-Tourcoing, complemented with an important cotton industry in Lille and a lace industry (dealt with specifically in the Task 3 Case description) in the Lys valley. The wool industry has disappeared entirely in the period 1995-2003 mainly because of the crisis in the French menswear sector, a low export performance and a lower

market position than the Italian competition. The French wool textile sector had a lower degree of vertical integration and in general outdated and inefficient plants because of decades of underinvestment.

The cotton and linen industry also declined drastically, in fact nowadays there is almost no industry of this kind left. The cotton industry is mainly oriented towards the home textile sector (bed and bath linen). The large clothing industry, still present in 2000, has all but disappeared. Less than 20 subcontractors can at the present time be identified. However, the Lille-Roubaix-Tourcoing *metropole* hosts the headquarters of major retailers in fashion (e.g. Pinkie,) or in sports (Decathlon) or in mail order (Trois Suisses, La Redoute). Nowadays, two industrial segments pertain: a technical textiles cluster in the agglomeration of LRT and a lace and broderies sector in Calais and Caudry. The two lace districts are made of 15 firms with 1200 jobs.

LINEN INDUSTRY

Northern France is the turnkey of the global flax or linen industry and the hub of research in bast fibres. The linen industry is an odd but interesting case in the European arena. Its importance is not in the magnitude of employment; this is at best, 3000 people employed, with a substantial agricultural share (most of them in France) and industrial employment below 1000 people (of which some 200 in France). The relevance of the linen industry is in the raw material production and connection to a very positive ecological footprint.

With some 120.000 Tons annual average production, the European linen sector is now the main natural raw materials sector in Europe. Although, the sector is now almost at par with the emerging biopolymer topic, the West European linen production represents 90% of the EU production and consists of a major basin in France from the Loire to the Belgian Border (ca. 95.000 T), Belgium (ca. 10.000 T) and the Netherlands (below 5000 T). The leading flax growers and primary processing are based in Normandy. Linen processing has been subjected to a strong crisis. Hence, only few spinners are left: some in Flanders, Poland, the Baltic States and one in Italy. Linen weavers are based in Northern France and in Flanders, in the Baltic zone as well as in Italy. The flax industry is a small system with intensive linkages. All but one company in the European flax sector can be classified as SME. The major industrial player in flax spinning in Northern France, a company called Safilin, has delocalized its production to Poland.

The linen industry has a substantial potential for growth, but the sector also has a backlog in plant selection and production processes. The linen sector can be a rallying point for a wider expansion of production of raw materials in Europe, expanding into hemp, nettle Spanish broom. It should be noticed that the flax industry has been identified as a key economic sector in France since it may provide for fibre autonomy in case of emergency. Flax and other bast fibres may unleash their potential if bulk fibres stay at substantially higher price levels. However, the small size of the flax industry makes any ambition dependant on a small number of gatekeepers. The main potential of flax can be unleashed if expansion of cultivation is enabled in the new member states.

Of more recent date is research in flax as a basic material for composites. Much research has been done in flax and other bast fibres as matrix for composites. Since 2008 the automotive sector has started to play a stronger role of launching customer. With the rising interest for cradle to cradle, composites based on natural fibres a natural resins gain in interest.

Flax research is based mainly in Northern France and to a limited extent in Poland (Poznan see Polish case) and in Lombardia. The French research groups are highly structured in a cross university group federating Lille, Picardie, Champagne and Normandie in the *Réseau Français des Parois* (French Network of Walls). The French/Flemish research cluster combines material sciences and agricultural sciences and has gained substantial progress because

of interactions with genomics and biotechnology. The *Vlaams Instituut voor Biotechnologie* (Flemish Institute for Biotechnology) is a point of reference also for French research. Research on genomics may enable the development of new family of plants with improved functionalities and with improved aligned properties.

TECHNICAL TEXTILES

The technical textiles cluster in NPC is nowadays the most vibrant sector in Northern France, it is a sector regrouping over 50 firms with around 3000 people employed. It is organized in Clubtex, which works as a forum of exchange, dissemination and mutual activities. The latter ones are mainly in the area of promotion. Except for three firms the technical textiles sector is made up out of SMEs. For instance, a company called Dickson Constant is an exception which is also being part of a USA group. The recently formed Fauchille group is formally no longer an SME, albeit a collection of SME's

The technical textile firms in Northern France have either a very specific niche in which they are specialists, this applies to manufacturers of coated fabrics for inflatable's, bio-implants, ropes and ribbons, and knitted performs. Or they are project oriented, which means that they develop products or modify products depending on the specific end user needs. This is for example the case for lace makers and knitters that often develop materials for a very specific use, like fabric for a Thalys train head.

RETAILERS

The retailing industry developed as a spin off or a redeployment of capital of textile manufacturers, as for instance applies to mail order firms as La Redoute and Trois Suisses, fashion retailers Pimkie and Camaieu and sport retailer Decathlon. Although their direct involvement in research is very limited, their size of employment (more than 5000 people at headquarter level) means that they are important recruiters for textile engineer and provide a basis for a healthy education system. In addition, retailers are important clients for technical assistance, training and testing thus they also provide critical mass for technical facilities.

RESEARCH DEMAND

The region has a reasonable number of innovative companies, mainly because of the presence of original technologies and very specific end user needs. The development of technical textiles from lace or very specifically into biomedical textiles can be qualified as a relevant trend.

The relations between companies and research centres are likely to be mainly programmatic and commercial. The professional relation is less relevant since most SMEs recruit few academic trained staff. The only exception, and this is for the region of NPC an important exception, is Decathlon. Decathlon is the largest sport retailer in the world employing 50.000 people and being part of the Mulliez group, it has its headquarters in Lille. Decathlon is by far the biggest recruiter of engineers trained at ENSAIT, both of French and of foreign students. It has several development teams based in the Lille region (materials and components, cycling, running and team sports). As it has a policy of delocalizing development teams close to lead markets and close to strategic centres, the team sport research centre will be based close to the *Centre Européen des Textiles Innovants* (European Center of Innovative Textiles, CETI). However, the relations with research are rather professional since it contracts out little research and if it does so, like in testing, it has no geographical preference.

The Northern French textile industry (only assuming firms that now exist) has filed slightly over 400 patents in total, of which around 40 in the last 2 years. This represents around 2% of all patents filed by textile firms in Europe. Northern France ranks second after the Rhone Alpes (more than 1000 patents of which almost 150 of the last two years) and at par with the Ile de France. We have only found 12 companies with a patent position, of them only two firms with more than 100 patents. The recent growth in patents is solely attributable to companies with currently less than 100 patents. All patents are held by firms active in technical textiles.

Unlike the German regions, Lombardia, or the Rhone Alpes, Northern France does not have an industrial complex comprising chemical industries and machinery industries. Hence it does not have a technology push inside the region, propelling demand for new technology. This is largely part of the dominance of traditional textile industries such as wool and cotton. Auxiliary industries were more service providers to textiles than knowledge driven innovators. The textile industry in the Rhone-Alpes has been more closely connected to original machine technology developed (e.g. the Jacquard weaving loom) and it was a seed bed of the chemical fibre industry.

However the recent picture changes and one should rather associate the Northern French textile cluster to end – users, especially of components for the aerospace and transportation (e.g. EADS, Mecaplast and Alsthom). Moreover the biopolymer sector is developing in Northern France with Roquette (associated to the Dutch DSM), Arkema and TotalFina as relevant firms. Finally it has been successful in associating medical firms and cosmetic firms (often based in Paris).

Therefore the industrial system is going into a transformation and indeed a redefinition of the industry has engaged in the region.

3.1.3 RESEARCH FUNDING

BASIC FUNDING

Basic funding for research and education depends directly from the Ministry of National Education and from the Ministry of Industry for specific research infrastructures. However some duties and funding is delegated to the regions. Currently the state covers 50% of higher education funding and the regions 33%. The remainder comes from local authorities and other sources. A recent development is to increase the autonomy of management and funding of research centres and universities.

CENTRES DE RECHERCHE ET CENTRES TECHNIQUES

Technical centres are funded specifically under various systems. Some centres fall under the national research infrastructure and are funded directly by a ministry (e.g. CNRS for technological research, INRA for agricultural research and Institut Pasteur for health research). Some of these centres have a regional antenna (e.g. INRA) or work together with university labs (e.g. Institut Pasteur). Technical centres of national relevance and with public tasks (e.g. in normalization) are often through an endowment of the state. This is currently the situation for the IFTH. However an alternative system is to fund research centres through a specific tax (taxe affectée). Currently a review of funding mechanisms is under execution.

POLES DE COMPETITIVE

The poles are funded through a double mechanism. They are funded to exist which could be considered a primary funding. This funding is a combination of national and regional funding. In addition poles de Competitivité have access to project funding (see below) and have a role to pre-evaluate proposals of companies and research centres. Poles have to be proposed bottom up, and indeed 71 poles have been funded (of which one in textiles in Northern France). The Poles need to bring together partners from research and industry. Their work should be based on a technology road map and a business plan.

3.1.4 GRANTS FUNDING

France has a comprehensive system of project funding. Of relevance is the connection of projects to the *Poles de Competitivité*.

FONDS UNIQUE INTERMINISTERIEL (Interministerial Fund, FUI)

The *Fonds Unique Interministeriel* is a joint fund for research fed by all ministries. It has succeeded the budget of Civil R&D. The FUI funds large multidisciplinary projects of strategic importance. The FUI allocates budget mainly to projects labelled by the “Pole de Competitivité”; textiles in Northern France (Uptex) is one of them. Under the FUI research projects must be consortium based and combine companies and research centres. Companies can be large or can be SME. Projects with more than 40% of their budget allocated to public research centres have to justify so. There is no regional constraint imposed. Project size is at least 750 K euro. Poles de competitive may also bring forward proposals under a specific line for “*projets structurant*”

INSTITUT DE RECHERCHE TECHNOLOGIQUE (INSTITUTE FOR TECHNOLOGICAL RESEARCH, IRT)

Institut de Recherche Technologiques is a new tool to foster concentration of research and innovation in key societal and industrial areas. The funding model is hybrid since it funds an overall institution (1st) but also a programme in a competitive call (2^d). In addition it demands substantial private involvement. The first six IRT receive a total funding of 2 Bill Euro. Materials are of great importance in the first six approved IRT's in 2011 since they are directly addressed by two IRT and indirectly by three others. Only one IRT is located in the Nord-Pas de Calais, i.e. Railenium focusing on railway technology. It does only edgewise involve textiles through the partnership of Armines-Douai and the University of Lille.

AGENCE NATIONALE DE LA RECHERCHE (NATIONAL AGENCY FOR RESEARCH, ANR)

Agence Nationale de la Recherche funds large collaborative projects, without discriminating between types of companies. 50% of budget is allocated to projects supported by the poles de competitivité.

OSEO

OSEO funds research and innovation projects of SMEs. The projects need to involve two partners, of which one beneficiary and one knowledge provider. This should not necessarily be a public research centre.

ERDF-Regional

Regional funding is often used to match national funding or it can be used to fund research infrastructures or projects. In Northern France all cases are in play. In addition the region can use Interreg IV A to promote cross border innovation/research structuring.

3.1.5 RESEARCH CENTERS

Northern France has a very dense research and education system with at least 6 centres substantially engaged or connected to the textile industry. The two main hubs in the system are ENSAIT, the textile engineering school and IFTH the technical centre. The landscape is currently going through considerable change, both in institutional context and in its structuring. Autonomy of Universities is being increased as well as more segmentation in terms of excellence is being aimed at by the current government.

UNIVERSITÉ DE LILLE AND ECOLE NATIONALE SUPERIEURE DE CHIMIE DE LILLE (UNIVERSITY OF LILLE AND THE NATIONAL SCHOOL OF CHEMISTRY OF LILLE, ENSCL)

Under this heading we examine a number of more general research and education institutes with a partial relevance for textile research. The University of Lille and the *Ecole Nationale Supérieure de Chimie de Lille* are important players in terms of education and can be characterized as centres with a “professional” outlook. Their contribution in terms of research comes mainly to the connection to other scientific disciplines and the potential and practice of transferring findings to textile applications, although they do not have a specific textile activity. The University is relevant for its key role in research in flax genomics, for which it is a global leader, and more extensively to fundamental material research and medical research in which it is a good player at the national level. ENSCL has textiles as one of its research themes, but it is also engaged in research on renewable and recyclable materials and in flame retardant and fire resistant characteristics of materials. Both centres are connected to the pole de compétitivité UPTEx. They are involved in projects supported by UPTEx and they are active in dissemination events such as the “*Journées Scientifiques du Pole*”.

ÉCOLE NATIONALE SUPERIEURE DES MINES DE DOUAI (NATIONAL SCHOOL OF MINES DE DOUAI, ENSMD)

École Nationale Supérieure des Mines de Douai (National School of Mines de Douai, ENSMD) was founded in 1878, at the time it trained and certified staff for mining activities. In 1965 ENSMD turned into an Engineering College dedicated to industrial activities. ENSMD has four research units that combine their research activities with educational purpose. The four units are: Materials, Processes and Environment (MPE), Technology of Polymers and Composites & Mechanical Engineering (TPCIM), Chemistry and Environment unit, Computer Systems and Automation Unit (IA), Industrial Energetics Unit (EI). Currently ENSMD houses over 230 staff members, of which 70 doctors and 77 PhD students. As stated on their website, the research activities in 2009 resulted in almost 200 publications and communications and 18 PhD theses. Furthermore, the contractual turnover and registered reached over 7 million Euro's including over 5 million Euro's in research. In 2006 ENSMD became a so-called Institut Carnot, a network of institutes compiled out 18 000 research professionals with a common goal: developing

partnership research for companies. Becoming part of the network recognized the effort and successfulness of ESDM in working together with industrial partners.

ECOLE NATIONALE SUPERIEURE DES ARTS ET INDUSTRIES (NATIONAL SCHOOL OF ARTS AND INDUSTRIES, ENSAIT - GEMTEX)

ENSAIT Ecole Nationale Supérieure des Arts et industries is the higher engineering school for textiles, based in Roubaix since 1881. It is an independent school with the status of Établissement public à caractère scientifique, culturel et professionnel. After a crisis in attraction and output it has now around 430 students, of which 30 PhD students, which is a growth of 40% since 2005. Its core activity is education, which may characterize ENSAIT as an institute with a “professional character”. The professional character is reinforced by a strong commitment of alumni to the school. However the growing importance of research gives a strong programmatic accent. Research activities are structured in a specific unit “Gemtex”.

ENSAIT is classified in our impact analysis as an institute within the first tier of European research centres, with over the last 5 years an annual growth of 10% in quality and quantity of output. It has been successful in connecting in the international arena in terms of recruitment of students and staff, involvement in international research networks and European funding. ENSAIT plays a leading role in AUTEX and is well connected to the European technology Platform. In addition ENSAIT is well matched to centres of comparable quality such as Gent, Aachen and Dresden.

Within the region ENSAIT has a niche position in a crowded and competitive education and research landscape. Compared to the centres of similar standing (e.g. Aachen), the lack of imbedding in a larger university is seen as a benefit in terms of autonomy and flexibility but a disadvantage in critical mass and long term strategy. ENSAIT has chosen to enhance linkages with other research groups in the region, especially with Ecole des Mines de Douai. In addition ENSAIT is closely involved with Uptex and benefits from its national and international exposure.

The ENSAIT has a large degree of autonomy, within the French regulatory context. It has its own governing council in which industry is represented (20% of members) and a chairman coming from industry. The research activity is not specifically steered by a committee with industrial representation. The HEI evaluation body¹⁹ mentions in its 2009 report a missing link in the governance which has been made up for only recently. This is compounded by the lack of a clear technology road-map. The research programming has essentially been determined by project opportunities. However a core focus on composite materials and on textiles with medical properties is emerging.

Relations with industry are intense and research programming is highly responsive to industrial needs or reactive to upcoming opportunities. The relations to industry have improved at operational level through the recruitment of former IFTH staff. However a closer look shows that the relations are mainly with a core group of 20 textile companies in technical textiles. In addition ENSAIT has successfully connected to end users of textiles mainly in transportation (Alstom, Renault) for research programming. In reaching out to end users and broadening its scope to composites, ENSAIT becomes less dependent on a declining textile industry.

INSTITUT FRANCAIS DU TEXTILE HABILLEMENT (FRENCH INSTITUTE OF TEXTILE AND CLOTHING, IFTH)

¹⁹ AERES, December 2009.

The Institut Français du Textile Habillement is the technical centre for the textile and clothing industries. It has been created as a merger of the CETIH (clothing) and ITF (Textile). The IFTH has the status of “Centre Technique Industriel”. This is a special status by law granting a state subvention (currently covering 40% of the budget). The core activities of the IFTH are normalization, testing and certification, research and engineering services and training, technology watch and dissemination. Most revenues come from services to its clients. In our classification the IFTH is an example of a technology centre with a “commercial” outlook.

Collective research is an important task of the IFTH, in fact all public funded research is to be collective. Most research funding is obtained in national competition for project funding under the FUI and OSEO programmes. The IFTH is in textiles the main partner for SMEs in textile research. The IFTH also has a strong track record in European research, with often the role of coordinator or work package leader. This enables them to bring along French companies in European projects. Moreover the IFTH sees EU funding as the best tool to be associated to centres of excellence in Europe.

The IFTH has a regional and sectoral matrix model. The centre in Villeneuve d’Ascq supports Northern France. This goes further than the Nord-Pas-de-Calais region. In addition it has substantial activities for Belgian firms and it covers also Northern Europe and Great Britain. The IFTH receives little regional funding, but this is not a structural element but rather the consequence of an intended centralisation of research activities in Lyon some years ago, which led to tensions with regional government.

It is specialized in extrusion/spinning and in non-wovens. The IFTH would like to strengthen the specialization of each regional centre, and shall join the CETI (see below). An important trend is that the IFTH is increasingly involved in sectors not usually classified as textiles and in particular for end users of textiles such as automotives, construction and medical. Therefore the focus is shifting from technology push to end-user pull. Hence the focus of the IFTH is for 75% on technical textiles, whereas this segment is only a minority of the sector as a whole.

This latter trend creates a dilemma for IFTH since its funding is essentially justified through its links to the clothing and textile industry. Both industries (with two associative systems) are represented in the governance of the IFTH. The governance and financing of the IFTH is now under discussion within the government. The objective is fund technical centres through an industry levy. The levy system (taxes affectées), is based on an industry definition (with a heavy representation of clothing for the IFTH) which does not reflect the current audience of the IFTH. In addition the specific levy funds a range of collective actions (promotion, export support and training) and the IFTH would have less certainty over its basic funding. This is all the more the case since it would depend more of a segment of the industry less oriented towards technological innovation.

CENTRE EUROPEEN DES TEXTILES INNOVANTS (EUROPEAN CENTER OF INNOVATIVE TEXTILES, CETI)

CETI is the foreseen and currently build technology platform of the competitiveness cluster Uptex. It is based on a former industrial site between Roubaix and Tourcoing. Being part of urban regeneration project its construction is supported by local and regional funds with ERDF support. The technological part is co-funded by the region and the government under the research policy. The concept of the CETI is of an office complex for actors in R&D and a laboratory and pilot plant. Indeed the IFTH shall move from its current site in Villeneuve d’Ascq to the CETI. The centre should also be the basis for rallying other players, such as ENSAIT and other higher education institutes. However this leads for them to a disjunction of activities and of governance problems.

A full physical test lab is foreseen as well as a pilot line to be dedicated to fibre extrusion and non-wovens structuring, both to be operative in 2012. A further technical expansion is foreseen for 2013-2014, involving finishing, coating or printing. The philosophy of the CETI is to create a technological offer, with the assumption that a specific offer will attract demand. This approach is in line with a more general trend (also seen in Aachen) to offer an integrated technological platform especially for partners such as end users without facilities or to companies that do not wish to divert their main production lines for test runs.

While the CETI has the term “Européen” in its name, the initiative is still firmly based in a French institutional context in terms of governance and funding. However in making a business plan a European and global benchmark has been done. In addition it is now engaged in actions to broaden its European outlook and visibility. The leadership of the region in Crosstexnet may contribute to that visibility.

HAUTES ÉTUDES D'INGÉNIEUR (UNIVERSITY OF ENGINEERING, HEI)

The *Hautes Études d'Ingénieur* (University of Engineering, HEI) was founded in 1885 by Christian leaders from the North of France in search for highly educated engineers and managers. In 2005 HEI joined forces with TIMEX (Technologies, innovation et management international textiles) and ESTIT (Ecole Supérieure des Techniques Industrielles et du Textiles).

HEI currently houses over 1900 engineering students and has a network of 15.000 graduates. The HEI has research centers in four fields Chemistry, Energy and Systems, Structures and Materials and finally Engineering and Sciences. HEI has research teams in multiple fields of interest. Civil engineering focuses among others on the characterization of materials and models, whereas the research done in the laboratory of spectrochemistry and infra-red focuses on the dynamics of liquid solution and environmental chemistry. HEI also offers companies the possibility to hire research teams and laboratories to for instance make a market analysis or give technical assistance in one of the areas of expertise. Furthermore, HEI has nearly 60 international academic partnerships. Besides having a long list of academic partners, the university also obliges its students to spend at least 3 months abroad and focuses on internationalization.

3.1.6 CHARACTERISTICS OF THE RESEARCH INFRASTRUCTURE

EXCELLENCE

The excellence of research in the region can be identified in the first tier at a European level. ENSAIT ranks amongst the best textile research centres in Europe and is growing in quality and impact. Its connection to a wider research arena in the region and the increased autonomy of Universities offers opportunities. However the opportunities have not yet capitalized in an IRT. The IRT based in Valenciennes only edgewise relates to textiles.

IFTH was for a long time the leading technical centre but has recently lost its prestige because of increased European competition (e.g. compared to Centexbel) and debates on its status. The stronger embedding of ENSAIT in a network of more fundamental research and the reaching out of all research centres outside of traditional textiles is an opportunity for strengthening the research infrastructure. The establishment of the CETI has the potential of creating an original technology platform in the region.

REGIONAL IMPACT

The impact of the knowledge structure is essentially regional but in a wider sense, going beyond the region Nord-Pas-de-Calais to entire Northern France. Since the specializations in the Lyon region and the Lille region differ, both poles have a national potential. Relations with Flanders are intense both between institutions and at service level between centres and companies. This applies to services in which IFTH and Centexbel have complementary and competitive offers, to some joint projects (e.g. Dimetex) and to joint dissemination actions (Futurotextile). Although Flemish companies and institutions are also well connected to the Netherlands and to Nordrhein-Westfalen, these are two sets of relations, although TenCate (NL) is now setting up projects with ENSAIT).

