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KNOWLEDGE GENERATING FEATURES OF INTELLIGENT TEXTILES INDUSTRY

Case study

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Abstract

The intelligent textiles industry uses the results of a wide range of scientific research fields which are multidisciplinary and cover the so called „key enabling technologies". For the moment there are only a few countries generating and using this knowledge with impact on competitiveness, national development and creating high level paid jobs. The cultural differences among countries regarding the business approach and the ability to use certain knowledge bring more or less advantages for those countries. This paper covers two case studies, one about Elmarco from Liberec, Czech Republic, producing nanofiber and the other one about GreenYarn from Boston, Massachusetts, producing advanced materials. Both examples are using nanotechnology, one of the key enabling technologies.

1.Introduction

The culture is a core explanation for the way institutions are organized (Bekaoui cited by Fah, 2008) and performing. People's behavior within these institutions is the result of their way of thinking (Bekaoui cited by Fah, 2008). People react according to a mental program and their life reflects their mentality (Fah, 2008) and values. Organizations and institutions are the mirror of the people and the result of all interactions will guide transformations at both levels of individual and institutions alike. As Allen(2008, p.141) says "the technology provides the means, relationships provide the value", which means there is an intimate link between technology and the human life at the level of the individual. All the history of the mankind shows a direct connection between the technological level of the society and the prosperity of life, higher technological level bringing better and longer life.

For a long period of time the advance in a certain field of knowledge was within the borders of that discipline. Today we see cross border interaction among all the sciences, a certain advance in one discipline bringing advances in other fields of knowledge.

Even in textile industry there are more and more links to research in other industries, especially to the most advanced technologies. The new industry created in this manner is called intelligent textiles industry that uses the results of a wide range of scientific research fields which are multidisciplinary and cover the so called „Key Enabling Technologies" (KET's). Today there are six types of KET's: photonics, nanotechnology, biotechnology, advanced materials, microelectronic systems and advanced manufacturing (IDEA et al, 2012).

This paper focuses on nanotechnology, bringing two examples of companies transforming into practice the nanofiber concept. Starting with 1900, ninofibers were present in different patents, regarding filtration, hygiene, apparel. Nowadays the applications are wide ranged using organic and inorganic nanofibers. Industries based on these technologies are growing rapidly but require a lot of investments and high level skills.

For the moment there are only a few countries generating and using this knowledge with impact on competitiveness, national development and creating high level paid jobs. The cultural differences among countries regarding the business approach and the ability to use certain knowledge bring more or less advantages for those countries.

For the Czech Republic, the goal of achieving 3% of the GDP for research and development (R&D), asked for by the Europe 2020 Strategy, will be met while focusing on the nanotechnology sector. Nevertheless, nanotechnology has a long tradition in the Czech Republic, starting with 1949 when Professor Armin Delong presented the first electron microscope (Czechinvest, 2012). Combining funds from EU grants, Czech government and the private sector, the Czech Republic is now a world leader in the field of nanotechnology (Czechinvest, 2012).

The paper presents as a case study, the Czech private company Elmarco S.R.O., one of the leading companies in the sector, manufacturing the Nanospider equipment, using an electrospinning process for the production of nanofibers.

The second example is from USA, the leader in nanotechnology research, where the Congress allocated 18 billion dollars for R&D in nanotechnology, over the period from 2000 to 2013. The case study is about GreenYarn, a nanotechnology company, producing eco-friendly fabrics, incorporating nano-particles obtained from bamboo, to cotton, polyester or nylon fibers. In this manner, the products are anti-bacterial, anti-fungal, deodorizing, static free, thermally regulating and aid the blood circulation.

The paper has two main parts, one presenting the link between culture and technology, with focus on KET's and the second show two companies of the nanotechnology field, one from the Czech Republic and the other from the USA.

2.AKET's overview from the perspective of technological culture

Some studies show (Welzel, 2013, p.5) that the prospering societies are more creative in comparison with the poorer economical conditions ones. There is a strong connection between "existential conditions, cultural orientation and institutional formats" (Welzel, 2013, p.6). Technologically advanced countries created conditions to involve intellectual capacities by expanding them at a mass level spreading the education and the information (Welzel, 2013, p.6).

The intimate link between technology and human life shows that people living in a modern and reach in technology society have a better and longer life (Welzel, 2013, p.6). In countries like that started the use of so called "Key enabling technologies" (KET's).

The traditional textile industry changed due to the globalization, moving production based on agricultural raw materials to the areas where there is a cheap labour force and the possibility to satisfy a big demand. This move created an entire new textile industrial environment by reconsidering its objectives from productivity and flexibility to ones concerning the technological development and targeting high performance of the industry (Rosendo et al., 2012, p.24). Every technological change had a direct impact on the market landscape and on the competitiveness by modifying the number and the structure of actors playing in textile industry, some of them being pioneers in producing products never seen before thus bringing their contribution to a new born industry with no connection to the past.

Nowadays, the initial objectives regarding the performance and flexibility are still valid but in new conditions taking into consideration the evolution of technologies which today are fundamentally new based on small consumption of raw material and offering substantial economic advantages. These technologies are called key enabling technologies or KET's and create competitive advantages for companies, sometimes placing them to the edge cutting zone of the market.

The European Commission (2010) defines KET's as incorporating a high percentage of research and development (R&D), the intensive use of capital and of a highly qualified labor force within extremely fast innovative cycles. They refer to an interdisciplinary approach that means an integration of ideas from different research fields such as IT, electronics, communications, design, chemistry, physic. The central point of the KET's are the small and medium sized companies usually organized in clusters, where the entire activity is concentrated on technological and commercial development with impact on the national economy and industrial structure.

There are six types of KET's: photonics, nanotechnology, biotechnology, advanced materials, micro-systems and advanced manufacturing (European Commission, 2010; IDEA et al, 2012). All these technologies have an important advantage as a wide range of applications in different fields of production activities with no connection between them, the preservation of surrounding environment, the use of a high