The actors in the region acknowledge that the regional traditional industry base is a weakness. Unlike the German regions the local industry does not have the size, the diversity or depth and ambition to sustain a strong research ambition. There is no regional champion (e.g. TenCate or Heimbach). Only 20-25 companies have the ability to relate on a structural level with research. None of them have a long term road-map implying a broad interaction in research with a range of players. It is also clear that even traditional sectors as the lace and the linen sectors may benefit from a strong research infrastructure.

Hence the different institutes have to broaden their scope geographically and in different sectors. All research actors, with industry association acknowledging this, agree that a new definition of textiles and of textile industry is needed. Composite materials, bio-based materials and bio-active materials are important themes to broaden this definition. However this is a transformation that is yet engaged but that has to be completed.

One can thus say that the ambitions of the *pole de compétitivité*, aligned with those of the research infrastructure and with public support present a major leap that is not without risk. This is all the more true in view of the depth investment in the CETI. The Say principle may apply that “each offer creates its demand”.

AUTONOMY

Autonomy and accountability is a subject now under debate in higher education and research in France. While the industry specific research organizations have enjoined a large degree of political autonomy, the more generic research and education system has lacked autonomy but is now undergoing reform. On the other hand ENSAIT is engaged in a reflection on associating itself to a larger constellation of centres. The IFTH is subject to a debate to make it less autonomous by making it depending on a sectoral levy, to be allocated by the industry leadership. The autonomy and accountability should be discussed in relation to the size, nature and evolution of research demand amongst the stakeholders. ENSAIT may benefit from association with a larger constellation in reaching out to other industries. IFTH may suffer in size and ambition by being more accountable to a less innovating clothing industry.

COORDINATION

Coordination is a complex matter in France since many instances claim some type of coordination action. In a generic way coordination occurs both at the national level and the regional level. With the upcoming reform of the status of the regions their role is at stake. This extends also to regional associations depending on regional funding. At industry level there is little research and innovation coordination. The textile federation has a role in this respect, but it is rather a lobbying and liaising role, and some delegated oversight of research organizations such as IFTH. Since both Nord Pas de Calais and Rhône-Alpes, vie for leadership the national role is rather one of

pacification and mediation. This is all the more so since the regional associations are traditionally well funded and embedded. The national association is indeed a federation of sectoral and regional syndicates.

Of particular relevance is UPTEx that has been officially named as a pole de compétitivité. In practice UPTEx is closely connected to the regional industry association UIT Nord, but independently funded. The industry is well represented in its governance. This status gives a number of coordination roles of relevance. In the first place the status of Pole gives a political legitimacy towards the region and the central state; hence it plays an important role as platform and voice. Its governance enables it to unite forces of progress in the industry. An essential role is to support and labellise – pre-evaluate - proposals. Hence it is an important motor in boosting the number of proposals

DIVERSITY IN FUNDING

Diversity and depth of funding is considerable in France. The focus is on national funding through the FUI, ANR and OSEO. The centres and companies interviewed have mentioned that funding is currently not a problem. Good proposals are funded. Evolution of OSEO funding in the period 2008-2010 is more a consequence of less proposals than of a lower quality of proposals or lack of funding. Regional funding is complementary with both project funding and infrastructural funding.

A challenge for the French research centres and for the industry is to intensify cross border contacts. For both companies and centres more cooperation with Flanders may be beneficial. The current funding infrastructure is not attractive for doing so. Interreg is too cumbersome, slow and bureaucratic as a framework for company to company projects. FP7 demands projects with a larger consortium at a European level.

The current French funding reform orients itself to centres of excellence. Nord Pas de Calais has not done well in the current round of IRT's. In view of the leverage this type of initiative has, like the Poles de Compétitivité, important leverage on other funding.

SCOPE

The scope of research is rather broad, or in the process of gaining focus. The current project portfolio of projects submitted or sponsored by the region entails some 40 projects with a total size of 65 Mln Euro. If calculated on an annual basis it is a portfolio of ca. 26 Mln year. This is a substantial sum in relation to the size of the knowledge infrastructure and the importance of the industry. It is also substantial in the European context, bringing total public funding for research in textiles close to the levels in the leading German regions. However most of the funding and funding increase is in secondary funding. Tertiary funding is lagging behind, although the funding mechanisms now in place demands matching funding from industry.

Two dominant lines emerge in the research portfolio. Composites and the use of renewable resources are the most powerful lines. They can be combined as in the Finather Project, or separate. Six projects focus on composite materials with a total budget of 16,5 Mln Euro. Recyclable materials and materials made from renewable sources a second accent with four projects funded 7,8 Mln. Textiles with medical properties represent seven projects of one larger, together a budget of 5,5 Mln Euro. Other large projects are related to geosynthetics for cleaning of polluted muds (Depoltex 3 Mln) the use of digital printing to functionalise fabrics (Intellitex, 3 Mln) and some projects aimed at understanding sensorial properties of materials (Intumat and Licorve, 6 Mln).

What is interesting in the architecture of the projects is that each brings together research centres with different backgrounds. Also the industrial partnership is cross-sectoral, either reaching across the value chain from raw materials suppliers to end users, or cross linking several materials especially textiles, plastics and paper. The force of the clustering is thus to federate actors across the region around an innovation agenda. Of particular relevance are the linkages to global leaders as EADS in aerospace and Alstom in railway equipment.

What is also relevance is the flexible geographical architecture of projects. Many projects connect firms in adjacent regions, which is possible because of the national funding tools used, or relate to the other pole de compétitivité in Lyon. In addition some projects are cross-border and associate firms and research centres in Flanders or Wallonia.

What is also striking despite the high level of industrial involvement is the narrow basis of company involvement in the textile industry. The entire project portfolio concerns less than 30 firms (ca. 10% of all textile firms in the region). The majority are active in technical textiles, some in the lace industry, and indeed some in linen. Only two clothing companies are associated to the project portfolio. The large retailers are except one not involved in any project.

3.1.7 BEST PRACTICES AND MARKETABLE RESULTS

The basic problem in the Northern French research structure is the cultural distance between academy and industry. The practice of industry oriented research is not well established in France. Industry tends to see research as a public good. However since the set up of Uptex and, independently of this the re-orientation of ENSAIT, have strengthened the co-operation between research and industry. Also an important enabler is the funding of innovation, which is partly consortium based (FUI, ANVAR, Oseo) and partly based on funding for individual companies (Oseo individual grants). The former are based on generic challenges as the use of textiles as a material of choice in technical applications. The latter is rather focused on process and product improvement. A weakening factor is however the constant restructuring of the IFTH and its availability for companies.

While the distance between research and industry has shrunk over the last five years, three trends in the region have emerged.

In the first place large scale projects are essentially between research centres and large companies outside the textile industry (e.g. automotive, aeronautics). However ENSAIT has been successful in linking technical textile firms to these projects. By creating a market pull, this has also led to exploitable results mainly in terms of materials, less so in processes. In addition these projects have leads to spin-offs. They are either in the combination of bio-based raw materials and primary processing or in the assembly of materials into components for end users.

The second is that less than 20 companies are very closely involved in research. These are mainly in technical textiles, and less so in more classic textiles. The exception is the lace and knitting cluster in Caudry that is using research projects to explore possibilities in technical textiles. However by focusing on new products and applications for textiles, more process oriented research has less attention. This could be to the benefit of the classic textile industry in terms of productivity improvement. Oseo plays an important role in funding small projects (45 in 2009) that are mainly product oriented. The majority have led to marketable results, often because these new products could be made in existing processes. Most new products are in technical textiles

The third is that the growth in research over the last five years might have led to exploitable results (e.g. Agrobiotex has led to 4 patents), but the overall impact in number of patents is limited. This means that companies have not yet developed a clear strategy in protecting Intellectual Property Rights. Amongst SMEs there is apprehension towards the cost of patenting and the perceived risk of losing control by publishing the results.

Agrobiotex (2006-2010) is a project organized under the umbrella of Uptex funded by a French national funding (FUI). The objective is to develop new materials and placcation based on agricultural resources. It has a wide scope since it concerns keratin from feathers, lignin from wood and biopolymers. It brings together 5 research centers and 7 companies (mainly SMEs). It is mainly Northern France based but also has three non-regional partners. The strength of the project is to bring together the entire supply chain, including non-textile firms. The project has generated scientific results (PhD and conferences) and exploitable results, such as three patents and 4 marketable products. The products range from cosmetic tissues made from biopolymers, to roofing materials made from flax and nets made from biofibres. The project has generated some 170 jobs of which 115 in a biorefinery for the production of lignins. The most relevant aspect of this best practice is the outreach to the agricultural sector (connecting two clusters) and the orientation to exploitable results.

EXAMPLES OF BEST PRACTICES

Case 1. Company 2 combines the approach of supplying materials to research centers with project research. The latter approach is mainly for classic textiles while the former approach has been applied to more novel technical textiles. The company is geographically very close to one research centre, and this also translates in a cultural closeness. This is helped by the fact that the CEO has a PhD himself. However the relationship leads mainly to inspiration or conformation of internal product/process ideas, which are mainly developed in house. Only one multi-annual project has been carried out since 2000 which led to a new technology for a new market. However since the company was too small to invest in the market, the roll out of this activity has been spun-off and sold to a larger player.

Case 2. Company 5 is exemplary for several companies in the region. It is engaged in small contract research and in medium size collective research. The smaller contracts are often to meet the needs of a new demanding client. This requires often rapid product development and testing. In Company 5, as with colleagues, it concerns technical textiles and rather new developments regarding materials, process and desired product. Most projects have led to new product introductions. They did not involve subsidies and only some assignments to the research centre where paid.

However this approach has its limitations and the company has engaged in a longer term vision to be ahead of potential client needs. The work with research centre has broadened the scope of fibres used and exposed it to new finishes. In addition collective research and more intense relations with research centers have also led to better contacts with end users and improved the ability to pre-empt demands of (prospective) clients.

Case 3. Company 7 was exemplary for several companies and was interesting while it is a client of Company 6 mentioned in cases for Nordrrhein Westfalen. It claimed that the technology used by Company 6 was developed by the company itself. Indeed Company 6 was active in developing the chemistry, but company 7 claims it had to develop the entire process. Company 7 has also chosen to rebrand the technology under its own name. This is a bit odd since the material functionalized by company 7 with compounds of company 6 is integrated in a larger system. The suppliers of these systems often rebrand the technology. Hence we have three brands for the same concept.

The patent still rests with company 6. Neither company 7 nor its competitors have an exclusive access to the technology. Hence this case of interest for the complex relations in the supply chain.

Company 7 has only contacts with research centres for testing the conformity of the material with the claims. Their clients do also tests and have done with the same centres to verify the performance of the entire system; this research also involves panels of consumers. Of relevance is that the testing is specific to the end market and that less than five centres in Europe have the knowledge and equipment to carry out these tests. This is exemplary for niches for which a European competition for tests exists.

Case 4. The conversation with Company 11 started from their involvement in an FP6 project. They joined it as a consequence of their relation with the University in the region. They had a minor role and conducted some trials. The project had no exploitable result for them, while it did for other partners.. Their judgment on the experience was fair. If you are a latecomer to a project and you have a secondary role, the results are likely to be disappointing. There was little harm done since the objective of the research was at the periphery of their internal technology road-map. They said that collective research is often for rather marginal and prospective subjects.

Bilateral co-operation with universities is of more relevance and is essential for support of the in-house R&D. The relationship is quite exclusive with the local University. The relation is rather rich but focuses on short term interventions such as second opinion on projects, short term research assignments internships and thesis. There is no programmatic research partnership.

Case 5. Company 16 is an active participant in bilateral (only with one research centre) and collective projects. The level of activity is largely influenced by attractive funding provisions both for individual technical assistance and for longer term research. The company has a clear vision, albeit not formalized in a technology road map. Long term research, with RTOs and often collective, is for non-competitive stages of research. It fits in the vision to shift from apparel textiles to technical textiles. The collective projects give access to state of the art research and also to key potential customers.

The individual projects with technical centres (often also involved in collective research) are focused on fine tuning product development and processes. These projects are always complementary to collective research. The project is often funded by OSEO under a specific scheme for SMEs. It is often followed by a commercial testing and certification track.

3.1.8 CONCLUSIONS

The region has engaged in an ambition to work at a renaissance of textiles. This ambition involves important public investments and is sustained by a very small band of industry. Hence the ambition to become a European hub is fragile in view of the more solid infrastructure and industrial strength in Germany. In the end less than 30 SMEs are closely associated to the regional ambition.

The ambitions have, despite all institutional difficulties, inspired research centres. ENSAIT is a runner up in European research, positioned in the first tier. ENSAIT being one of the few growing textile education centres in terms of student enrolment, offers human potential to leverage innovation. In addition the cluster has brought in new research resources from non sectoral research groups.

However the region has succeeded in creating a clustering going over the regional borders and over the sectoral borders. The focus on composite materials is far from original but is well integrating key players such as EADS and Alstom. The secondary focus on biobased materials is of high relevance and it is probably the main research hub in Europe on the application of biopolymers and biofibres. The world class research position in linen could be exploited in a specific sectoral raw materials action encompassing several regions.

By taking the leadership in the textiles ERANET, the region has put itself in a steering position at the European scale. The region tries to strengthen linkages with the adjacent Flanders and with the Netherlands and Germany. However the policy framework lacks instruments for sustained cross border research bundling.

3.2 NORDRHEIN-WESTFALEN, GERMANY

3.2.1 RATIONALE OF THE CASE

Nordrhein-Westfalen (NRW) hosts three centres of excellence in textile research and higher education, and a number of smaller more focused research and technology centres. It is thus in a leading position in quality and quantity of research output. This justifies on its own the selection of the region. In addition Nordrhein-Westfalen is the second region in number of patents held by textile firms and has an important complex of firms engaged in textile relevant chemistry and machinery. It is the first region in Europe in number of companies engaged in technical textiles.

The case study was conducted through 12 face to face interviews in the region over the period February-May, one round table discussion and several shorter interviews held by phone or during Techtextil in Frankfurt in May 2011.

3.2.2 PROFILE OF THE REGION

Nordrhein-Westfalen is the largest *Bundesland* (state) of Germany and home of 40% of the German Textile and Clothing Industry. The employment was in 2010 at 24.000 people in the 270 companies with more than 20 people employed. Total employment is likely to be around 50.000 people including small companies. In addition the *Bundesland* is the main hub of retailing with major headquarters in the Ruhr area, Düsseldorf and Köln. Düsseldorf is considered as the hub of the fashion sector since the demise of Berlin in 1945, although the latter is regaining attraction. Moreover the region is also important for its chemical industry relevant for processing and for machinery suppliers.

Geographically the NRW industry extends on the Northern side into the *Bundesland* of Niedersachsen and in the west, the Aachen wool district extends into Belgium. The districts of Krefeld and Mönchengladbach extend into the region of Eindhoven (NL) and the district in Westfalen extends into the region of Enschede (NL). The fibre sector in Arnhem (NL) is closely linked to the fibre sector in the Rheinland (e.g. Wuppertal). Hence one can speak of an extended industrial system operating across the border.

The textile sector is composed of components each with its own characteristics. The largest section of the industry is the clothing industry (if clothing firms reclassified as wholesalers are included). This industry is nowadays

dominated by companies with the majority of production or sourcing outside Germany. Leading players are in the Bielefeld region (Seidensticker, Ahlers, Brax, and Brinkmann) or in the Rheinland (Gardeur, van Laack, Esprit, Gelco) and to a lesser extent in Münsterland (e.g. Gerry Weber) or the Sauerland (e.g. Falke). The apparel textile sector is still of some importance but has downsized considerably. The wool industry has almost disappeared from Aachen (except Becker) and Monchengladbach (except Stohr). The cotton industry has downsized considerably in the Münsterland. The home textiles sector is still sizeable mainly in Westphalia (e.g. Bierbaum, JAB, Schmitz, and Kock).

The sector of technical textiles is nowadays the largest industrial segment in both the Rheinland (Heimbach, Mehler, Verseidag, AundE) and in Westphalia (Borgers, Kümpers, Hüsker, Schilgen). Nordrhein-Westfalen brought most exhibitors (suppliers and auxiliaries included) at Techtextil in 2011: 12% of the 136 participating firms on the technical textiles fair in Frankfurt. Within the field of technical textiles the main segments are automotive textiles (Borgers AundE), constructive textiles (Mehler, Verseidag) and protective textiles (Kümpers, Blücher). Very specific is the cluster of firms specialized in technical felts and filtration media in Düren (Heimbach, Voith, Andritz and Kufferath).

An important characteristic of the German textile industry is the dominance of large companies: in all segments companies have an average turnover of 50 to 100 Mln Euro and employ between 250 and 1000 people. Especially the technical textile industry has all characteristics of the German *Mittelstand* (small and medium enterprise) firm: technological leadership, substantial market shares in niches serving global markets, family ownership and strong and deep skills base. Alongside these characteristics comes a prudent financial management, but also openness to external managers. Larger companies have international ties, with manufacturing subsidiaries in Eastern Europe and Northern Africa. However outright multinationals are rare.

Of importance is also the industries supplying to textiles. The fibre industry was once a major player in the region with companies like Bayer (acrylics) and Akzo/Enka (most synthetic fibres). Nowadays only the production of specialty fibres prevail, wherein Toho Tenax in Obernbruch and Teijin in Wuppertal are examples. Of more relevance is the chemical industry supplying auxiliaries for finishing and coating. In the supplying industry, such as chemicals, the large public quoted companies dominate (e.g. Bayer, Evonik) although the medium size companies are becoming more and more innovative. In the machine industry larger companies dominate the sector (Monforts, Trutzschler, Oerlikon-Schlafhorst). The majority of machinery suppliers work on traditional concepts. In the region, Monchengladbach is the hub of the textile machinery industry.

3.2.3 RESEARCH DEMAND

The relation of the four segments between companies and research centres can be qualified as follows:

Table VII: Segment research demand

| | |
|---------------------------|---|
| Technical textiles | Intensive relations programmatic, commercial and professional |
| Home textiles | Intensive commercial and professional relations |
| Apparel textiles | Only reflective relations (no testing and no recruitment) |
| Apparel | Intensive professional relations and reflective innovation (commercial) |

The region of NRW has 25 companies in the textile industry with a relevant patent²⁰ position, as is shown in a dataset of 235 companies; hence it represents slightly over 10% of patent holders in the European textile industry. The total patent position of textile companies in the region is around 2000 patents, which is around 8% of the whole European dataset. Whereas all these companies have more than 20 employees, one can assume that close to 10% of larger companies are sustained innovators. Almost all patents are of a sustained character, implying that they seem to fit in the current business model and product market combinations of the companies. Nevertheless, NRW ranks amongst the top five most innovative textile regions in Europe. This does not take into account patents held by chemical companies (e.g. Bayer, Henkel) or machine builders (e.g. Monforts, Schlafhorst); the patenting level of chemical companies stays stable after a dip in the period 2000-2005. In textile machinery companies the patenting level declines.

The research centres in NRW altogether hold around 60 patents. Co-publication, whereas patents mention research centres (or their staff) and companies (or their staff) as inventors or applicant are rare: less than 5 patents were identified. Hence if these patents are exploited it is rather through licensing than through co-ownership. However, this study has found little evidence of licensing. The dominant model of co-operation, as interviews show, is one of research contracting for which the company gets all intellectual property rights. Of the 26 textile companies, 7 companies have more than 100 patents and a sustained level of innovation which means more than 10% of patents are less than 2 years old. One company owns over 100 patents, but has not added any new patent over the last two years. Six companies have between 10 and 100 patents; six companies have more than 5 patents but not added any new patent in the last 2 years. Finally, about 5 companies have less than 10 patents but they are all filed in the last 2 years.

A closer analysis shows that all but three companies holding patents are active in technical textiles. One company is engaged only in mattress ticking (for which hygiene is an important element), one is active in sun screens and curtains and one in apparel. An analysis of trademarks shows a substantial presence of firms from NRW, however,

²⁰ The data on patents is approximate since we are not sure to cover all patents, nor are able to identify the relevance of all patents. See the methodological note in the section on patents.

the trade marks do mainly prevail in the fashion sector, less so in home textiles and even less in technical textiles. Using patents as an indicator is rather a measurement of branding than of innovation.

3.2.4 RESEARCH FUNDING

Research is funded in Nordrhein-Westfalen, as in all German states, through the federal state and the regional states (*Länder*). Overall the majority of research funding in Germany comes from the private sector.

BASIC FUNDING

The basic funding of research and higher education is a shared responsibility of federal and regional state. Education as well as the educational sites (buildings) are funded by the *Bundesländer*. Institutes within Universities get a basic allowance for funding a research chair, a research assistant and a secretariat to a maximum of 600.000 Euro. Key research facilities are directly funded from the Federal State. Research programming is not funded directly (as a lump-sum) from the federal state nor regional states.

GRANT FUNDING

At federal level, the main responsibility lies with the *Bundesministerium für Bildung und Forschung* (Federal Ministry of Education and Research, BMBF). The BMBF supports research in several ways; among the tasks of the ministry there are research promotion and the promotion of international exchange of students, trainees and other young scientific talent. Furthermore, the BMBF promotes key technologies in several fields, from biotechnology to research and development to improve working conditions. BMBF implements a range of instruments, such as grants-in-aid based thematic R&D programmes, institutional funding for large research associations and organisations, participatory foresight processes and horizontal R&D activities and is responsible for the international dimension of R&D policy in Germany.

The most important funding organization is the *Deutsche Forschungsgemeinschaft* (German Research Community, DFG), which is the largest of such organizations in Europe. The DFG is financed both by the regional and the federal state (represented in Grant Committees) and serves all branches of science and the humanities. The DFG has several funding programmes, like the Individual Grants Programme, Coordinated Programmes and the Excellence Initiative. Furthermore, the DFG gives out scientific prizes like the Heinz-Maier Leibnitz Prize and the Copernicus Award. Proposals can be submitted by individual research or research groups, depending on the programme. Members of DFG are German research universities, non-university research institutions, scientific associations and the Academies of Science and Humanities.

The German federal system has recently been reformed to create a clearer division between the governmental levels (*Föderalismusreform*). The competence for teaching now lies exclusively with the *Länder*, although the federal government stays involved in the provision of university funding to take account of increased costs and reflecting the number of students. Taken the conclusions in the ERA Watch report of 2009, the states provide 45% of the overall budget for R&D (including universities) and the federal government provides about 55%. The different *Länder* allocate different amounts (in %) to R&D, ranging from 3 to 9% of the total budget. Herewith one cannot make conclusions about the correlation between budget and R&D capabilities, a well performing state can

spent a relatively big part of their budget on R&D whereas less performing regions spent a smaller part of their budget.

Where the biggest part of the federal expenditure on R&D is spent by the BMBF, another approximately 20% is given out by the *Bundesministerium für Wirtschaft und Technologie* (Federal Ministry of Economics and Technology, BMWi). A difference between the two ministries is that the BMBF funds thematic programmes with narrow definition of the field of activity, whereas BMWi favours a horizontal and bottom-up approach. Most of these programmes focus primarily in the areas of media, energy and ICT. Another specific feature of BMWi is that it finances the *Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke"* (German Federation of Industrial Research Associations, AiF), to support R&D in SMEs and at the same time uses funds provided by its members (industrial associations).

Several sectoral ministries also maintain their own research institutes (*Ressortforschung*) and some ministries even have dedicated sectoral research programmes. The coordination of research and innovation initiatives of the different federal ministries has been laid out in the *Hightech-strategie 2020 für Deutschland* (Hightech Strategy for Germany 2020). The overall goal of this strategy is to reach the "3%-rule": 3% of GDP should be spend on R&D as defined by the European Commission as one of the headline goals for "Europe 2020". Regional project funding differs from *Bundesland* to *Bundesland*. Nordrhein-Westfalen does not have a standing innovation funding instrument as other regions like Baden-Württemberg or Bayern. The *Bundesland* uses the ERDF funds in order to finance specific infrastructure, innovation networks and some projects.

CONTRACTS FUNDING

Contract funding consists mainly of research funding directly by companies. Research in Germany is performed by a wide number of institutes; universities make up the largest part of the public research whereas private companies (or non-university research institutes) perform most of the basic research. Industry stays the most important funder of R&D in Germany, accounting for about two-thirds of all investments. However, some research funding comes from foundations or collective levies. The textile industry itself has no longer a research levy; hence it has no financial instrument of relevance to influence research. An instrument that is sidewise relevance is the funding of research related to occupational safety. This is channelled through the *Berufsgenossenschaften* (BG), institutions that provide for illness and invalidity insurance. In addition Germany has a large number of particular funds available for research.

3.2.5 RESEARCH INFRASTRUCTURES

Nordrhein-Westfalen has a diversified research infrastructure of substantial scope and depth. In total the region houses 10 specialized institutes working on textile oriented research. Two of them are amongst the best research centres in Europe and in the World. The Hochschule Niederrhein is the largest textile school in Europe, and besides its research work, the main provider of candidates for PhD research in textiles. This makes altogether NRW the main hub for textile research in Europe with more than 300 researchers and an equal number of technicians. The region has no sectoral testing centre except for TFI and TBU that are highly focused. The main testing centre is TUV Rheinland, which has taken over TNO testing in the Netherlands. Coincidentally TBU is part of the Dutch KIWA group, also a testing organization specialized originally in water management. Therefore only two smaller research centres can be qualified as having a commercial model.

RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN (TECHNICAL UNIVERSITY OF RHEINISCH-WESTFALEN AACHEN, RWTH)

Rheinisch-Westfälische Technische Hochschule Aachen (Technical University of Rheinisch-Westfalen Aachen, RWTH) is the main hub for textile research in NRW. The university has three institutes fully oriented towards the textile industry:

- *Lehrstuhl für Textilmaschinenbau und Institut für Textiltechnik der RWTH Aachen* (Department of Textile Engineering and Institute of Textile Technology of the RWTH University Aachen, ITA);
- *Deutsches Wollforschungsinstitut an der RWTH Aachen* (German Institute for Wool Research affiliated to the RWTH University Aachen, DWI);
- *Teppich Forschungsinstitut Institut für Bodensysteme an der RWTH Aachen* (Textiles and Floorings Institute, TFI).

It is of importance to see the difference between institutes that belong to the university (ITA) and the so-called ‘An-Institute’ (DWI, TFI) that are *angegliedert* (affiliated) with a university. Such *An-Institutes* are organized under private law and owned by different combinations of state, university and industry. *An-Institute* are often managed by professors who hold a professorship at the university and work part-time at the institute.

In addition closely connected to textile research are four other institutes:

- *Fraunhofer-Institut für Lasertechnik* (Fraunhofer Institute for Laser Technology, ILT);
- *Fraunhofer-Institut für Produktionstechnologie* (Fraunhofer Institute for Production Technology, IPT);
- *Werkzeugmaschinenlabor der RWTH Aachen* (Laboratory for Machine Tools and Production Engineering of the RWTH University Aachen, WZL);
- *Lehrstuhl für Technologie- und Innovationsmanagement der RWTH Aachen* (Technology and Innovation Management Group at the RWTH University Aachen, TIM);
- *Universitätsklinikum Aachen der RWTH Aachen* (University Hospital of the RWTH University Aachen, UKA).

For the measurement of excellence we have considered “Aachen” as one institute. Aachen is currently the best research centre (measured in impact of publications) in textiles in Europe and also belongs to the top of the list in materials research. The score of Aachen is made of an excellent score by DWI (reached partly by research done with the University Hospital) and a score within the first tier of ITA. The degree of excellence of the Aachen Institutes is partly related to an orientation towards fundamental material research and partly to the ability to reach out to more knowledge based industries. The ability to network and cooperate inside the University is also an important element. RWTH has recently been recognized by the Federal Government as one of the nine excellent universities. This is part of a drive to increase quality and transparency. It has the impact of changing the mentality in the university and it creates better opportunities to attract funding and students.

DEUTSCHES WOLLFORSCHUNGsinstitut AN DER RWTH AACHEN (GERMAN INSTITUTE FOR WOOL RESEARCH AFFILIATED TO THE RWTH UNIVERSITY AACHEN, DWI)

DWI is an *An-Institut* at the RWTH in Aachen, it is associated to the Faculty of Chemical Engineering, employs almost 100 people and has a total budget of 6 Mln Euro. In addition it has substantial education activities connected to the Faculty of Chemistry. Its research has always been embedded in chemistry, unlike ITA that is rooted in mechanical engineering. DWI has been established as the *Deutsche Wollforschungsinstitut* in 1951. It has

served this industry, based on the role of Aachen as a leading wool production hub into the 1990s. It had even developed as a centre of reference for the entire European wool industry. The decline of this industry had already prompted DWI in the 1980s to widen its scope to the protein fibres in general and to hair in particular. By 2000 DWI had become a leading centre for research on hair and hair hygiene in Europe. It has also expanded its activities to skin and cosmetics. Nevertheless DWI had steadily declined in size and impact to 35 people in 2003. In that adverse situation a merger with DTNW was considered but has been put on hold. DWI seeks critical mass, but prefers to get a status as Leibniz institute.

DWI is established as an industrial association, with companies represented on its board. The association has over 50 company members and close to ten institutional members. Almost all company members are large companies. Textile companies are a smaller group, 11 companies of which 4 in the wool industry. The textile industry is certainly no longer in the driving seat, except technical textile firms such as Heimbach. The largest group consists of chemical firms supplying to the textile industry (12) and chemical companies engaged in cosmetics (11 companies). It has also 100 supporting members without voting rights. Most important members are Evonik and BASF and in cosmetics Henkel and L'Oreal. The focus of partnership is not regional. One third of activities are in the region, one third in Germany and one third abroad, with the Netherlands and Belgium providing most partners (from Unilever to Devan, an SME).

An Interreg funded project into the development of additives based on keratin, opened the door to research in polymers especially protein based. In the last 10 years the focus on macro-molecular chemistry has been strengthened and DWI has expanded its position in issues like biocompatible materials or biomimetic materials and more general advanced materials engineered at nano-scale. Medical textiles are seen as a clear opportunity and in general all products with an interaction with human bodies. Research at DWI is applied, but a connection with more fundamental research is required. The linkage to large companies such as BASF also provides much impetus to quality.

DWI is an example of a centre with a programmatic approach. The research programme represents 60% of financial revenues, with a mere 30% for testing and 10% for education. Primary funding represents 1 Mln Euro out of budget of 6 Mln Euro; 3 Mln is the budget of secondary funding and tertiary funding. Services represent 2 Mln Euro budget. Research funding consists of project funding mostly national and a bit regional, as well as some European funding. DWI has currently 6 DFG funded projects in 2010 in 3 AIF funded projects. ERDF funding has been relevant to modernize and expand buildings and equipment.

LEHRSTUHL FÜR TEXTILMASCHINENBAU UND INSTITUT FÜR TEXTILTECHNIK DER RWTH AACHEN (DEPARTMENT OF TEXTILE ENGINEERING AND INSTITUTE OF TEXTILE TECHNOLOGY OF THE RWTH UNIVERSITY AACHEN, ITA)

ITA is an institute of the RWTH Aachen, it has been set up as the *Institut für Textiltechnik* in 1934 as part of the faculty of mechanical engineering. ITA is linked to the industry through a *förderverein* (a support and funding foundation) and an association of alumni. Technical textiles are the main partners (e.g. Hartmann, Heimbach) followed by chemical groups (BASF) and machinery manufacturers. End users of materials are increasingly involved with research (e.g. EADS). ITA also animates a cluster of companies in textiles and light constructions, in which a spin off company has been established.

It has had a healthy existence ever after World War II as an education centre for mechanical engineers with strong connections to the textile industry and to the machinery in the region. The institute declined in size in the 1990s to

reach around 25 staff members in 2003. The new director, Professor Gries, started a reorientation of the centre in the direction of the application of textile materials, especially in composites for automotive and construction. In addition he had the ambition of offering a fully equipped pilot plant for companies without the entire production chain. ITA has a full production line encompassing extrusion, spinning and weaving and special equipment for braiding (for making tubular structures). In 2010 staff size exceeded 100 people of which 2/3 in research and 1/3 in technical staff. The centre is able and ready to grow further to around 200 people.

The ITA is an example of a centre with a programmatic approach. The research programme represents 85% of revenues. ITA is currently leading or involved in 17 DFG projects and was involved in 2010 in 5 AIF funded projects. It is also involved in several European projects in which it always brings in German partners albeit not necessarily in the region. National funding is the most important for projects. Regional funding has been important for the expansion in building and equipment. Regional project funding is considered erratic and too much based on discretionary decisions. In general ITA cannot be qualified as a regional centre. Only 20% of projects are with companies in the region. The remainder 15% of revenue serves as an institutional coverage and a contribution for education. The testing and engineering activities are not substantial. Through the expected cooperation with TFI that is expected to move into ITA's premises growth in testing and engineering is expected. ITA is co-organiser with DWI and the University of Dresden of the Aachen-Dresden bi-annual conference.

INSTITUT FÜR NÄHTECHNIK (INSTITUTE FOR SEWING TECHNOLOGY, IFN)

The Institut für Nähtechnik e. V. (Institute for Sewing Technology, IfN) founded in the 1960s was a European, unique and independent institute that provided scientific advice and research on technical sewing, especially in Aachen, and the technology transfer to industry. The main intention of the IfN was to find possible solutions to problems of a diverse nature in the entire textile chain. Therefore IfN brings together their knowledge of both the textile and clothing industry and their understanding in the area of technical textiles, machinery and sewing supplies.

Close cooperation with other textiles centers in Aachen made it possible for IfN to use their excellence in especially sewing, as the institute name already implied, to find solutions for complex problems within the entire process chain. Seminars on various topics presented the results on research on complex relationships and interactions of the manufacturing process and outcome. Furthermore, IfN also served as an educational institution where trainees were offered the possibility to develop on the one side their interest and skills in research and on the other to gain experience in working with a wide branch of industrial companies.

IfN worked as a partner in public funded projects and on a demand-driven basis for industrial partners. The latter, or as they called it on their website 'the practical front work', included the provision of advice and guidance during development and production processes as well as in the work practices or quality issues. IfN has had a diverse composition of members; this could be explained by their user-orientated approach which results in orders from a wide range of industrial companies and partners. IfN joined forces with ITA in 2003. Activities on sewing are nowadays very limited within ITA and are restrained to assembly of technical textiles.

TEPPICH FORSCHUNGSMITTELSTELLE INSTITUT FÜR BODENSYSTEME AN DER RWTH AACHEN (TEXTILES AND FLOORINGS INSTITUTE, TFI)

TFI stands for the Teppich Forschungsinstitut as it was originally named in 1964 at its foundation in Aachen. The current name is the Textiles and Flooring Institute. It is set up as an industry based institute as a spin off of DWI.

Indeed the carpet industry was originally based on weaving of wool technology. The advent of tufting technology and the use of new materials made carpets a mass-product hence the need was felt to set quality standards. This was the focus in the 1970s while in the 1980s and 1990s the focus shifted on process intensification and environmental impact. Now the focus moves to new materials as alternatives to oleofins, to REACH and Cradle to Cradle product concepts and to extension of life time. Sport surfaces is not an item at TFI, this is the area of expertise of Twente and of Gent. However the centre diversifies in all type of surfaces and interior ecology and ergonomics. TFI is a niche player with Centexbel as main competitor in flooring, and the University of Twente (Institute for Sport and Leisure) for artificial grass.

TFI has the status of *An-Institut* at the University of Aachen. It currently has 34 staff members. Two thirds of activities are related to testing and engineering services. These are the non standard tests, since volume testing is done by TUV. Testing provides ears and eyes into the industry. Research provides the remaining 35% of activities. TFI uses some public funding (AIF, EFRO) but no DFG or European funding. It feels not to be equipped to handle complex projects. TFI is currently planning to move close to ITA in order to optimize synergies. TFI wants more exposure to students and fundamental research. ITA wants more access to testing for the “ears and eyes” it provides.

TFI still has an association status. The members are mainly from Germany but across the entire country. Its function is more than regional. It has also some members from Belgium and the Netherlands and is an important research centre for the carpet industry in those two leading countries. The board of TFI is exclusively German. TFI is an example of a centre with a commercial approach.

FORSCHUNGSINSTITUT FÜR TEXTIL UND BEKLEIDUNG DER HOCHSCHULE NIEDERRHEIN (RESEARCH INSTITUTE FOR TEXTILE AND CLOTHING AT THE UNIVERSITY OF APPLIED SCIENCES NIEDERRHEIN, IFN)

The Hochschule Niederrhein, with its location in Monchengladbach is currently the largest applied engineering school in Europe with in total 1800 students. Currently it has a yearly intake of 320 students (numerus fixus) out of almost 2000 students applying. Although its main purpose is to train students for a bachelor or masters degree it offers applied research as part of the curriculum. In view of the number students the impact is substantial, especially in relation to clothing and more classic textile firms that are fond of using thesis work to identify potential graduates. Of relevance is that besides a more fashion curriculum, the textile school still has an important technical curriculum. It is also an important training centre for students continuing for a PhD in Aachen or Gent.

The school has a small research department called FTB which disposes of very comprehensive technical facilities, in fact a complete pilot plant in spinning, weaving and textile finishing. The total project portfolio is 3 Mln Euro. The current annual turnover in research is some 500.000 Euros which is modest compared to the centres in Aachen. It employs 10 researchers and technicians, albeit not full-time. However it is growing and it is attracting new funding sources. Funding is currently mainly from regional funds, (three projects) but it has gained access to DFG and AIF funding. The school wishes to be less dependent on regional funds that are less reliable. It is also growing in privately funded projects. The University grants a bonus for externally acquired funding.

Since most research is done with involvement of students, research projects are small, short term and rather applied. Of relevance is that since IfN has been amalgamated into ITA, it is the only centre of competence on clothing technology and on logistics and organization of production processes. It is increasing its involvement in

management research and in design research, since it is an area with less competition. It also engages itself in subjects related to mass-customization, although proposals for larger projects have not been selected for funding.

The Hochschule can be qualified as a professional centre. The industrial community is well involved in the School since 25 companies sit on an advisory council that advises on its strategy, evaluates proposals and is involved in curriculum development. However in upgrading its research potential HN suffers of being less well connected to a network in Europe. Its frequent application to Autex has been rejected, and it does not qualify for Textranet. HN has some bilateral relations e.g. with Hogeschool Gent and with Saxion as well as with the London College of Fashion.

3.2.6 CHARACTERISTICS OF THE RESEARCH SYSTEM

Autonomy

The dominant structure in NRW is the An-Institut form, institutes with an associated status to Universities. This gives on the one hand the benefit of academic status (funding for education, core institutional funding, access to fundamental research grants – DFG), but on the other it also gives substantial autonomy in management. Governance over research is multiple: some institutes have an advisory board or board of trustees with industry representatives, but they are also driven directly by contracts and thus a “quasi-commercial” influence. Others have an associative status with industrial firms as members. A minority of centres is “In-Institut”, being fully part from a University; these centres also have a scientific or industrial advisory board. Both types of institutes have in common that they have a large degree of autonomy combined with substantial long-term industry involvement

COORDINATION

Germany has a number of soft-coordination mechanisms in textile research within a competitive overall system. The coordination comes from the *Forschungskuratorium Textil-Bekleidung* that evaluates the economic potential of proposals. However, the role of the *Kuratorium* has changed from a distribution system to a labelisation system. Originally it would assure a fair distribution of funding across the research system, in that time the FTB had the role to evaluate proposals. Now it labelled projects only according to its economic impact while scientific evaluation is done for the AIF by independent evaluators. Another mechanism existing at the scale of the *Bundesländer* is *Zukunft Initiative Textil* (ZiTex). ZiTex has been set up with three objectives. First of all, to mediate between regional industry associations and the Government. Secondly, to liaise between industry and research facilities and to organize dissemination events. And thirdly, to carry out activities of promotion to attract young people into the industry and its specific education. ZiTex has been instrumental in promoting innovation oriented clusters in Mönchengladbach (Texcellence), Aachen (medical textiles and automotive textiles) and Münster (technical textiles for construction). These also provide for coordination of research and enterprise although the focus on research or rather on dissemination differs. Several players in the region are associated with CFK Valley, a cluster of composite oriented companies initiated at Airbus in Stade (near Hamburg).

DIVERSITY IN FUNDING

Research funding in Germany is substantial and diversified. Basic funding for education and research is provided by the *Bundesländer*. Research infrastructure of strategic importance is funded directly from the Federal State. Basic funding is based on the number of students and allows some share going to research. The major grant systems are - either oriented to fundamental research as offered by the DFG or applied research grants offered by AIF. DFG funds medium size research projects of several years. Research excellence is the key qualifier. Valorisation is an add-on. AIF grants are dedicated to applied research, with the potential of industrial application. Valorisation is necessary and companies have to be associated to the research.

National grants are the most important sources of funding and both systems have the character of open contests without specific textile programs. In addition some but not all *Bundesländer* have regional funding systems or rely on funds made available through ERDF in the regional Operational Program for either infrastructure funding or project funding. This funding type is less reliable. NRW, Baden-Württemberg and Saxony have their own regional programs and have research capacities in the region. Bayern and Niedersachsen have a regional funding scheme but for textiles no substantial research facility. Hence they allow firms to use research capacities outside the region. In addition Germany, Austria and Switzerland have coordinated their research funding policies in the *Dachverband*, which enables cross-border research. A similar ambition has been expressed towards Belgium and the Netherlands but it is limited to Interreg IV A projects and the reciprocal acceptance of innovation vouchers. The first instrument is too complex and the second does not foster critical mass.

BROAD SCOPE

The region has a high quantity and quality of research. It hosts more than 400 researchers and technicians, and it has been able to grow the infrastructure despite a declining “classic” clothing and textile industry. It also offers a large variety of centres, although with a strong focus on technical textiles. Nevertheless other sectors are being served. However as funding drives research indeed the focus on technical textiles is strengthened around 80% of the research portfolio in project funding is oriented towards technical textiles. The focus is with the two leaders ITA and DWI on constructive materials and on materials with bioactive functions.

Research centres are not regionally oriented but have an international scope, and have specialized in a subdiscipline of fibre/textile research. Each centre has a clear focus and specialization. The funding system as well as the structure of the industry indeed fosters specialization and a cross regional outreach. Most centres have a fundamental outlook and an applied outlook. Therefore besides an outlay of laboratory equipment, several centres have substantial pilot-production facilities. Certified testing facilities are rare with only TFI and TBU in specialized segments. The major testing centre in the region is TUV Rheinland. Within Germany as a whole, Hohenstein (in Baden-Württemberg) is the leading player.

It appears that a substantial share of funding is obtained from or with non-textile firms, either in chemistry, either in end users (automotive) or in adjacent industries (cosmetics). Hence the institutes have become less depending on the “classic textile” industry.

3.2.7 BEST PRACTICES AND MARKETABLE RESULTS

The exploitation of results of research in NRW is rather good, which is also reflected in the first position in patenting regarding textiles. Most technical textile firms have an active patenting policy. The uptake of technology is however not visible in trade marks and designs. The latter can be explained by the dominance of technical textiles related research and development.

Most of the results of research are taken up by end users, especially in aerospace, automotive and constructive applications. The second most active category of companies exploiting results is suppliers to the textile industry, mainly machinery suppliers and manufacturers of chemical auxiliaries. The textile industry comes in a next position and with regard to NRW the uptake of research results is led by technical textiles, somehow with home textiles (carpets and applications in contract markets) while is negligible in apparel textiles and fashion.

However the number of patents resulting from collective or cooperative R&D is only a minority of patents. In regulated markets each research project also leads to follow up projects with regard to engineering of process, prototypes and testing of products to be put on the market. This thus leads to a very intensive relation between research centers and some 30 companies, of which only a small majority is in the region itself. However these 30 firms represent only 10% of medium size and larger firms in the region.

The good uptake of research results derives from the structure of the industry, dominated by technical textiles and rather larger companies with in-house R&D facilities. There is a high convergence of qualifications between RTO staff and company R&D staff. The funding system has a diversity of tools enabling a differentiated pattern of relations from observing fundamental research to contract testing activities, via collective research or small consortia based research. Finally good connections are enhanced by strong institutional linkages.

The intensity of the uptake could be higher since 80% of relations between RTOs and companies concern some 30 companies. There is however little impetus to improve linkages between SMEs in fashion and RTOs. The ambitions and competences differ, and at first sight there is no critical mass in demand to engage into the process. The incentives and funding system is not in place and classic textile firms do have less institutional embedding into RTOs, except when there is a strong education link as there is for example with Hochschule Niederrhein. In order to assure a more intensive relation towards innovation, developing instruments and networks for more applied research and setting up of competence centers would be a consistent approach. The RFID (Radio Frequency Identification) project under Interreg IVA is a good example.

An example of active collaboration is the project Textilbeton (1999-2011). Initiatives to develop textile reinforced concrete products are structured in three consortia: an interdisciplinary project inside RWTH funded by DFG (national grant); a German network with TU Dresden and of a RWTH led consortium with five industrial partners (of which three in NRW, none SME) across the value chain. Textilbeton is a long term program funded from 1999 till 2011. It has generated 5 PhD theses and more than 15 master theses. It has led to a number of demonstrators, such as the panels used in the outer wall of the ITA institute and a lightweight bridge in Albstadt-Lautlingen. The industrial partners have taken up results in marketable products. The duration of the project is of importance, as a best practice, this has enabled to develop a solid fundamental knowledge, develop human resources and given time for companies to step in.

CASES OF BEST PRACTICES

Case 1. Company1 is a traditional textile firm and albeit in a classic segment it has an outstanding position because of a good knowledge of materials and processes it has a well establish deposition in the market. The company has a long standing interest in industry associations and boards of research centers. This notwithstanding that its research interests are limited. Its engagement is a form of public responsibility.

However the firm is keen to supply materials (yarns and fabrics) to research centers for experiments. In exchange it gets access to the results. Sometimes these results are used to improve products and processes. Moreover it processes the waste of experiments in some products. The relationship with research centers does not involve any funding. The benefit for the company is to have an easy access into state of the art and the results of research provide for regular incremental improvements. Results have been applied to new or improved commercial products.

Case 2 refers to Company6, situated in another member state (that we cannot disclose) but is mentioned by several research centres in the regions as a good example of an innovative company. Since it was mentioned as an interesting partner of a NRW research centre it is mentioned here. It is an active participant in several European and cross border projects, it works intensively together with the research centre in its own country, but it maintains a wide network of contacts in Europe with at least ten RTO's. The company works together with several research centres to develop new concepts, test the processes and carry out the required activities to validate and certify the results. It has also experience in taking-up spin offs emerged for Universities. The relationship with research centres is non-exclusive and broad, as it concerns collective, contract research and testing activities. The partnership is mainly programmatic and, only to a limited extend, commercial.

The company is not a classical textile firm since it produces specialized textile chemistry. It is an example of a trend in which smaller and medium size companies in chemicals are innovation leaders, operating in an open innovation model. Impulses for innovation comes mainly from fundamental research (e.g. the inclusion of specific active agents in textile finishes) and from end users (e.g. in sports). Textile firms are rarely for them the initiators of innovation. Price pressure and lack of pro-active connection between marketing and product development inhibit them to act as the driver of innovation. However a chemical company does not want to limit its market scope on one client. Indeed this company protects its inventions with patents and trade marks. Surprisingly some of its clients are "rebranding" the same innovation under a different name.

Case 3 refers to Company9, a large company in NRW. Its involvement in R&D is double on the one hand the management is active in several boards and associative bodies. However its intervention is neither strategic nor pro-active but more on the governance of research centres. As other firms in the region it takes a rather passive role when it comes to collective road mapping and programming of research. The company does not participate actively in collective research but sits as an observer in several national projects. EU projects are considered as too long, too slow and bureaucratic. This perception has inhibited them to participate in any EU funded project. On the other hand the company is active in practical research and product development based on an internal vision and road map. Most R&D is carried out internally and has led to a substantial portfolio of patents and trade marked products or components.

In working together with textile and chemistry schools, the focus is more on attracting graduates than on funding research projects. The bachelor and master thesis is the key activity the company sponsors offering explorative subjects or validation research combined with internships. Besides this the company requires often conformity

tests for its products. The company uses regional centres for most tests but has also relations with partners outside the region.

Case 4 refers to a Company12, which we visited together with a University Professor that has active collaboration with the company. He had some samples to deliver and there were some students at work there. The kindness of the encounter at the company shows a more than only professional relationship. The closeness is embodied in many small projects and the director of the firm also sits in the examination committee of the school. The partnership is very close but mainly built up of small student researches, smaller contracts. About one third of the projects lead to new products, but also those not leading to concrete applications feed the knowledge base of the company and not certified testing. The University is not accredited for tests hence they have to outsource this other centers.

The director expressed the wish to step up its R&D policy. One step was to become more active in EU funded projects, to extend partnership to research centres outside the region. This mainly to gain a broader outlook on R&D in Europe and to connect to like minded companies. The other step is to set up together with colleagues in the region a joint extrusion line. The involvement of the University would be beneficial. The company did not know that similar equipment was already installed across the border (100 km) and to be installed in Northern France (300 km). This confirmed the company in the importance of networking.

Case 5. Company15 was one of the few fashion companies visited in the survey. It was a relevant interview since its CEO sits on the board of two schools. The CEO has a PhD and has a high degree of curiosity (I am a reader, he says). One is the scientific committee. Its participation is more for inspiration than for practical purposes. The school is of great importance for the recruitment of graduates. This importance is expressed in the number of trainees recruited for the school and the range of bachelor and masters thesis assigned. These cover a broad range of topics from improvement of sizing methods and cutting room efficiency to mass-customization. Beyond this the company is engaged with several colleagues in a collective project on RFID and future store technology. Collective research is appropriate since a common stand of several brands makes the roll out in retailing easier. This project still has to deliver exploitable results.

A range of successive student projects on mass-customisation has enabled the factory (located outside the EU) to be a leader in mass-customized products servicing the brand but also third parties. The company attaches great importance to place students in its foreign subsidiaries in Asia and Northern Africa. Most recruits are female and it is importance to get experience with global production in the early stage of the careers. This has extended in a research project with a close by University on improving female careers in the fashion sector. This is to remember that research can go beyond technology. The latter project, as well as the RFID project, was funded by ERDF, otherwise all projects are internally funded.

3.2.8 CONCLUSIONS

Nordrhein-Westfalen is in quantity and quality the first region in terms of research infrastructure dedicated to textiles in Europe. Public research is of high relevance whereas in Baden Wurttemberg, private research is more profiled. Despite perception of a Rhineland model, with a high degree of coordination between actors in the innovation system, the system is rather more competitive with a strong public funding dimension. It is striking that each institute has a high degree of autonomy while industry is always represented in a decision making or advisory capacity. In practice the principle *“who pays, says”* is more important. Project funding drives the technology road

map. Hence chemical companies, end users and technical textile firms have become most influential. The classic textile industry and the fashion sector is only a factor of influence at the Hochschule Niederrhein.

The significance of the research infrastructure goes further the region. In fact since most funding is national or private, there are no mechanisms to constrain industry-research partnership to the region. The Bundesländer is seen as an erratic funder for projects although it supports ZiTex which is considered a useful soft coordination and dissemination tool. ZiTex fills a gap that textile associations leave open since at the regional level they are not actively engaged in R&D policy coordination. European funding is considered by companies and institutes as less attractive than national funding, and the focus on SMEs in EU funding does not correspond with the dominance of larger (but still SME in culture) companies in the region.

3.3 LODZKIE REGION, POLAND

3.3.1 RATIONALE FOR THE CASE

Poland and in particular the textile region of Lodz represented an interesting case to present research and development in Central/Eastern Europe. Poland features one of the most relevant R&D capacities of textile considering the importance of the Lodz textile institute. The quality of the research according to the preliminary findings is also high. On the other side, during the formulation of the hypothesis of this study it has been assumed the offer of R&D capacity doesn't match the demand from the industry that, still constrained in a restructuring process, has a different view on the technological priorities.

The case was conducted through a short field visit involving a round table at the Technical University of Lodz, a round table with some participants in FP6/7 projects in Warsaw and interviews with manufacturers on site and during Techtextil. In addition we contacted coordinators of three projects with polish involvement.

3.3.2 PROFILE

The Polish textile industry is still facing the restructuring phase that started with the radical reforms towards a free market economy launched in 1989. After this comprehensive economical and political intervention, Polish manufacturing industry, including textile and in particular the cotton industry, was struggling to reorganize in order to successfully compete. Poland's cotton textile industry has fallen, along with the general economy, into a severe recession. The industry lost its domestic markets and export to the COMECON countries. The clothing industry could develop exports to the EU but mainly by tapping into outward processing trade, thus using Western European fabrics. This was somehow beneficial to the clothing industry, but of no help to the textile industry. However for the clothing industry, firms were reduced to subcontractors without need of design departments or of development activities.

One of the main textile areas in Poland is the Lodz Region, where the first cotton mill opened in 1825, and until 1990-1991 its economy was based on textile, while nowadays no major textile company survive. As result of the long crisis many textile enterprises closed, while the surviving ones are compelled to dismiss assets, cut their costs and reduce employment. It is not surprising then that employment in the industry manufacturing fabrics diminished by a half in 1994-2000. The Lodz industry was once characterized by large conglomerates, with more than 2000 workers, nowadays only SMEs survived.

On the other hand the disintegration of old large enterprises facilitated the slow emergence of new firms which not only manage to find ways to survive on the market but also to ensure themselves stable development. Some of these enterprises not only operate successfully on the domestic market but also manage to export their products to such demanding markets as France and Germany. Some of the former giants of the Polish textile industry have also managed to win a strong position on the market owing to prompt decisions to switch to the production of modern and sought for goods such as decorative fabrics, industrial fabrics or protective clothing, which sell well both at home and abroad. After accession to the EU the Polish textile industry benefited somehow of delocalization of textile production, and by relocation of the car industry and the need to have local suppliers. However it should be said that at this day the factories of automotive textiles do not have design and development functions.

The textile industry supplies linen, decorative fabrics and fabrics for the clothing industry, but also products used in the manufacture of packaging, tires, conveyors and protective clothing. The raw materials for the production of cotton and linen fabrics as well as wool cloth are imported. Beside traditional textile activities shall be noticed growing companies in the field of nonwoven technical textiles and synthetic turf.

In Lodz Province 93.4% of the regional textile and clothing companies are micro enterprises which employ up to 9 people, although they are also prone to escape statistical registration²¹. In 2003 Textile and clothing represented a nearly 20% share in the production of the province and over 33% share in its employment. It is interesting to note that between 2003 and 2006 the dynamics of the increase in the number of textile and clothing companies exceeded the dynamics of the increase in the total number of companies registered in the Province.

3.3.3 CLUSTERING AND CROSS SECTORAL BRIDGES

No specific activities of clusters have been analyzed during the investigation. According to the people interviewed there is no policy of clustering, although the Municipality of Lodz has expressed some ideas in the years 2008/2009. There have been attempts to set up a sectorial technology platform. Its impact a success according to the research centres but not relevant for the industry.

3.3.4 RESEARCH FUNDING

The policy for supporting research and innovation is highly centralized, and almost totally managed by the Ministry of Science and High Education.

The role and influence of regional authorities is limited, but the situation might change. In the framework of the EU Structural Fund interventions 2007-2013, it is foreseen that the 16 Regional Operational Programmes will support in total 965 R&D projects, 686 science-industry interventions, and 14,536 investment grants for SMEs.

The Ministry of Science and Higher Education – Ministertwo Nauki i Szkolnictwa Wyższego - is the main body responsible for the formulation of Polish research policy. Due to the fact that most policy instruments are based on legal acts, the role of the Parliament (notably the Parliamentary Commission for Education, Science and Youth) is crucial in the policy development. In addition, all the legal acts to be valid must be approved by the President. It acts as a large financing agency, creates overall research strategies, defines priority research areas and finances them through various subsidies, grants scholarships etc. It is also responsible for assessment of the research proposals as well as evaluation of research performance. The situation is going to change diametrically after the Building upon knowledge: Science reform for Poland's development is implemented.

Currently, the entire Polish system is undergoing a very significant and complex reform, which aims at splitting the competencies in funding over specialized agencies allowing them to formulate, organize and coordinate funding competitions and to include more active role of scientific community (Building upon knowledge: Science reform for

²¹ ANNA Rogut, Bogdan Piasecki, Transformation of textile and clothing industry from a labour intensive into knowledge based, Entrepreneurship and Economic Development Research Institute at the Lodz Academy of Management, LorisTex project, 2005

Poland's development). At the time of the production of this study (July 2011) two new funding agencies were created in order to distinguish the role between fundamental and applied research.

The main advisory body to the Ministry is the Science Council – established by the Act on Principles of financing science of 8 October 2004 – which constitutes a formal representation of research community, who advises the Minister of Science and Higher Education in the field of scientific policy and funding of R&D activities. The Council consists of renewed scientists arranged in several working groups according to the scientific disciplines²².

3.3.5 RESEARCH INFRASTRUCTURES

POLYTECHNIC UNIVERSITY OF LODZ

The faculty of Material Technologies and Textile Design has been known as Textile Faculty for several years. It was founded in the academic year 1947/48. It was chronologically the fourth faculty of the Technical University of Łódź. Educational profile of the Faculty evolved gradually and educational offer was extended, reflecting the changes in the labour market. Gradually more and more attention was paid to subjects concerning biomaterials, nanocomposites, wearable electronics or advanced human-friendly material technologies. Moreover modern trends in industrial design, new technologies and material innovations are taken into account in the educational offer. The faculty counts 136 students in textile engineering, 109 in material engineering and 98 in health and safety at work. With reference with research staff currently the faculty employs 94 academic staff members, including 24 professors and scientists with post doctoral degree. The budget of the university is defined by the Ministry of Science and High Education, while research projects conducted by the faculty staff are partially supported by EU via operational program for ERDF and Framework Programme funding.

Company investments on university research are almost absent due to structural problems of the industry and a lack of financial resources. For this reason university developed different business models to attract industry: for example mutual cooperation in using the respective facilities. Cooperation with industry is also supported by the organization of cyclic conferences and workshops, training courses. For example this is done by the department of knitting technology.

Area of interest for research is broad and covers different aspects of the textile research: Bio and nanotechnologies, PPE, knitting technology, wearable electronics, filtration, biobased and biodegradable materials, process technology. The collaboration with other RTD centre is active at European level and mainly based on personal contacts that are built during conference and events. Via this channel each research develops knowledge on expertise and excellences of other centers to be used in case or search for a specific capability. There is the tendency of overcoming knowledge barriers by collaborating with other faculties of the University: for example collaboration with medical university of Lodz for the project “Textronic system for muscles electro stimulation”.

The Technical University of Lodz is ranked in the third tier in our system. It has an important quantitative output and also the potential to increase its ranking qualitatively. The industrial impact is however limited, both regionally and nationally. The University s often invited to join EU funded project. It plays according to some interviewed coordinators a positive role, with good research quality but sometimes a lack of realism in exploitation potential

²² Source: ERAWATCH website (<http://cordis.europa.eu/erawatch>)

and view on industrialization. The more applied institutes have a much better reputation with industry. They are all well connected to international networks. CIOP is recognized in the personal protective equipment community. INF in Poznan has played a leading role in structuring research on natural fibres in Europe and could be a strategic player in a raw materials oriented initiative in textiles.

ROLE OF TECHNOLOGICAL INSTITUTES.

An important role is played by technological institutes. They belong to various Ministries and are evaluated every 4 years. The state financing depends by this evaluation and goes to from 5 to 30 percent of their budget. The remaining of the budget is filled by commercial activities. Their work is important at the level of applied research and technology while Universities are recognized as the reference for fundamental research. Institutes can have different commercial scopes: Testing certifications and internationalization, production of small scale of testing facilities, research and development.

There are 3 institutes of reference for textiles in Poland:

INSTITUTE OF NATURAL FIBRES, POZNAN

The Institute of Natural Fibres is a research and development institution, which carries on the achievements, experience and tradition of the former Central Experimental Station of Silk Industry, the Experimental Station of Flax Industry and the Institute of Wool Science.

The Institute of Natural Fibres consists of 11 research departments, 7 research laboratories (2 of them, the Toxicity Laboratory and the Flammability Research Laboratory with accreditation), 7 agriculture experimental stations, 1 fibre art design studio and auxiliary divisions as the financial, technical, service and planning.

INSTITUTE OF TEXTILE, LODZ

The Institute of Textile Architecture is a scientific centre whose scope of activities includes processing and technologies as well as the application and promotion of textile products. The Institute was established in 1957 as the Central Laboratory of Cotton Industry; from 1978 to 1996 it has been operating under the name of the Research and Development Centre of Cotton Industry. The Institute's staff consists of 77 persons, among them 41 scientific workers.

The Institute is specialized in creative designing and development of novel structures, end-use properties, new technological processes for cotton and blends of cotton with chemical fibres, application of textiles for technical and special products, modern methods of textile raw materials and products assessment, and quality assurance systems according to the ISO and PN standards, finishing of textile products.

CENTRAL INSTITUTE FOR LABOUR PROTECTION, WARSZAWA

The Institute conducts research in occupational safety and ergonomics, thereby providing scientific bases for Poland's social and economic policy in this area. Research conducted in the Institute is interdisciplinary, and comprises work in the following areas: ergonomics, physiology, sociology and psychology, environmental engineering and protection as well as safety engineering (acoustics, machinery and robot construction, chemistry,

chemical technology, electrical machines and equipment, automatics and robotics, materials engineering and textile industry).

The Institute has competencies, confirmed by the Polish Centre for Testing and Certification, for testing personal protective equipment (respiratory protective equipment; head, hand and foot protective equipment; fall-arresting equipment; protective clothing; face and eye protectors; hearing protectors; gloves against vibration) and collective protective equipment together with the materials used for their manufacture, machinery, ladders of general use, parameters and factors connected with the working environment (accreditation certificate No. L 38/3/99); certification of personal protective equipment, collective protective equipment, machinery, high voltage insulation and protection equipment, ladders of general use (accreditation certificate No. 18/Cw-20/2/97); certification of management systems (accreditation certificate No. 69/Cs-77/1/00) and certification of personnel (accreditation certificate No. 71/Cp-76/1/00).

3.3.6 BEST PRACTICES AND MARKETABLE RESULTS

In general Lodz Region presented a mismatch between the research capacities of main technology centre (university of Lodz) and the companies in the region.

In fact University collaborates in a number of innovation projects, together with other research centers and companies in western Europe, Industry in the Region is still focused in internal incremental innovation and is not able bring technological advance to the market. This is because the industry is still mainly a subcontractor of bigger companies and lack the structure and strategy to sustain collaborative innovation activities.

CASES OF BEST PRACTICES

Project BioOchrony, Technical University Lodz.: The project “New generation of filtering materials with nanofibres and modifiers” was realised with the use of European Regional Fund

This project was realised by PRO HUMANO TEX- Centre of Advanced Textile Technologies Friendly for Human Beings in Lodz and the consortium was composed by:

1. Faculty of Material Technologies and Textile Design, Technical University of Lodz – Department of Material and Commodity Sciences and Textile Metrology
2. Personal Protective Equipment Department of Central Institute of Labour Protection – National Research Institute
3. Filter-Service Ltd. (producer of filtering half-masks) from United Kingdom

As a result of a project, bioactive filtering non-wovens have been developed and introduced into production, which were designed to purify the air of pathogenic microorganisms and also bioactive filtering half-masks and particle filters that were protection of respiratory system against biological factors.

Modification of traditional nonwoven materials has been developed in the range of the following techniques: the stitching technique with triboelectric effect, melt-blown and electrospinning.

As a result of a project, the special intelligent protective clothing for firemen has been developed and introduced into production.

The clothing monitors the following parameters:

- Temperature of the skin
- Temperature between skin and clothing
- Outside temperature
- Heart rate frequency
- Mobility (move/ non move)

The project was warmly welcomed by professional fire fighters

Filtrating devices of respiratory system in form of filtrating half-masks and filters completed with half-masks based on bioactive filtrating layers, is designed to be used in food industry, pharmaceutical industry, farming and in health-care: hospitals, private surgeries, dentistry, laryngology, dissection rooms, etc.

Case 1. Companies 13 and 14 are both based in Poland and they are exemplary of the more (and few) innovative companies in the country. In both cases the companies developed a new business line in a highly regulated market. Before that they were engaged in more bulk markets but these were declining. In the major restructuring of both companies (each lost 70% of its size) they were looking for new markets exploiting their technology base.

Company 13 participated by coincidence in two European projects. A Polish University was involved in the same projects, but there was limited cooperation with them. None led to exploitable results, but it enabled them to gain knowledge, a network and led to a better understanding of market trends in Western Europe. This inspired them to develop a range of products for the local market. The testing was done by a local technical centre.

Company 14 did also work together with a local technical centre for validation and testing of results. The partnership was successful even if the tests were paid on a commercial basis. There was no connection with the University and the inspiration to develop new products came from visits to fairs and input from the trade press.

3.3.7 CONCLUSIONS

The hypothesis of misbalance between offer and demand of innovation in Poland was confirmed by the results of the interview with companies. In fact the impression of an industrial panel is that the research activities of the University of Lodz are not going to be implemented in Polish companies, but their focus is rather at European Level. The collaboration between technology centers and companies in the region are mainly finalized to testing and setting up of machinery, hence to the last part of the development activity.

University could represent an important talent base to export high educated talents to companies and reduce the cultural and management distance that is one of the causes of the mismatch between research and industry.

The distance between research centers and industry reside also in the different themes they are interested in. This leads to a lack of networking that was confirmed by investigating the path of involvement of Polish companies and RTD institutes in European FP projects: while they appeared as working together, the dynamics of the involvement sometimes does not reflect a recurring pattern of reciprocal involvement in each other activities.

3.4 NORTH WEST ENGLAND

3.4.1 PROFILE OF THE REGION

Latest official ONS Annual Business Inquiry data provides the latest financial information for the North West England region, which is for 2008. This source points Northwest as the lead Region in the combined manufacture of Textiles, wearing apparel; Leather and related products. According to this source²³, the Northwest achieved a total turnover figure of £1,976 million (or nearly £2 billion) out of a UK figure of £8,763 million. This Northwest turnover represented 22.5% of the UK and was ahead of all other regions with East Midlands in second place. In terms of Textiles Manufacture only the Northwest dominance is clearly shown with a total turnover of £1,552 million or 28.8% of the UK figure of £5,380 million. In this Sector Yorkshire & the Humber is in second position with a turnover of £962 million. In terms of Manufacture of Wearing Apparel the Northwest, with a £311 million turnover is in third place to East Midlands with £705 million, and London on £424 million. The UK total was £2,524 million. A feature of Apparel production in the Northwest, however, is the existence of a number of specialist manufacturers. These figures for textile products et al are useful but they are not able to take in a variety of activities that bestride sector definitions including the dynamic field of Advanced Flexible Materials or even composites.

According to <http://www.themanufacturer.com>, as with much of the industry in the UK, today the Northwest is more renowned for its high value technical expertise in industries such as aerospace, defence, automotive, technical textiles, biomedical and energy while also having a strong food and drink industry. Iconic brands in each of these sectors dot the region and are supported by a range of organisations and Northwest Development Agency (NWDA)²⁴ sponsored regional cluster groups; The same web source points the Northwest as Europe's largest cluster of technical textile companies with over 480 companies employing over 37,000 people. For NW TEXNET, which now plays an active role as cluster facilitator and business developer in the field of flexible advance materials and technical textiles, those are the figures. Turnover for the industry is over £3.97bn with more than 70% of the region's output exported. As a hallmark of the areas textile origins, the technical textile sector is concentrated in central Lancashire and the northern part of Greater Manchester.

3.4.2 RESEARCH INFRASTRUCTURE

NW TEXNET

NW TEXTILES is a sort of developing agency acting as cluster / business facilitator within the UK North west region and is the only organization in the UK to be given Cluster Status by a Government body. NW TEXTILES activities are mainly oriented to innovative and new product and business related issues, such as: Informing companies of new market opportunities, making companies aware of new product areas; Helping companies make the most of potential new business ideas; linking companies together. This cluster facilitator is based in Bolton and has focused his strategy in the latest years into technical and high performance textiles. The EURATEX membership and the

²³ <https://ktn.innovateuk.org/>

²⁴ "Manufacturing Strategy & Action Plan for England's Northwest", Northwest Regional Development Agency, 2009

participation in most of the ETP (European Technology Platform) activities, puts this organization in a privileged position in what concerns the link and promotion of European research and innovation within the UK Northwest;

THE UNIVERSITY OF MANCHESTER

This worldwide known University fairly claims an exceptional record of generating and sharing new ideas and the quality, breadth and volume of its research activity is unparalleled in the UK. The University is built on the shoulders of academic giants and can lay claim to 25 Nobel Prize winners amongst its current and former staff and students. In 2010 MU ranks at 44th at World level and ranks 9th positions at European Level. The textile related competence is based within the School of Materials in the faculty of Engineering and Physical Science. The leading research in materials includes the following topics: Biomaterials; Ceramics and Glasses; Composites Materials; Corrosion & Protection; Metallic materials; Nanostructured Materials; paper Science; Polymer Science and Engineering; Textile Design, Fashion and Management; Textile Science & Technology; MU accounts with 1877 researchers in total, the Textiles and Paper academic staff integrated within the school of Materials counts 22 members;

THE NORTHWEST COMPOSITES CENTRE

It is Active as a regional Centre of expertise supporting, evaluating and introducing innovation in composite manufacturing, design and testing. The Northwest Composites Centre was established by the Universities of Bolton, Lancaster, Liverpool, Glyndwr and Manchester to create a Centre of international scientific reputation to the benefit of industry. Accessing 60 academics and State of the Art equipment and facilities, The Northwest Composites Centre claims to provide the following benefits: A research Centre offering new, low energy, rapid manufacturing techniques for industry and academia; Long term research projects aimed at improving company performance; Short term evaluation of processes and materials. This competence Centre is based in The University of Manchester, namely within the Paper Science Building; This Centre has a straight and closed connection with the MU School of Materials Textile Science & Technology group, with excellent research/prototyping facilities in cross knowledge areas regarding composites and textiles.

BTTG

BTTG (British Textile technology Group) is based in the North of England. It was founded 1989 by the merger of the Shirley Institute and Wool Industry Research Association, organisations with histories stretching back 85 years. The Group has two operating companies: 1) BTTG Testing & Certification specializes in the testing and Certification of Personal Protective Equipment, Geosynthetics, Floor coverings and other construction products. It offers Certification to EU Directives. 2) Shirley Technologies provides a broad range services to the traditional apparel sector. It's specialized in chemical testing and provides certification under the Oekotex scheme.

Regarding the innovation system, BTTG has clearly assumed a service provider position to the textile industry in the field of product and materials testing and certification. Based in North West England (Manchester and internationally spread within 4 spots (Singapore, Pakistan, India and China); BTTG link to European research is mostly ensure through TEXTRANET where BTTG Shirley Technology Holds a membership position.

UNIVERSITY OF BOLTON

The University of Bolton came into being in January 2005 as a sort of evolving process from the Bolton Institute of Higher Education that had become Britain's newest university just in the previous April; The University of Bolton claims to be one of Britain's fastest growing universities and in what research is concerned it is organized into 3 major areas: 1)Institute for Educational Cybernetics; 2)Centre for Research for Health and Wellbeing and 3) IMRI - Institute for Materials Research and Innovation; The textile related research is mostly comprised within the IMRI which is a multi-disciplinary Centre designed to cultivate research and innovation activities in collaboration with industry and other academic institutions and which major research & development lines are: Fire Materials; Materials Modelling and Simulation ; Medical and Healthcare Devices; Microsystems and Technologies ; Smart Materials and Systems; Specialty Composites; Technical Textiles

OTHER PLAYERS INTERACTING IN THE RESEARCH & INNOVATION SYSTEM

Manchester Metropolitan University; Manchester Metropolitan University was established as a Polytechnic in 1970 and became a University in 1992. It developed initially as a Centre of Technology, Art and Design from Manchester Mechanics' Institution (1824); Today it has an academic Department of Clothing Design and Technology but it does seem so involved in product research or material research;

TECHNITEX - is a research and knowledge transfer organization for the UK's technical textiles and advanced materials sector. It's a UK government funded initiative of the Heriot-Watt University, the University of Leeds, UMIST (now MU School of Materials) and the British Textile Technology Group. A network group within the Materials Knowledge Transfer Network, it offers the opportunity of privileged membership for its industrial partners; Based in Manchester, probably has some overlapping with NW TEXNET activities.

LTMA - Lancashire Textile Manufacturers' Association provides practical and up to date advice on any problem that its textile industry member companies may face, acting as a first point of contact for sales or supply enquiries from third parties. It works as an industry promotion agency, regarding members who are drawn from an area encompassing Cumbria, Lancashire, Greater Manchester and West Yorkshire.

UKTI - UK Trade & Investment (UKTI) works with UK-based businesses to ensure their success in international markets, and encourage the best overseas companies to look to the UK as their global partner of choice; basically has the role of foreign trade promotion agency;

3.4.3 CHARACTERISTICS OF THE RESEARCH INFRASTRUCTURE

A workshop and interviews have been carried out with Industry and other relevant organizations within the research & development scenario; the working session involved more 30 representatives from Industry, academia and technology transfer organizations; the research has been complemented with a few individual interviews.

NW TEXNET (resulting from the initiative of the regional developing agency) has assumed a role of representative of the North West England textile & clothing sector in important R&D and innovation forums like EURATEX, ETP (European Technology Platform) and others, acting as hub of the competences placed in the North West England region. Its work is recognized and some results are already available. For instance, the very recently started FP7 3D Lighttrans project is pointed already as a highlight and success story regarding this brokerage work assumed by NW

Texnet. However companies do still claim that there is not enough information or knowledge about what is being developed by universities or about the opportunities available in European research programmes; the fact that NW Texnet was for some time focused on advanced materials, has been somehow criticized by some of the companies. However is clear that in the present the scope of NW Texnet is no longer solely focus in that specific technical area, but following a more broad approach, aiming to integrate as much as competence and opportunities for the technical textiles business ; Despite there is a positive evaluation of the work developed by NW Texnet, is clear that from the industry point of view there are some remarks to be noticed regarding the research offer within the region: Employers still have difficulty to locate competence providers and speed on interventions does not meet employer need, giving a feeling that research results does not reach the companies in the more effective way and that communication from R&D providers is weak.

Manchester University (MU) and Bolton University (BU) are identified as the more relevant and active competence centers in terms of research, but it is clear that there is a lack of cooperation or articulation between those two centers; Is clear that for instance in the case of MU (which is technologically well equipped) there is a lack of showcase regarding activities and competences or formal marketing activities of its competences towards textile & clothing companies in terms of R&D; There is no such thing as a technology transfer office or a marketing promotion office that can exploit knowledge and R&D marketing activities namely in exhibitions or fairs; Despite BTTG been identified as a player in the research & innovation network, it is also clear that they have been progressively (extremely) focused on Testing and Certification and that there is no institute or technological Centre playing an interface role between industry/business and academia, like in other European regions. This role seems to be solely assumed by NW TEXNET. Therefore is clear that competence exist, the actors are more or less identified by companies, but the offer is not that well organized and not so easily accessible;

It was also being stated that the fact that some research is being developed by overseas students, temporally set at local North West England Universities, is contributing to some research results being exported (exploited) to/by third countries (Hong Kong, China and India) but probably not under the most profitable “business” model; This is somehow confirmed by the fact that most of the recent patenting activity being actually linked to far east PhD students and addressing areas like innovative weaving structures for composites, digital printing or textiles for medical applications;

As stated by various contributors during the workshop and interviews involved with this study, European projects are still seen as something difficult to get or to achieve by most of the companies, due to factors like bureaucracy, lack of information about how to join consortia or project dimensions or even due to mismatch between company’s needs (SME’s) and programs priorities; Some of the key research interests in the case of companies acting in the traditional textile value chain are difficult to frame within the research priorities that have been placed in the last FP programs; many companies, which have not yet shift to more technical or high added value products stated to be in “Survival Mode”. It was clear that large scale research projects are not the way forward since normally there is a high tendency to loose sight and in most cases they do not benefit industry as planned. SME’s and Micro companies have a greater need to get involved but timescales and commitment required is too big for long term projects. Therefore is clear that smaller projects, with smaller consortia, and with funding schemes for innovation related activities would most probably lead to better results in terms of innovation, namely when it comes to new products, or new processes. An available study about the impact of the EU RTD Framework

Programmes on the UK²⁵, identifies that the top motive for UK organizations to be involved in FP6/FP7 projects is quite different for Industry and Research Institutes: A) Industry top motive: To develop new or improved relationships or networks; B) Research Organizations top motive: To access research funding; If the top motive for industry to get involved into EU RTD projects is simply relationship and networking and not knowledge and technology development, is clear that expectations on this matter are quite low.

Still on the side of research and innovation funding, It has been pointed out that innovation vouchers were an interesting measure promoting innovation and R&D links with companies, but financial resources per voucher were reduced (7.000 £) and this kind of measures are no longer available; National funds are still being used to support R&D activities, even though they are more reduced and difficult to access;

Manchester University is the only surviving actor with an assumed technologist approach on scientific lecturing of textile and clothing related areas; Most of the Universities in the North West England and in the UK (Leeds and Bolton) choose the path of design & fashion courses instead of technology/production oriented courses. However they all keep their research strategy oriented to the most promising and advanced technological areas, such as smart materials, composites, medical textiles or innovative fibres. This sort of double life between research and lecturing on Universities with textiles & clothing tradition seems not to be an exclusive from North West England and confirms the lack of *“attraction” on textile technology based careers* when marketed as such.

Despite not been pointed by any of the companies or organizations involved in the workshops/interviews, Leeds University does have a competence and research Centre (CTT – Centre for Technical Textiles) within the structure of the Textile Design School; This Centre seems to have a coherent and interesting R&D strategic line but effective link to industry is unknown and it's strange that this Centre has been away from relevant on going R&D and innovation forums like the ETP (European Technology Platform).

Composites and non-wovens have been pointed as success stories regarding competence and expertise available within the region and as a strategic area, where some breakthroughs have been achieved within the North West England region. This is shown at the Composites Centre of Manchester University (New). This centre is a clear evidence of the breakthrough regarding knowledge and competence within this specific area; the participation in FP7 projects and patenting activity also shows competence progress and is a clear demonstration of high level scientific and research capacity in this field, which expertise is also somehow integrated and connected with the weaving/braiding technology and expertise available in MU School of Materials Textile & paper Dep.; The fact of composites related technologies being present in some recent patenting activity and also in a few FP7 R&D projects, demonstrates that there is a coherent line in that research topic, crossing different kinds of organizations.

When looking at the of the North West England region, namely those considered The “Manufacturing Strategy & Action Plan For England’s Northwest” (3) drafted by the Northwest Regional Development Agency in 2009²⁶, considers 8 key manufacturing sub-sector/clusters: Aerospace; Automotive; Chemicals, Biomedical Technology, Advanced Flexible Materials, Energy & Environmental Technologies, Food & Drink, Digital & Creative Industries. In

²⁵ “The Impact of The EU RTD Framework Programme on the UK”, Technopolis; Paul Simmonds, James Stroyan, Neil Brown, Andrej Horvath; 2010

²⁶ “Manufacturing Strategy & Action Plan for England’s Northwest”, Northwest Regional Development Agency, 2009

this context composites technology has clear match in several of those clusters and therefore the opportunities for the textile industry as a relevant component part in composites innovation are relevant;

3.4.4 BEST PRACTICES AND MARKETABLE RESULTS

When it comes to how successfully R&D results are transformed into marketable products the scenario is not that clear. It is somehow understood, either by companies, either by research organizations, that in several cases R&D might led to important knowledge improvements and valuable incremental production/technological advances, without really achieving the “stage” of a real new product/service/technology in the market. On the other side, the reason behind some R&D results not reaching such an “innovation” statute or being successfully transformed into marketable products or services, is also connected to the fact the in most of the EU R&D funding schemes, close to market activities or developments are not supported or considered as eligible activities. Accurate market research was identified as a critical factor for transforming R&D results into marketable products, but once more, it was also stressed that in most cases that kind of activities do not fit into existing funding programs, for instance like it was in the FP5 Exploratory Awards instrument.

The fact that today most of textile related R&D projects are targeting non traditional application markets (medical, aerospace, automotive, etc.), with specific and different technical & scientific knowledge requirements, bought into the textile research scenery, new players come from a wide range of different knowledge fields. This trend is also demonstrated by the fact that other Universities (not the Textile Technology Traditional ones) are assuming a more active role in textile research. This is somehow confirmed when we look at MU and BU participation in FP6 and FP7 textile & clothing related projects, which is quite divided with a large group of other Universities traditionally connected with other fields of expertise, such as CRANFIELD UNIVERSITY; THE UNIVERSITY OF THE ARTS LONDON; THE NOTTINGHAM TRENT UNIVERSITY; COVENTRY UNIVERSITY; WESSEX INSTITUTE OF TECHNOLOGY; UNIVERSITY OF BATH; UNIVERSITY OF SOUTHAMPTON; LOUGHBOROUGH UNIVERSITY; UNIVERSITY OF SURREY; THE UNIVERSITY OF READING; DE MONTFORT UNIVERSITY; UNIVERSITY OF LEEDS.

There is an interesting patenting activity in the last 5 years.

Patenting Universities and institutes in this field, under the same search criteria, are: University of Bolton, Manchester University, University of Sheffield, Heriot Watt University, Southampton University; Brunel University; Reading University; Bolton shows a slightly more active role in what patent applications is concerned;

No consistent or significant match between patenting organizations and participating organizations in FP6 and FP7 was found and there is no predominant player in terms of patenting organizations and companies; Composites and fibre reinforced materials are well represented in the patent titles keywords, confirming that this area is one of the key innovative active areas;

Chinese PhD student are responsible for the more recent patents, particularly in MU University, meaning that there is a real risk of knowledge transfer to the country of origin of such students that are temporarily developing research at UK Universities.

BEST PRACTICES CASES

Project 3D-LightTrans. A recent achievement for the composite cluster in the region is the FP7 project 3D-LightTrans. The goal is to provide groundbreaking, highly flexible and adaptable low-cost technologies for manufacturing of 3D textile reinforced plastic composites. 3D-LightTrans aims at open the way to a totally new concept for the design, manufacturing and application of composites for low-cost mass products in a wide range of sectors. The Consortium brings together multidisciplinary research teams involving five relevant industrial stakeholders from machine tools and machine automation (P-D Glasseiden, Van de Wiele, Lindauer Dornier, Coatema) and several OEM active in the field of processing of flexible materials and composite manufacturing, including Federal Mogul, among others, as well as from the application sector (FIAT and Bentley), and extensive expertise from well known research specialists in the area of materials, production research and technical textiles in particular, like AIT, TU-Dresden and University of Ghent.

Case 1 ENASHAW is a made to measure curtain manufacturer established since 1932, in Saint Helen, England's Northwest region. All production is located at ENASHAW's industrial facilities that counts with 180 employees and generates a turnover of 12.3 Million Pounds (14.200.000 Euros). The interesting fact of this SME is managing to be a competitive company in a relatively traditional product, even operating and producing in a country like the UK, with high labour costs and where mostly of the manufacturing business has shifted to more high tech sectors, like technical textiles or even composites. The success of ENASHAW was built upon an innovation strategy focused in process innovation and business/marketing innovation. All production is oriented to small independent retailers as well as big retailers on the domestic distribution and more recently ENASHAW is also operating in the contract business, like for example supplying the curtains for all the 2012 London Olympics villages.

By investing in a very innovative handling system, specifically design and developed for the company's production line, ENASHAW's managed to reduce dramatically both the production lead time and the operation costs. Ever since the focus has been in innovative processes towards a very competitive lead time and cost structure in order to allow the sustainability of the business, even with all production been located in the UK.

When asking Mr. Stewart Taylor (Contract Director) and the company's CEO, if this kind of innovative thinking and development is either performed within the company, with its own resources and staff or subcontracted to external players, the answer is clear: "Such innovative developments should be led and developed by external specialised organizations that can be extremely focused and exclusively concentrated in achieving the best result on terms of innovation. Normally an SME itself does not have the resources, the knowledge or even the time to manage innovation and at the same time run the business efficiently.

When asking the company about the importance of product innovation and about who are the drivers for such kind of developments, the answer is in line with the findings in other case studies performed in other regions: "Product innovation is the way to differentiate constantly the product. In our case, we have been mostly interested in green innovation, namely the use of recycled fibres towards more sustainable products and more eco-friendly products. This is one of the key distinctive elements for differentiating traditional products within a global market.

The drivers for such product innovation developments could be external (essentially pushed by the client) when it comes to big contracts and major clients or the ideas can be internally generated and developed, in the case of small costumers. In this case the company considers that visiting fairs and product exhibitions are part of critical process for feeding innovative ideas and products and that should be more supported in terms of public policy. Normally this kind of activities which are consider critical for "feeding" creative thinking and innovative ideas for development are not eligible in most of the R&D and innovation supporting schemes.

Another interesting success factor of ENASHAW's strategy was innovating in the way business was managed, namely for the bigger retailers, by incorporating a service component in the global package to the client. Soon the company realised that by complementing the product with innovative customer service, the added value resulting from the operation was considerably higher.

Nowadays, ENASHAW has design the web platform for on-line sales for one the most important UK retailers. ENASHAW hosts that platform, manages the platform and ensures the entire production of the orders arriving through this online platform. The retailer has nothing to care about but the marketing strategy for the overall on-line business done through that trading channel. This quite innovative business approach, which brings together production and on-line retailing, but managed as a fully integrated service package to the final customer, allows the company to complement its business strategy (small retailers and contract business) with a different market: The on line retailing market.

For an SME's like ENASHAW, finding new access to new markets is critical for business development and for growth, therefore on-line retailing can be a very interesting option to address millions of potential clients, spread all over Europe. However it seems clear that to transform this strategy into a successful story, the very competitive lead time of the company, based on the innovative product handling system, allowing order production and deliver in extremely short times, cannot be disregarded.

Regarding innovation funding and support as well as R&D and innovation projects, the company's CEO believes that funding programs and schemes are too fragmented and therefore difficult to access. "This high fragmentation and heavily bureaucratic system to access project funding is more interesting for consulting companies or for other organizations that have become specialist in accessing the available funding". Shorter projects with a more direct impact in industry are consider to be more interesting than most of the projects that are being promoted within England's Northwest Cluster, with a more scientific approach and in most cases with an excessive academic orientation, but rarely reaching a final solution or a very applied development for the companies. According to ENASHAW's CEO the link between Universities and companies should be significantly improved and Universities should pay more attention to the needs of having well trained and skilled people for the sector, which in the short term can be a real barrier for industrial based business development in Europe.

ENASHAW is a very good example of how process and business innovation can be the supporting pillars for a successful and competitive manufacturing business strategy, based upon a relatively traditional product and at the same time fully operating in a European country, with high labour costs as the UK.

3.4.5 CONCLUSIONS

Analyzing all the information and inputs collected, it seems that composites are one of the strong competences that have been developed within the region, profiting from an excellent knowledge of textiles fibres and materials as reinforcement materials in such kind of products. The 3D Light Trans could be a good recent example, since it addresses that specific area and is pointed as one of the first results coming from the work developed by NW TEXNET as a competence and business promotion agent; The presence of Bentley Motors is relevant.

NW TEXNET is trying to fulfill the communication gap between Universities and Companies which is an issue that stills catch the attention from both poles with the classical discussion about how to improve the level of cooperation between higher education and business. It's assumed by both parties that higher education

institutions and businesses benefit from working together and that the transfer and sharing of knowledge, contributes to the identification of new product & market opportunities and to more technologically advanced products and processes. This intermediary role in-between companies and Universities can be provided by professional organizations that deal with this position in a more market oriented figure (technological services providers) or by the Universities themselves, through specific institutes or technology transfer centers, assuming a clear market approach whilst actively promoting their competences and services in the market place.

Both models are present in Europe. Regarding North West England the situation is somehow mixed. NW Texnet is playing a role that is closer to an innovation promotion agency than really building a business around this role and Universities are not ready to market their research capacity to companies in an effective and practical way. Research priorities for companies, mainly for SME's, are still driven by their clients' needs and short term development projects are seen as an interesting tool to match those needs. However those short term needs and more close to market developments might not always be in line with the research that is being developed at Universities, that in the best scenario is probably attractive only to companies working in more advanced products and process than to those companies which business is built on more traditional textiles.

However, like the ENA SHAW company case shows, even those companies which are active in more traditional products can be quite competitive and very innovative in terms of business and processes and they do look for R&D providers to fulfill their development strategy.

The North West England Region, within the composites specialty area, has managed to make the convergence between interesting research areas for Universities (mostly in the side of material science) and the set up of a specific Centre that provides services to companies in that expertise field. This strategy can contribute to orient University research to areas with stronger market potential that are pointed out by this Centre and indirectly market through this facility. This allows building a more sustainable bridge between existent knowledge in the Universities and companies' demands through valuable technological services offered by an interface infrastructure, which is organized in such a way (different from a University) that allows an effective intermediary and business activity towards the market.

3.5 LOMBARDIA REGION AND THE DISTRICT OF BIELLA

3.5.1 RATIONALE OF THE CASE

Lombardia and the textile district of Biella represent one of the biggest macro regions for the European Textile industry. Merging together Lombardia and a province of Piemonte case represent an exception to the criteria of developing regional cases at NUTS 2 level. In fact Lombardia is a geographical entity for the application of regional policies separated from the province of Biella that belongs to Regione Piemonte. But the analysis of the structure and the trends of the textile industries entail relevant cross relationships and complementarities.

For the development of the case a preliminary research of the most relevant actors has been carried out; the research has been carried out by cross checking the entries of the European Projects database, together with the information about regional and national projects. The result was the list of most relevant research centers and companies. These actors have been contacted for personal interviews in order to discover the dynamics of the collaboration.

The interviews have been carried out between May and June 2011, during personal visit or by telephone.

3.5.2 PROFILE OF THE REGION

Lombardia and the neighbouring district of Biella 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 comakership 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.

In Lombardia there are 4.767 companies operating in the textile industry and 8525 in the clothing industry. 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.

3.5.3 INNOVATIVITY OF THE INDUSTRY

The patent position of Lombardia is in the second tier of the European region and is, with little over 500 patents, far below the relative size of the region in the European industry. Around 50% of these patents are held by textile firms (a low score) whereas 35% are held by machinery manufacturers (a high score) the remaining part being held by chemical companies (a low share). While being 4 times larger than the leading innovation regions in Germany, it holds 6 times less patents. This is mainly attributable to the absence of innovation powerhouses in the fibre industry or in technical textiles. No single company holds more than 100 patents. However about 300 patents are held by the first 35 companies, all in the textile industry; this means that only 1% of textile companies hold patents, but nevertheless the patents are well distributed over those companies. 80% of patents are held by companies not falling under the EU SME definition. While the majority of patents are held by technical textiles companies, especially in non-woven, an interesting and rather recent trend is the growing number of (recent) patents held by companies engaged in other segments such as bed textiles (Zucchi), fashion (Loro Piana) or furniture fabrics (Italvelluti).

3.5.4 RESEARCH FUNDING

NATIONAL LEVEL

At the level of central government Research policy has a prominent position concerning overall policy and policy intentions. It is discussed within high-level policy formulation and coordination bodies and is overseen by a committee of higher level representation. This is called CIPE (Interministerial Committee for Economic Planning). Besides the roles played by CIPE and MIUR *Ministry of University and Research*, the conceiving and implementation of policies is overseen by two permanent commissions in the bicameral Parliament.

The funding activities are mainly centralised into two ministries: MIUR Ministry of University and Research, which is in charge of universities and public research institutions, and the Ministry for Economic Development, which is mainly concerned with innovation policies. MIUR operates through specific funds. Talking about applied research and financial resources for companies the contribution from the central government is declining. To be mentioned is the competitive call for proposal "Industria 2015" with different strategic action lines launched in 2007. The evaluation process was based on a 2 step proposals. Many of the companies and research centres that participated to the study applied. Although many of them received a positive evaluation of their projects and are ranked for funding, none of the projects have been financed and kicked off for the start of the activities. All interviewed expressed a bad opinion on the way this tool has been administrated by the Government.

REGIONAL LEVEL

Regions have acquired more responsibility through a change in the Italian Republic's Basic Law (L. 3/2003, which enables them, along with the state, to adopt autonomous Science, Technology and Innovation (STI) policies). As to the division of competencies between the state and its regions, the 2004-2006 national research plan clarifies that the regional legislative authorities are concurrent in STI policy. This means that regional authorities can regulate aspects that have not been regulated by the state in relation to STI policy; all regions are allowed to have local regulation and will establish specific regional STI policy.

For the purpose of this study the Director General for Industry Craftsmanship, Construction and Cooperation (*Direzione Industria, artigianato costruzione e cooperazione*) in Region Lombardia, Francesco Baroni has been interviewed.

The policy of *Direzione Generale Industria* aims at supporting Micro and SMEs and their aggregations by sustaining innovation, promoting of the excellences on applied research, entrepreneurship, also in specific divisions (manufacture and craftsmanship) and different sectors (fashion and design). They support the development of companies on national and international markets, facilitating the internationalization of the Micro and SMEs.

Direzione Generale Industria supports the development of the Lombardy industrial system also through the activation of special policy for industrial districts and the so-called *Metadistretti*. *Metadistricts* are areas that feature a high interaction among districts corresponding to different municipalities, not necessarily adjacent, where are concentrating companies belonging to the same strategic supply chain.

Those areas which are characterized by the presence of production sectors, where physical vicinity between firms is replaced by network relationships and a growing interaction between manufacturing companies, research and knowledge centers and service activities of the sector.

The way Regione Lombardia is supporting growth in the textile sector is radically changing with regard with the approach and the instruments used. A consistent reduction of the resources from central government (*Fondo Unico*, the main financial instrument for regions has been eliminated after 2010) pushed regional authorities to concentrate their effort into priorities selected with a roadmapping exercise and the production of a long term vision. This new approach is still in definition and is going to be implemented at the time of this study.

The instruments that are being developed are addressing different aspects: access to credit, Innovation, internationalization and aggregation.

The access to credit policy is a system of financial guarantees will improve access of SMEs to the credit market generating a leverage effect. This will improve in the short term the level of investments in R&D from SME without committing relevant amount of funding from the Region.

Regarding the policy on innovation, the aim of this priority is to increase the level and the quality of the investments in R&D of SMEs. The amount of resources is around 120 millions Euros. Due to the limitations of the resources a pool of strategic Excellencies in the region have been selected:

- Biotech
- ICT
- Fashion and design
- Mechanics
- Automotive
- Aerospace
- Energy
- Materials

Those excellences are connected with the *Metadistretto* definition and aim at clustering the 30 official districts areas in Lombardia. The support to those will be project call based and in general there will be 50% of revolving funds and 50% as free grant.

The DG industry is also trying to introduce innovative financial instruments for the contribution to the projects introducing new concepts like success fee in a project. This tools might not be implemented in the short term because of all the difficulties of conform to all the different financing guidelines and eligibility criteria at European and national level. Beside the priorities resources will also be committed for improving RTD infrastructures.

In order to introduce innovative tools like a *success fee*, an evaluation of success criteria is being introduced: this can be based on patents produced, or product/business plans delivered during the project.

For the internationalization priority different tools are developed, in particular voucher to support SME in participating to international fairs

Aggregation is an action that aims at supporting SME in working together in strategic supply chains and improving their competitiveness. 24 millions of funding provided by the Region, National government and chamber of Commerce are committed for the so-called programma *Driade* that is a special program for the consolidation of clusters in the Region.

DG Industry plays a primary role regarding European Programs (2007-2013); In fact it is the Managing authority for the operational program for all the actions financed by EDRF.

3.5.5 RESEARCH INFRASTRUCTURES

CENTROCOT - CENTRO TESSILE COTONIERO E ABBIGLIAMENTO

Centrocot is a no profit organization that aims at providing technical services, to textile and clothing sector, including technical and innovative textiles, and other related sectors, and textile machinery manufacturing sector. Shareholders are for 62, 5% local public owners, namely Chamber of Commerce, Local governments and the Lombardy public funding company. For the rest are trade union and private owners. Centrocot employs 68 people, of whom 24 are University graduated and 41 are technicians; 3 support staff.

The activities of Centrocot are: Laboratory services, certifications, technical courses, technological observatory, internationalization, research projects and other Consultancy services. They have an important role in the industry for testing, since they are exclusivity for Italy for the certification of Oekotex label. It features advanced facilities for laboratory textiles testing accredited for different worldwide standards. They can perform around 1200 tests: physical and mechanics, dyeing, chemical, ecological, and biological, fire, comfort, chemical risk, UV protection, electromagnetic protection. Their client base is mainly composed by Italian SME from the textile and clothing sector, while they don't clients from composites / plastics.

The participation to research projects is strictly connected with their focus on services: projects that include research activities that can increase their knowledge in test are pursued, creating a strong synergy between testing and research. Strategy is to perform all kind of research that gives the possibility of introducing new test or a new laboratory.

The service-based orientation to research influences the dynamic of the involvement of industries. Without a programmatic relationship, companies collaborate with Centrocot mainly for 1 time solution to a problem. For each case Centrocot analyze the needs and direct the company to the right program, organizing at the same time a

cluster. A long term strategic agenda is not explicitly elaborated, although every year a mission and vision on technology is reviewed. This means new ideas are followed but only with a short term vision

Centrocot meets regularly different body and associations in the region but there's no formal coordination in actions. The same for the collaboration with other research centres: connections are indeed strong and wide but they are done only at personal level without any programmatic involvement. Anyhow there is now a pressure from different institutions in order to establish programmatic relationships for the future.

Centrocot have experience with different national public funding programs in particular Industria 2015 at national level with 3 projects and Metadistretto at regional level. At European level they are involved in several framework projects; their success rate for them is quite high. They find that participating to European framework programs have an added value in terms of networking compared to the national level.

The vision in order to improve the participation of SME in the research process is to involve them in a "Rete" (net) as legal entity, while there still a lack of mechanism of coordination for this kind of coordination: in fact companies not only need support for research, but they also support to redesign a new organization in order foster a sustainable research capacity.

STAZIONE SPERIMENTALE PER LA SETA

Stazione Sperimentale per la Seta is an independent research organization and services providers for the textile / clothing sector and silk in particular. It was established in Milan in 1923. It features two highly advanced research laboratories, based in Milan and Como that are equipped to process a wide variety of services and research essential for textile sector advanced applications. The activity of SSPS includes: Applied research for companies business and public bodies; tests, inspections and advice on raw materials, processing, finished products, also in relation to environmental issues.

It provides professional trainings for specialized technicians at different levels; they organize and supply basic courses, internships, specialized courses on different technical topics. Moreover it offers scholarships and training for young graduates; science and technology students can conduct an experimental thesis in the laboratories of the organization. With this regard SSPS collaborates with Politecnico of Milano. In addition, SSPS publish sector magazines, silk industry statistics, folders on color trends, books and manuals on features and technology of silk.

The budget for the organization comes from public funding, in particular from part of the customs and import duties on silk. Anyhow the research activity is self financed by collaboration with companies and participation to competitive project funding (both public and private).

With regard with the collaboration with companies: the linkages with the industry association for silk are still active, but the research focus is on many topics mainly outside the silk. Their research topics are functional textiles, Biotechnologies, biomaterials, process innovation in addition to the traditional specialization in silk technology. SSPS policy on collaboration is usually problem-solution based, although at the moment they are stepping further on this topic by starting a "*protocol of collaboration*" some companies that entails a long term relationship in research.

SSS applies regularly on public funding at national and regional level. They have 2 projects running under the framework of *Metadistretto* and one under the national framework of *Industria 2015*. While the national framework presented structural problems of organization and reliability among the participants, *Metadistretto*

from Regione Lombardia seemed to be quite successful. Negative effect of the regional framework (that aims at strengthening the relation between clusters in the region) is to enhance the boundaries for collaborations outside the regions.

SSS collaborates with other centres in Europe; the linkages are strong and started years ago. In particular to develop themes like biomedical applied to textiles. The relations are mainly based on the work of personal contacts. Publications are not considered as a primary objective for the staff of SSS, due to the fact that will not contribute directly for the career of the staff.

POLITECNICO DI TORINO

Textile research for Politecnico di Torino is carried under the Department of Materials Science and Chemical Engineering (DISMIC). DISMIC has a strong interdisciplinary approach to research, both theoretical and applied. The main areas of work are: biotechnologies, the multiple phases of catalyst and reaction, the study of ceramic, metallic, glass, polymer and composite materials; electrochemistry and the electrochemical conversion of energy, corrosion, metallurgical processes, fracture mechanics and failure analysis, safety and environmental engineering. Research subjects range from the fundamentals of chemistry and materials science to the production and behaviour of engineered materials.

Research in textile engineering excellences is on development of innovative water treatments and super-critical fluid processing.

Education is mainly directed towards a Process engineering approach, dealing mainly with chemistry. In order to increase their attraction to foreigner students they opened a textile engineering course in English; at the time of this study the department counted 40 textile students of which: 30 Bsc and 10 MSc. Moreover 5 PhDs are working in the department.

The level of collaboration with industry is seen at different levels. One can be at the *idea* level, where a company ask university to develop a concept or solve a problem. This entails short-medium term view. A higher level is collaboration on a *Joint program* that entails a long term vision on innovation and strategy.

Collaboration with other institutes is active and regular and goes at least at European level excluding any geographical barriers. At the moment the department is not involved in European funded research projects.

UNIVERSITY OF BERGAMO

In the University of Bergamo Textile Education and research are organized under the faculty of engineering that started in 1990. From 2003 to 2010 a textile engineering course was activated designed by a joined University industry committee. Due to reduction of financial resources and lack of students, since 2010 textile engineering is only a curriculum of the management engineering course. So, together with a general management engineering background, student acquire textile competences about the manufacturing process, product knowledge and production management.

University of Bergamo have a strong focus on education according to the data that 85% of the students educated in the course will work in the textile sector, but still the request for textile engineers is larger then the actual textile students. The job functions involved are production process, production design, R&D and the commercial area.

Beside the education area the university of Bergamo provide services from a Textile Technological lab (TCCF) dealing with textile chemistry, colourist, and finishing research area. In this area they collaborate with companies by providing opportunities and solutions for fashion and textile in terms of consultancy, stipulation of contract for research, participation in joint ventures and projects. The Research Staff counts 1 Assistant professor, a PhD student and 2 Scholarships; due to the limited staff they prefer to participate to big European projects as subcontractor rather than partner.

A network with major public and private research centres all over Europe is developed (University Gent, SSS, Politecnico Torino, University Duisburg Essen, University of Zagreb, Centrocot, DTNW, and Next technology). The network counts mainly on personal relationships of the research staff.

The department funds for research are based mainly at national level (70%), including both central government and regional authority. European funding counts for 20% of the budget, while private investors and companies only for 10%

Collaboration with companies is a priority for University of Bergamo mainly for the fact that can attract investments from alternative resources, while national government are funds are decreasing. Moreover it is a way to improve prestige and awareness of the university: attracts students and relations with other colleagues.

3.5.6 ASSOCIATIONS AND CLUSTERS

CONFINDUSTRIA

Industry in the area is represented by the National *Confindustria* that is organized in provincial sections. Each provincial section of Confindustria includes a committee and members from the board for the textile sector. Textile representation in the local Confindustria is very active in the provinces of Bergamo and Como. The participation to the local network is high also considering the big of Small Medium Enterprises.

In terms of support for research and innovation local Confindustria regularly organizes seminars, workshop and conferences about new initiatives and funding opportunities. They also provide support services for company to apply to regional funding, defend intellectual property and collaborate with other clusters. Companies usually prefer to collaborate with the local Confindustria on those topics rather than sector specific association. The local Confindustria system contributes in creating a strong local cluster but might raises some barriers when it comes to coordinate events at bigger level (region or country).

Centro Tessile Serico in Como, owned by the local Chamber of Commerce, local Confindustria, Sistema Moda Italia and other local institutions, contributes to the development of knowledge and research for textiles. They provide services for laboratory testing, training and consultancy. Centro tessile serico also owns the trade mark “Seri.co”.

SISTEMA MODA ITALIA

SMI, based in Milano is the Italian textile and clothing industry federation. It is one of the world’s largest organizations representing the textile and fashion industry. The Federation represents a sector, with over 510,000 employees and nearly 60,000 companies that is a mainstay of Italy’s economy and manufacturing industry. The Federation protects and promotes the interests of the sector and its members. It represents the entire industry on

a national and international level and maintains relations with government agencies, public administration, and with economic, political, labour, and social organizations.

At European level SMI is represented by Euratex. In this context the associates of SMI are informed about for all the European Technology Platform Initiative and the opportunities of European funding under FP7. The level of interaction of the companies for this initiative is quite low. Companies they have a preferred channel with the local Confindustria. SMI have the capacity of being partner in a European consortium, especially in the role of dissemination.

The role on the research and innovation environment of textile is limited; in fact their role is much stronger in the strategic positioning of the Italian industry, lobbying with government, and with market intelligence and export services. Sistema Moda Italia does not have a role in fostering local clusters (since their focus is national) and collaboration between companies and Universities. There are also no official agreements for a vision of innovation with technological centers. They have impact on European policy only through European Technology Platform. Their focus is also on traditional textile and clothing companies while technical textiles representation is carried by the technical textile association TEXCLUBTEC.

TEXCLUBTEC

TEXCLUBTEC is the Italian association that aims at promoting the development of high-tech and innovative textiles and fostering greater awareness of this particular category of product. The focus is on the technological aspect for all the textiles materials that need to perform with special characteristics

TEXCLUBTEC includes a broad cross section of manufacturers, representative bodies and users who all share a similar interest in sector. It collaborates with textile and non-textile trade associations, companies representing the entire technical textiles chain (from machinery to fibres, yarns, cords, nets, fabrics, nonwovens, coated, chemical treatments, finishing, end-uses), research centers and laboratories.

The collaboration with companies begins at technical level, to promote their production and to spread knowledge about technical and innovative textiles at all levels. This role entails the fostering synergies among all the actors in the field: contacts with institutions, customers and potential users in Italy and abroad as well as with European and International associations and key authorities (CEN, Euratex, and IFAI).

There are 3 main area of intervention: Technical (information, publications, and newsletter), Commercial (participation to several fairs with a systemic approach), and Service support (testing, international standards). For the information it publishes an Internet newsletter containing information on technical issues and opportunities relative to the industry pertaining to specific end user sectors covered (textiles for agriculture and the building industry, interiors, fashion and footwear, transportation, geosynthetics, protective and medical textiles, textiles for industry, packaging, environment, sport). Very important is their role for promotion and internationalization through participation at fairs in Italy and abroad, conferences and press.

The importance of having a horizontal association for technical textiles rose after the shifting trend of the early 90s, when many companies decided to convert their facilities from traditional textiles to technical textiles. At the beginning the process was neither structural nor organized. It had no impact at international level in terms of promotion or events. The organization of TEXCLUBTEC at the end of the 90s, helped to create an Italian cluster for technical textiles and introduce the concept of “*Sistema*” as a way to create synergies among all the actors in the market. TEXCLUBTEC collaborates with the European Technology Platform for development of a technological road

map for technical textiles. There are also regular contacts with national public bodies but it doesn't turn into a relevant lobby action that can influence the public support to the sector

POLO INNOVAZIONE TESSILE (PO.IN.TEX) BIELLA

Po.In.Tex is the textile innovation cluster in Piemonte. It was created in 2009 by Regione Piemonte to support companies that operate in technological domains of strategic importance. The cluster aims at promoting competitiveness and employment by favouring access to high value services.

The mission is to promote transfer of knowledge and technology between centres of excellence and companies, between different companies, with a specific focus on SMEs. The textile cluster is composed by companies in the textile, clothing and machinery sector, and research institutions affiliated in form of ATS (Italian for Temporary Business Association); the cluster affiliates are 57. The coordinator of the cluster is "Citta' Studi SPA", while affiliation ad scope extends to all provinces of Piemonte.

The activity focus is on advising for the definition of research project initiatives, support in the preparation of project proposals. Networking at sectorial and cross sectorial level aiming at building project partnership (at regional, National and International level). In order to perform their mission Po.In.Tex organizes events (e.g. innovation days), deliver questionnaires to assess the demand for innovation and for education. Moreover fosters the collaboration with synergic Innovation Clusters and other centres of excellence.

Some innovation themes that Po.In.Tex supports are: completely recyclable technical textiles for automotive applications, textiles for technical application from biopolymers, innovative production equipment and systems for spin mixed yarns, high efficiency dyeing processes, intelligent textiles based on metallic yarns, functionalized textiles for connectivity applications

BEST PRACTICES AND MARKETABLE RESULTS

The preoccupation of research centres in Lombardia/Piemonte is to remain close to industry needs. This goes at the expense of reaching out to non-textile industries and at the expense of academic excellence. Hence it leads possibly to less external funding and therefore limits the size of the research infrastructure. The problem of Italy is therefore one of critical mass and durability of the research infrastructure.

The nearness to industry has also led to a focus on process oriented research. Especially when it comes to collective research this is of a non-competitive nature focusing on generic knowledge. A good example is the Biotex project (see cases). This project focuses on biotechnology in textiles. Rather than to gear itself to fundamental research, it has positioned itself on bringing technologies to industrial scale, connecting to other research centres in Europe for more fundamental knowledge.

A positive effect of process oriented research is the support research centres can give in engineering assistance in companies. In connection to the education programmes it prepares graduates very well for the industrial context. The negative effect is that research does not lead to fundamental new approaches and hence it does little to create a foothold in technical textiles. Moreover much process oriented innovation is carried out in a direct partnership between machine builders and textile firms in which research centres have a secondary role.

BEST PRACTICES CASES

Biotex (2007-2014) is a project lead by Stazione Sperimentale della Seta and Centrocot with the involvement of the Universities of Bergamo and Torino and seven industrial partners (partly SMEs). It is funded by regional funding (Metadistretto). The objective is to develop enzymatic techniques in fabric treatments, to obtain bioactive functionalities and to use biotechnology in the treatment of waste water. The strength of the project is to be close of needs of companies, to combine product development and process engineering to have a focus on scaling up processes. Another strength is that the consortium is closely connected to other European initiatives such as research on bioscouring in Twente, enzymes at TU Graz and research done at the universities of Gent and Manchester. The project has produced 6 exploitable results and 4 patents. Some results are generic and may be applied in many companies. The project is now continued in two separate projects: BioInNano and Greenmade. The project is a best practice because it addresses the interest of a substantial number of companies in the region. The project has also brought together most research centers in Lombardia and Piemonte.

Case 1. Company 3 worked together with a research centre in the region in a project developing new textile finishing methods. It also worked autonomously in developing similar equipment before discovering, thanks to two papers presented at the same conference that also the centre had worked on the same topic. This example showed a lack of closeness in working on a same technology and has led to a realization that the relationship between the company and the research centre should be closer. Hence the projects are now carried out without public funding but by associating the two projects. The RTO has regional funding for its project, while the company uses only internal resources. The cooperation has resulted in the implementation of a process with improved product characteristics.

Case 2. Company 4 is a textile company that has worked several times with the machinery sector and with research centers, following the typical approach of collaboration in the supply chain. During the interview it has been highlighted that the company claimed to have developed products with improved properties thanks to new processes although the process itself was outsourced to another company (also studied). However the knowledge to select, commission and control these processes resulted from knowledge from a research centre. The choice to commission the process to a competitor was initially a method to reduce risks. Now that the sales are picking up, the company is considering acquiring the technology to carry out processes in-house. The technology is not patented but the company has developed a Business to Business communication strategy and branding strategies.

Case 3. Company 8 is a large textile company with a clear trend develop technologies internally and in autonomy. The orientation of cooperation with research centres is mainly regional, but they work with all relevant centres in collective projects, in some smaller research contracts and for testing and engineering activities. It participated to European funded projects and has past contacts with Universities in Germany. The management of the company is active in board of trustees or advisory boards of different centres but without clear link to operational activities. In addition it is active on the European scene in several instances such as the ETP textiles. Active involvement is mainly seen as an activity of technological intelligence, rather of programmatic development.

The company has as many others in the region a double approach in its external R&D. Involvement in collaborative research is mainly in more fundamental research (e.g. biotechnology) or in process oriented research. This concerns non-competitive research. For competitive research, which is rather product oriented it tends to work directly with machine builders and chemical suppliers. In order to get exclusivity specific legal arrangements are made. In all instances the company tries to create barriers to competition by modifying machines and processes. Hence the company has developed a rather large development and engineering department. It fosters an active

attitude of its staff to conferences, fairs and involvement in activities of research centres. However their role is mainly to learn. In addition the company has some gentleman agreements with competitors in other countries but in other markets to exchange experiences and to use each others pilot lines. The company expresses the wish to structure a network of leading companies with in house laboratories and pilot line equipment.

Case 4. Company 10 is based in Lombardia has been instrumental with several colleagues in setting up a chair and a department in textiles at one of the Universities in the region. It has an important advisory role in the curriculum and in examination. The intensity of cooperation is however low, the interest in the University is more for training of graduates than in the development of a research programmes. The company is very concerned about the future of textile education, but it is tired of the institutional barriers in the Italian system of public education. Nevertheless the contribution to the University is also seen as an active involvement in the regional economy since most textile firms and its suppliers are active in the University. The active involvement has also led to the sponsoring of a vision and programme on the Valseriana, the main textile geographical area in the Province.

However the company is critical towards programmatic research. It has no involvement in regionally funded projects (Metadistretto) and a nationally funded project (Made in Italy Programme) is still waiting for approval. Its involvement in a bid for a project to be funded under FP7 was unsuccessful since the proposal was not selected for funding. Hence the company has become critical of public funding, even if it acknowledges that the state of the art research for them is no longer in Italy. It now works with suppliers when it comes to more applied projects, but it is concerned that it is no longer attuned to more fundamental research.

CONCLUSIONS

Lombardia is the main textile region in Europe. However in the most research and innovation oriented segment, technical textiles it has a second tier position. Few companies are interested in outcomes of research and if they are they rather seek connections with research centres in Germany or Switzerland. On the whole Italian firms are masters of incremental innovation and foster in house capabilities over open innovation models. Nevertheless there is often a very responsive attitude to new technologies having attained the proof of concept stage.

The research structure is fragmented with little impulse for excellence. This is partly due to the lack of autonomy in the management of Universities, the paucity of national funding and the strong role of regions in developing policies. Individual centres are often attached to a specific cluster that is highly localised or connected to a provincial context. The overall size is thus modest Lombardia and Piemonte count less than 200 researchers in institutions compared to over 500 in Nordrhein-Westfalen.

Lombardia and Piemonte have policies and active funding schemes to integrate capacities in the region and also attempt to foster clustering and to include SMEs in innovation. Regional policies for innovation create a geographical barrier that prevent the strengthening of cross-regional clusters; regional support usually is dedicated to local companies (e.g. for Metadistretto). Although there are attempts on developing instruments that enable regional policy for the support of innovation to collaborate, their impact is not relevant at the moment.

National government needs to improve the stability of their policy for support of innovation. All the interviews confirmed difficulties of participating to national programs.

Textile education seems to be too small in size, and at least is not able to cover the demand of the industry.

The intensity of relations between research centres and companies depend, it seems from the interviews and the cases, on four factors:

- Dominant is the level of convergence in content. Since most research is on technical textiles it is likely that firms engaged in technical textiles have the most intensive relations with RTOs. The relation is linked to research, education and testing. Testing provides a daily access to RTOs I regulated markets for which conformity tests are important.
- Relevant is the attractiveness of the institutional system. In countries/regions where funding depends on partnership of industry with academia relations are more intense as when merely fundamental research is funded or where funding is limited. Relations are also more intense when companies are institutionally (by law or statute) involved in the operation of research centres.
- Additional is the cultural distance between companies and research centres. Industrial leadership with advanced academic degrees have fewer barriers to be a pro-active and critical partner for research centres. Moreover additional bonds of loyalty exist then through alumni linkages. An active alumni policy of RTOs has added value.
- Additional is a clear policy inside the company regarding innovation. This means that there is a technology road-map deriving from the strategy. The technology road map is made up of research lines or programmes. There is a structured method (stage-gating) to set up projects and there is a professional project management organization. Innovation is reinforced by a clear link with (end-user) marketing, human resource management and control.

Table VIII: Best practice factors in the regions

| Factors/Region | NRW | NWE | NPC | LOM/Pi | PL |
|-----------------------|------|------|--------|--------|------|
| Convergence | Good | Good | Medium | Medium | Poor |
| Institutional Context | Good | Fair | Good | Fair | Poor |
| Cultural distance | Good | Good | Medium | Fair | Fair |
| Company strategy | Good | Good | Fair | Fair | Poor |

Companies in highly regulated markets have more regular contacts with RTO's than companies in low regulated markets. Textile companies have more contacts with RTOs than clothing companies. Inside textiles companies involved in technical textiles have more intensive contacts as well as those firms engaged in complex fibre blends, complex weaving structures and complex finishes and coating. Companies engaging in a major investment do also intensify the contacts with RTOs as well as those diversifying into new markets. This all leads to heavy bias of textile firms towards RTOs and of technical textile firms.

Small companies have limited contacts with RTO's impulses come mainly from suppliers and clients. However smaller companies are less often present in complex and highly regulated markets, have proportionally less qualified management (to deal with RTO's) are less present in institutions and are less likely to have an R&D strategy. Medium size companies have mainly contacts with applied research centre. Large companies focus on contacts with more fundamental research and use applied RTOs rather for testing and training activities. Collective research projects are more popular with companies for process oriented than for product oriented research. Collective research is most popular with medium size firms.

The last factor (strategy) is not so much decisive in the intensity of the relationship between companies and RTOs but rather in the ability to translate research results into commercial products and industrial processes. The last factor may also explain the scope or outlook of firms. While the first three factors explain a strong regional orientation of R&D relations, the more structured internal approach may also lead to a more strategic set of relations outside of the region.

The research landscape in Europe in textiles is in transformation. This is a result of transformation of the industry and transformation of research actors to business oriented organizations.

The background of the transformation process is that leading suppliers to the industry are no longer the powerhouses of innovation: fibre companies no longer have the scale they had in the 1970s while chemical companies still have scale but like the machinery sector they are more interested in big volumes and Asia is a more potent market. In private research, end users have become the main players, therefore the companies have to rely on internal knowledge resources, which they do in traditional niches (wool, lace) or they have to relate to public research, but with substantial in-house development and engineering skills. This happens especially in technical textiles. The data we have for Europe as a whole and more in depth for the cases show that a very small minority of firms have strong links to research. Altogether less than 1000 companies in an industry counting over 100.000 firms. From region to region the intensity of relations between research and industry goes from insignificant to marginal.

The strongest conclusion of this section of the study is that all trends tend to focus research on technical textiles. This is the section of the industry with most interest for research, with most skills in planning research and protecting intellectual property. In fact 85% of all patents in textiles are in technical textiles, and this contributes to the global leadership Europe has in this segment. Technical textiles segment is organized in rather large companies, with a high level of organization and the necessary skills to compete worldwide. For Universities and research centres this industry offers stable source of funding for programmatic research or for commercial services. In addition research in technical textiles enables to publish in journals with high impact and contribute to excellence.

All funding systems, regional, national and European collide in funding research in technical textiles. In fact technical textiles are always at the core of European, national and regional road maps and this attracts a large majority of funding of research. More focused inside technical textiles is the focus on composites: this sector only represents 2% in volume of the textile industry but attracts between 30 and 40% of funding. Unlike the textile system which is made up of a large number of medium size companies and SMEs, research in composites is driven by the aerospace sector and increasingly automotive companies.

Collateral of this trend is that the research infrastructure is able to maintain itself. Indeed when well connected to technical textiles, the research funding goes up and this contributes to the development of a vibrant innovation system. This might lead to spin offs to more traditional segments, although we have found little evidence of it. The major effect would be that well funded research centres are important providers of graduates, but the most research oriented centres are small in training graduates and contribute little to education of potential researchers in industry.

Therefore a more important consequence is that large sections of the industry are left on their own, although they also abandon themselves the realm of research. The more traditional textile sectors and the clothing industry are unable to articulate a research demand, and the research community does not engage fully in this process, most often because of the research volumes envisaged are small. This may not be a substantial problem in regions with a

vibrant technical textile sector, since there is critical mass for R&D. But in regions with mainly a clothing industry and especially subcontractors, the companies are not included in the research arena, hence the research system is disconnected to industry and also small in size and in impact. Besides the structural differences between industry and research there is also lack of dialogue.

The difficulty of liaising between the majority of the industry and research is compounded by a gradual reduction or disappearance of levies and in general less attention for collective research. This happens notwithstanding that for the clothing industry a number of trends may need more attention for research or at least structured innovation processes. The first one is that if one aims to attain more environmental sustainability in the supply chain, the impact in volume shall be in clothing and home textiles. This is certainly of relevance for mainstreaming the use of biofibres (e.g. Linen) or biopolymers and to come to processes with a lower footprint. The second one is to maintain a skill base for high quality traditional luxury products that requires a good skills base. In the third place with changing retail behaviour, focused on mass-customisation and production close to the market, there is a need for developing new business models and working at operational excellence. This is especially true for the new member states, where the R&D infrastructure is very weak.

Indeed one of the striking elements is that research infrastructure is strong where there is only a modest industry left, and where there is still a substantial industry left the R&D infrastructure is weak. Scandinavia, the Benelux, Germany and the UK host the best research centres but they have a small industry, albeit heavily oriented towards technical textiles. The Southern member states and the new member states have a sizeable industry but lack a strong R&D infrastructure. The most striking case is Italy, still the largest textile and clothing producing country in the European but that has a very modest and fragmented infrastructure. The industry has relied too long on technology push by its suppliers combined with fostering tacit knowledge in companies.

This brings us to one of the main questions, the relation between excellence and regional impact. The problem is that excellence is measured on a global scale and impact ultimately depends on competitiveness on a global scale. However research is mainly funded on a national level and clustering occurs at a regional level. Thus the mechanisms to attain excellence are still local whereas the ambition is global. Our conclusion from the general data and the cases that excellent research centres save an important regional impact, but often an impact wider than the region itself. The centres with only a regional impact are not excellent. The contrast between Italy and Spain against Germany and France is of relevance. The former countries fund their research largely with regional funds or by linkages with the local industry, hence there is little competition, limited specialization and excellence. The latter ones are funded mainly by national funding and compete with each other. They tend to specialize and to work with companies across borders (also national borders).

Beyond this analysis a number of more detailed remarks are to be made

Policy matters. Policy matters mainly in the organization of research and technology organizations. The two key terms are autonomy and critical mass. Excellence in research is obtained by giving more autonomy to centres. Autonomy should be seen in terms of government instructions or top down directions from the University. However autonomy works best in combination with a governance model in which industry is involved. However the involvement of industry is most effective when companies actively connected to research are involved, not when it is a reflection of the local associative structure. Critical mass is also relevant. Critical mass is of relevance in a horizontal way, in being associated with other material sciences departments and with research relevant to end-users. Research centres gain from competition inside institutions for excellence and gain from cross-fertilization. If these mechanisms are not attained through integration, it may be attained by clustering. Also vertical integration is of importance, meaning not only to be able to do fundamental research at lab scale but also to develop them in

pilot lines at quasi-industrial scale. Moreover research centres should be able to engage in a range of relations with industry, from programmatic research to testing and training.

Funding matters. The dynamics of research is related to the systems of funding in place. The members with best public funding are also those with most private research. The quality of funding is determined by the diversity of funding and the reliability of funding. Diversity implies different systems for more fundamental or more applied research, for individual researchers or for large consortia. In Nordrhein-Westfalen and Nord Pas de Calais, the research system has been very apt to absorb the different instruments. It is considered of importance that an element of competition is present. The leading centres prefer funds gained in competition than those earmarked for the sector. Hence framework programmes are preferred over negotiated procedures. In general research firms and companies prefer stable, recurring national programs over incidental and targeted regional programs. The benefit of a regional is rather in creating a physical and human infrastructure and to foster clustering. European funding is seen as an important element in the funding landscape and the textile sector has been active in using it. However in some countries the bias towards SMEs makes it impossible to associate the more dynamic firms. Moreover action lines are often too narrowly defined. Most actors are seeking for stable instruments to foster cross border research. There is a gap between the large framework projects and national funding. Interreg is the right context but the instrument itself is a put off.

Clustering matters. Clustering matters in a way to create a structural dialogue and forum for debate between research and industry. Moreover they create a sensible platform for dissemination and for generation of new projects. Clusters need to have a bottom up adhesion, although funding needs to be largely top down in the first years of existence. Clusters work well if they get the appropriate management and if they are rich in activities. It is also of relevance to foster exchanges between clusters and to keep a linkage between research policy and regional policy.

A question that remains open about the relation between RTOs and companies is whether research initiative is something RTOs had to bring to industry or that industry had to get from RTOs. We felt this approach was merely the question "how to get started". We found that successful relations between industry and research are rather emerging from a high frequency interaction: a social pattern of intensive interaction made of involvement in seminars, testing activities, student assignments, small and larger projects. What also characterized these interactions between firm and centre was that several staff members were involved.

The institutional context is relevant when some of the following factors are in place:

1. When RTOs are intrinsically incited to develop active relations with companies. This can be through the business model of RTOs (substantial testing activity), the governance with industry with R&D interests in a supervisory board, the funding system that requires RTOs to work together with industry, and the recruitment and motivational strategy of the RTO. Regional culture, in terms of a joint commitment for regional development also helps. However such a regional embedding needs to be challenged by interaction with a wider industrial and research network.
2. When Funding of research seems to incite partnership. Firstly an accessible generic funding tool is of relevance such as vouchers to commission small research at RTOs or a fiscal scheme for staff working on research and development. These tools make it possible to get started and make it easier to allocate staff for the pick up of research into internal development. Also of relevance is the existence of funding tools that enable companies to choose a RTO partner. France and Germany have funding instruments that give freedom to companies to select a

research partner. Regional instruments often restrict the choice. Similarly instruments demanding that the RTO is submitter and coordinator.

3. It is of relevance when the collective organization of industry is oriented towards innovation and towards research. An impartial intermediate is of importance. This intermediate needs to be responsive, competent and seen as acting in the interest of the companies (not of the research centers). Clustering has the strongest legitimacy when is emanating from the industry itself (industry associations), it is however more professional when it is set up as a specific body. Successful clustering seems to be based on a technology vision or technology road map; a permanent activity of sensibilisation and an in-company consulting service. Most clusters focus on events, less have a vision oriented towards action and few of them have an active plan.

ANNEX 1: LIST OF AUTEX MEMBERS

| Members | Contact information |
|--|--|
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| ENSAIT - Ecole Nationale Supérieure des Arts et Industries Textiles | Address: 2, Allée Louise et Victor Champier - BP 30329 - 59056 Roubaix Cédex 1 - France Tel: +33 3 20 25 64 50 Fax: +33 3 20 24 84 06 Email: vladan.koncar@ensait.fr |
| ENSISA - Ecole Nationale Supérieure des Ingénieurs Sud Alsace | Address: 11, Rue Werner - 68093 Mulhouse Cédex - France Tel: +33 3 89 33 63 20 Fax: +33 3 89 33 63 39 Email: laurence.schacher@uha.fr |
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| Technical University of Iasi - Faculty of Textiles and Leather Engineering | Address: Prof. D. Mangeron Str. n° 53 - Corp Tex 1 - 70050 Iasi - Romania Tel: +40 2 322 30 491 Fax: +40 2 322 30 491 Email: cloghin@tex.tuiasi.ro |
| Technical University of Liberec - Textile Faculty - Department of Textile Materials | Address: Háfkova str. 6 - CZ-46117 Liberec - Czech Republic Tel: +420 48 5353228 Fax: +420 48 5353542 Email: jiri.militky@vslib.cz |
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| University of Ljubljana - Faculty for Natural Sciences and Engineering - Department of Textiles | Address: Snezniska 5 - 1000 Ljubljana - Slovenia Tel: +386 1 200 32 00 Fax: +386 1 425 31 75 Email: krste.dimitrovski@ntf.uni-lj.si |

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| UPC - Department of Textile and Paper Engineering | Address: Colom 11 - 08222 Terrassa - Spain Tel: +34 93 739 82 21 Fax: +34 93 739 82 25 Email: carrion@etp.upc.edu |
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ANNEX 2 : LIST OF TEXTRANET MEMBERS

| Member | City, Country | Founding member | Still Active | Certified | Test fac. |
|--|--------------------|-----------------|--------------|--------------|-----------|
| AITEX - Asociacion de Investigacion de la Industria Textil | Alcoy, ES | x | x | Yes, various | Yes |
| BTTG - British Textile Technology Group | Manchester, UK | x | x | Yes, various | Yes |
| C.S.I.R Textile | | x | | | |
| CENTEXBEL - Scientific and Technical Center for the Belgian Textile Industry | Ghent, BE | x | x | Yes, various | Yes |
| CENTROCOT | Busto, IT | x | x | Yes, various | Yes |
| CETEMMSA Innovation & Technological Centre | - Mantaro, ES | | x | No | Yes |
| CETTEX - Centre Technique du Textile | Ben Arous, TN | | x | No | No |
| CITEVE - Centro Technologico das Industrias e do Vestuario | Quinta da Maia, PT | x | x | | |
| CLOTEFI-ETAKEI - Clothing Textile and Fibre Technological | Athens, GR | x | x | Yes, various | Yes |

| Member | City, Country | Founding member | Still Active | Certified | Test fac. |
|---|----------------|-----------------|--------------|--------------|-----------|
| Development S.A. | | | | | |
| DTI CT - Danish Technological Institute | Taastrup, DN | x | x | | |
| DWI AACHEN | | | | | |
| | Aachen, DE | x | x | | |
| EMPA - The Swiss Laboratories for Materials Testing and Research | St. Gallen, CH | x | x | | |
| EURATEX | | | | | |
| | Bruxelles, BE | | x | Yes | |
| HOHENSTEIN INSTITUTES : | | | | | |
| Forschungsinstitut Hohenstein GmbH & Co. KG - Reg. No. HRA 392 -Bes | | x | x | Yes | Yes |
| Bekleidungsphysiologisches Institut Hohenstein e. V. - Reg. No.107 | | x | x | Yes | Yes |
| Swerea IVF | | | | | |
| | Möln dal, SE | | x | Yes | Yes |
| IFP - SICOM AB - A Company Limited by Guarantee | | | | | |
| | | x | | Yes | Yes |
| ITV - DENKENDORF - Institut für Textil und Verfahrenstechnik | | | | | |
| | Denkendorf, DE | x | x | Yes, various | Yes |

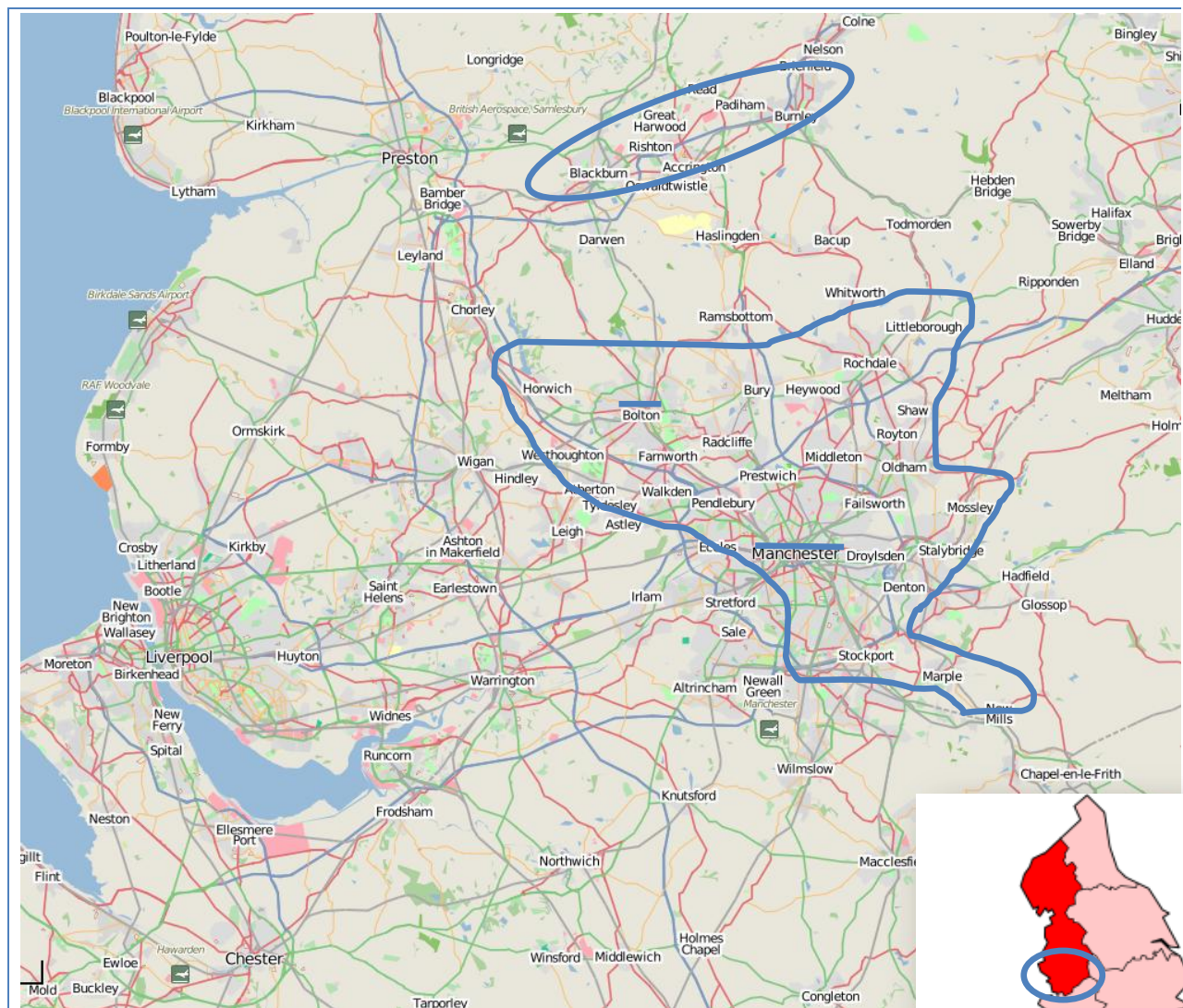
| Member | City, Country | Founding member | Still Active | Certified | Test fac. |
|--|------------------|-----------------|--------------|--------------|-----------|
| INTEXTER - Institut d'Investigacio Textil i Cooperacio Industrial | Terassa, ES | x | x | Yes, various | Yes |
| I.F.T.H - Institut Français du Textile et de l'Habillement | Ecully, FR | x | x | Yes, various | Yes |
| INCDTP - The Research Development National Institute For Textile and Leather | Bucharest, RO | | x | Yes, various | Yes |
| INNOVATEX - Textile Engineering and Testing Institute Co. | Budapest, HU | x | x | Yes, various | Yes |
| INOTEX - Innovations and Technology Transfer for Finishing Mills | Dvur Kralove, CZ | | x | Yes, various | Yes |
| KITECH - Korea Institute of Industrial Technology | | x | | | |
| LEITAT Technological Center | Terassa, ES | | x | | |
| LTI - Lithuanian Textile Institute | Kaunas, LT | | x | Yes, various | Yes |
| Norwegian Textile And Clothing Institute | Bergen, NO | | x | Yes, various | Yes |
| OTI - Österreichisches Textil - Forschungsinstitut | Wien, AT | x | x | Yes, various | Yes |
| STFI - Saxon Textiles Research Institute | Chemnitz, DE | | x | Yes, various | Yes |
| TESSILE DI COMO Spa | Como, IT | | x | | |

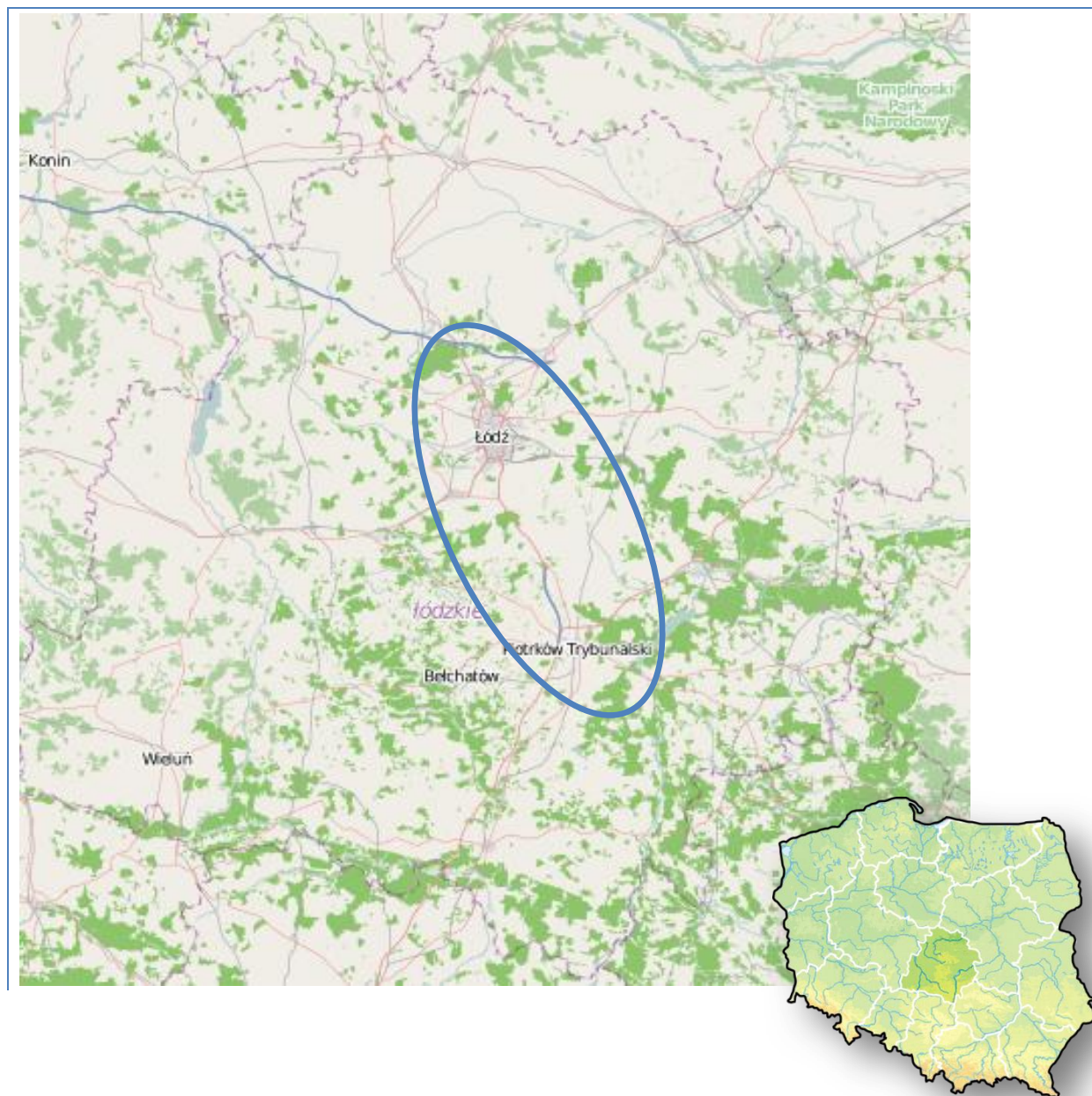
| Member | | City, Country | Founding member | Still Active | Certified | Test fac. |
|---------------------------------|------------------|---------------|-----------------|--------------|--------------|-----------|
| TEXILIA | | Biella, IT | x | x | | |
| TNO - Textile Department | | Eindhoven, NL | x | x | Yes, various | Yes |
| TZU - Textile Testing Institute | | Brno, CZ | | x | | |
| VTT Technology, Group | Chemical Textile | Tampere, FI | x | x | Yes | Yes |
| IW – Textile Research Institute | | Lodz, PL | | x | | |
| ITA - RWTH Aachen | | Aachen, DE | | x | Yes, various | Yes |

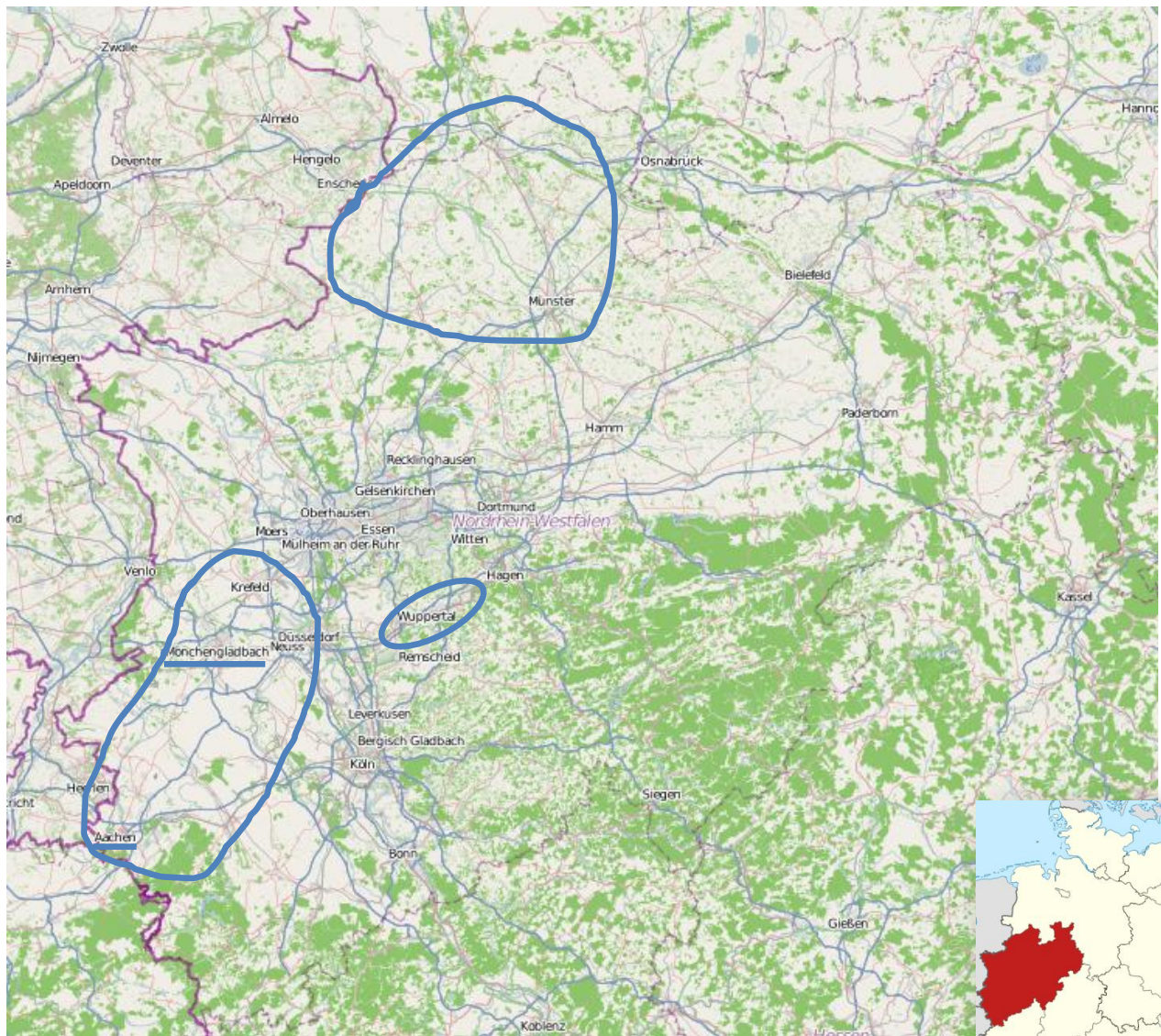
ANNEX 3 : MAPS OF THE REGIONS

Outlined are the parts of the region in which the textile industry is concentrated. Innovation centers of excellence are located in the underlined places

NORTHWEST ENGLAND, UK

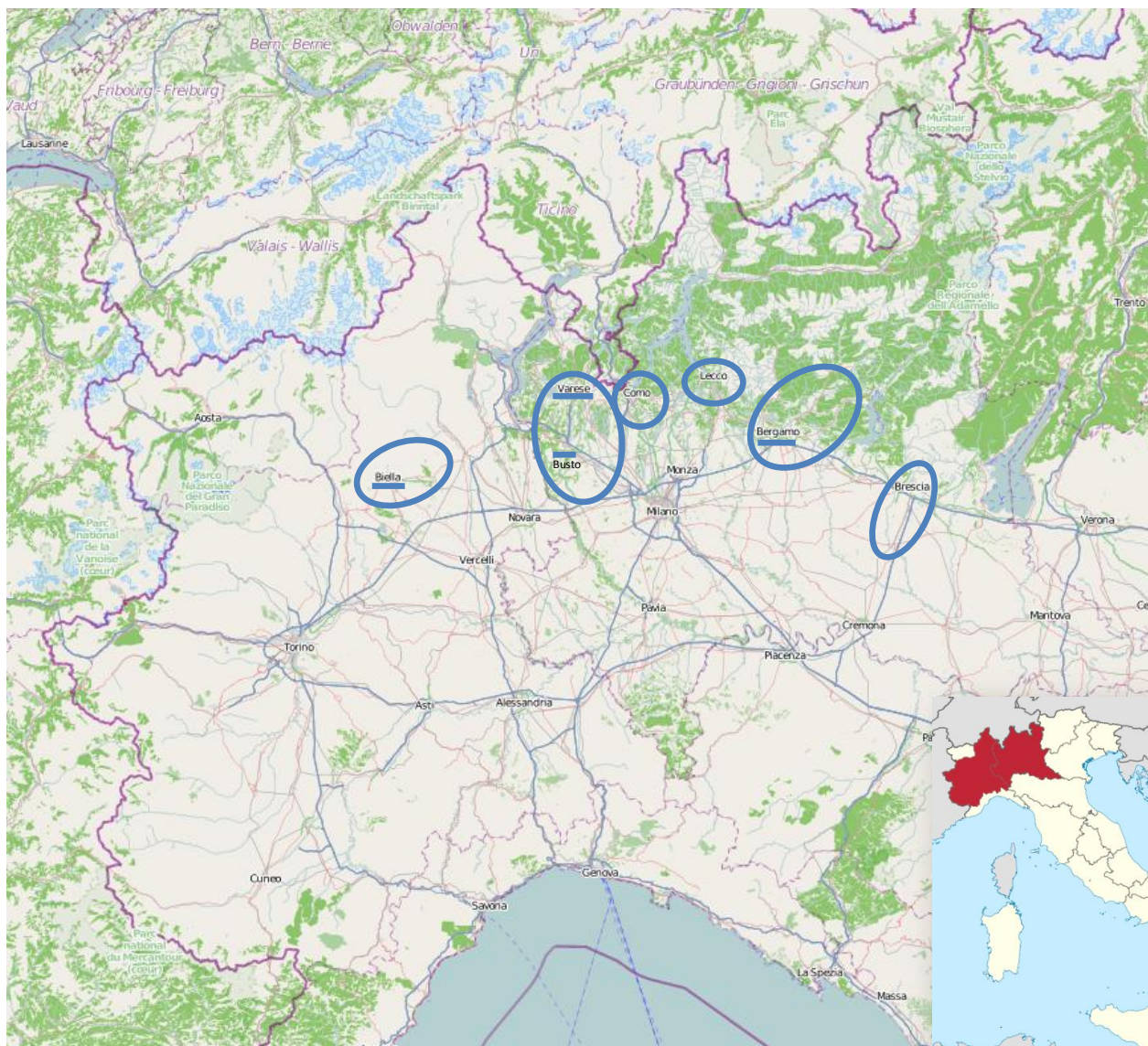






NORD-PAS-DE-CALAIS, FR





DEUTSCHES TEXTILFORSCHUNGSZENTRUM NORD-WEST E.V. (DTNW, GERMAN TEXTILE RESEARCH CENTRUM NORTH-WEST)

The Deutsches Textilforschungszentrum Nord-West e.V. (DTNW, German Textile Research Centrum North-West) associated to the University of Duisburg-Essen can look back on a history of 90 years of textile research. The center was founded as Reichskuratorium zur wissenschaftlichen Förderung der Textilindustrie in Krefeld in 1925. In 1978 three textile research centers close to Krefeld joined forces and called themselves DTNW, six years later the institute officially became part of the University of Duisburg-Essen. Since September 2010 Jürgen Gutmann, professor of physical chemistry, is the managing director. DTNW focuses its research on the fictionalization of textile products, those which can be found in airplanes, automobiles, construction and in pharmaceutical applications.

DTNW has a long list of projects currently being worked on in several fields within textile research, both European and regionally funded. First of all there is Dephotex (Development of Photovoltaic Textiles based on Novel Fibres), a FP7 funded projects which focuses on the development of photovoltaic cells on the basis of new fiber materials and textile coatings. Possible applications range from outdoor textiles to sports clothing and materials used in the automotive sector. DTNW also performs research about the production of biogas from textile effluents as part of a project funded by the German Environmental Foundation (Deutschen Umweltstiftung). The main goal of this project is to find a new strategy for producing biogas by biologically conversing sugar-containing waste water using methane-forming bacteria. Besides environmental benefits the project foresees significant savings of about 0,4 ct/m² raw cotton because of among others reduced sanitation cost.

DTNW also currently works in the following fields of research:

- flame-retardant properties of polyphosphazenes on textiles;
- permanent flame retardant finishing of textiles;
- conductive polymers for textile design heaters
- polyelectrolyte layers on textile materials;
- super hydrophilic surfaces;
- long-time relaxation behavior;
- photo-catalytically active surfaces;
- UV Protective Textiles;
- antibacterial surfaces - silver nanoparticles
- cosmetic and pharmaceutical textiles.

DTNW also provides three services for the textile industry: audit reports from the Oeko-Tex test laboratory, chemical and mechanical textile technology testing for court cases in the Krefeld area and answering specific

research questions from industrial clientele (contract research). The possibility exists to become a member of DTNW. The current members list consists of companies from the chemical and paint sector as well as from spinning and weaving, textile finishing and textile machinery. The centre sees itself as a mediator between industry and research, since DTNW is on the one hand closely affiliated with the university, but has on the other hand a diverse group of industrial members. DTNW can be qualified as a centre with a programmatic approach but also with a strong commercial side.

WfK - CLEANING TECHNOLOGY INSTITUTE (WfK)

WfK – Cleaning Technology Institute e.V. (WfK) is a research institute that focuses on cleaning, hygiene and recycling of various materials. Within the textile industry WfK, which was founded in 1949 in Krefeld, contributes especially to the fields of personal protective equipment, medical textiles and cleaning materials. Over the last decade the company has grown considerably, currently counting a staff of approximately 80 employees and a total floor space of over 3600m². WfK works both in the context of publically funded research projects and as a contracted research group for companies. It is possible to become an industrial member of WfK.

WfK has defined four research priorities: innovative cleaning methods, preservation and renovation of the functionality, hygiene and clean room environments. Within the field of innovative cleaning methods the main goals are resource conservation and cost-effectiveness. In other words, WfK tries to find ways to save energy, water and chemicals in cleaning and disinfection processes without making costs. For example, the centre developed a completely new method to work without any water nor chemicals. New techniques within the second research priority, the preservation or restoration of the functional properties of different materials, prolong the useful life of the treated material as for instance in renewable soil-release functions for work wear and industrial production. The third research priority WfK defined is hygiene. More and more materials have hygiene requirements for which convenient disinfection and sterilization methods are unsuitable, therefore WfK develops innovative methods whereby the achievement of the product, required product quality and environmental compatibility are taken into account. WfK's fourth research priority, clean room environments, has its main market in the medical sector, electronics and semiconductor industry, microbiology and pharmaceutical industry.

WfK works has worked in numerous projects and is nowadays involved in European, national and regionally funded projects. The project 'New hygiene services for the cleaning and preparation of medical products by using liquid carbon dioxide and extremophilic enzymes' is funded by EUREKA and CORNET (Collective Research Network). Many other projects where WfK participates are funded by the BMWi under the flag of the so-called *Industrielle Gemeinschaftsforschung und Entwicklung* projects (Industrial Community Research and Development, IGF). Herein several mostly medium-sized companies or institutes join together to solve a problem or explore an idea, together these companies are called an IGF - an industrial community. The dissemination of project results and transfer of knowhow is performed through the organization of several events: conferences, meetings, seminars and workshops.

FORSCHUNGSSTELLE FÜR ALLGEMEINE UND TEXTILE MARKTWIRTSCHAFT (CENTER FOR RESEARCH IN GENERAL AND TEXTILE MARKET ECONOMY, FATM)

The *Forschungsstelle für allgemeine und textile Marktwirtschaft* (Center for Research in General and Textile Market Economy, FATM) is a scientific institute specialized in market developments regarding the textile and garment industry. FATM is associated to the University of Münster and since its foundation in 1941 by Alfred Müller-Armack. The central objective of FATM is to become the leading management and marketing institute for the entire textile industry in Germany. The main research topics are marketing, consumer behavior, strategic planning, network management, internalization, controlling and brand management. Since the retirement in 2007 of Gustav Dieckheuer, responsible for the economics department, the centre has moved its focus more and more to business topics.

In 1991 FATM signed an official partnership agreement with the North Carolina State University (NSCU) in Raleigh (United States). Within this agreement the two universities share information, cooperate in research projects and facilitate the exchange of faculty members. Besides their American partner, FATM also cooperates with the *Fachbereich Textil- und Bekleidungstechnik* (Department of Textile and Clothing Technology) of the University of Applied Science Niederrhein in Mönchengladbach. A closer cooperation between the two institutes was a result of a project called *Internationale Markenführung in Dienstleistungsnetzwerken* (IMADI.net, International Brandmanagement in Service Networks).

One of the projects currently performed at FATM has core objective to uncover the reason for the previous non-acceptance by consumers for organic apparel products. Organic food is booming and this is seen as an ongoing trend, but will this trend be transferred to the clothing industry? In-depth interviews with experts as well as experiments with focus groups will examine the buying patterns and generate initial insights about buying barriers. Another ongoing project is the above mentioned IMADI.net, which has been divided in three parts. FATM works on the third approach which deals with the internationalization of the textile industry.

FATM can also be asked by companies to assist in knowledge transfer, implementation of business tools such as controlling, certification, project management and project monitoring. This process is according to FATM two-fold, since besides working as a contracted researcher the institute also benefits of industry-orientated research. Furthermore, because FATM works as a training institute the members of FATM – brought together in the *“Gesellschaft zur Förderung der FATM”* – also will profit from the macro- and micro-economically trained management talent for the German textile industry.

INSTITUT FÜR BAU- UND UMWELTECHNIK (INSTITUTE OF CIVIL AND ENVIRONMENTAL ENGINEERING, TBU)

The *Institut für textile Bau- und Umwelttechnik* (Institute of Civil and Environmental Engineering, TBU) in Greven was founded in 1992 by Jochen Müller-Rochholz. It is part of the Dutch managed quality control group KIWA since 2010. KIWA focuses on certification and quality management of water systems, civil engineering and environmental management. Since TBU is affiliated with the University of Münster, the institute can rely on over thirty years of experience in interdisciplinary research. TBU tries to transfer know-how between research and industry, which

according to the institute relies on flexibility and serious efforts. Hence, TBU operates on a great variety of application field and has numerous partnerships with industries and other scientific institutes.

“Despite being passionate scientists, we do not loose ourselves in pure theory” states the website of TBU and this simple assumption might be just right. TBU acts in three fields of activity, which show more practical research goals than scientific achievements within projects. One of the fields of interest is geosynthetics and technical textiles, wherein TBU acts as a global-playing partner of manufactures, construction companies and engineering consultants. TBU can be asked to perform testing methods on construction sites, ranging from mechanical tests to experiments on fire resistance and long-term behavior of the material. Also within another field of interest, building conservation, TBU acts as a down to earth partner which operates in close cooperation with engineers, planners and private builders on for instance construction damages and possible flaws in building construction.

TBU participates in several committees to discuss research results and confer about best practices in testing and analysis methods. These committees are active in different areas, from building and construction to the ecology office. Also in the selection of employees TBU tries to focus on people that can work in an interdisciplinary manner, which allows the institution to both focus on scientific research and know-how in testing and industrial possibilities.

INSTITUT FÜR KONSTRUKTIONS UND FUNKTIONSMATERIALIEN (INSTITUTE FOR STURCTURAL AND FUNCTIONAL MATERIALS, IFKM)

The *Institut für Konstruktions und Funktionsmaterialien* (Institute for Sturctural and Functional Materials, IFKM) associated to the University of Applied Sciences in Münster (Fachhochschule (FH) Münster). The IKFM is centrally located in the Business and Innovation park in the FH Münsters location in Steinfurt. The main competences of the IKFM are material characterization, material development and material processing. The institutes describes itself as combining expertise in materials research and development. Another important task of the IKFM is that it serves as an institute for teaching and training. It organizes seminars, work shops and summer school. Furthermore, IKFM has set itself a goal to build a network of (international) universities for the exchange of knowledge and continuous learning within their specific fields of interest.

Within the IKFM different disciplines - material characterization, analysis, development and processing - which were formerly disconnected within the FH Münster come together. Hence, all research concerning composites can be handled more effectively using a one stop-approach. This promotes on the one hand interdisciplinary research within the IKFM and on the other hand, having one contact point improves the accessibility for industrial parties.

The IKFM has three laboratories where different tests can be carried out:

- Laboratory for Machine Tools and Manufacturing Technology Material Characterization and stability tests. Examples of what is researched here are surface analysis (microscopy), dynamic mechanical testing, lifetime assessments and 3D measurement of components.

- Laboratory for Polymer Technology and Macromolecular Chemistry and Material development and construction.
Examples of what is being processed are fiber-reinforced plastics (GRP and CIPP), stainless steel, ceramic and mineral building materials and technical textiles.
- Laboratory for Machine Tools and Manufacturing Technology Material processing and recycling.
Examples of what is being researched here are protective equipment, resource management and recycling and surface technology.

Besides contracted research for industrial partners, IKFM applies for public funding on a regular basis. The IKFM is involved in several projects in the following fields: corrosion tests on an existing building, elemental analysis of polyurethane samples, analysis of deposits and analysis of material properties. A project that is currently running with funding of the German Ministry of Economic Affairs and Technology is Smart Surf, which is concerned with microorganisms on plastic surfaces.

ⁱ Leonaviciute, G., (2009) *Knowledge spillovers effects and approaches for innovation amongst SMEs involved in Eu funded research consortium*, Unpublished Master Thesis, Radboud University Nijmegen, The Netherlands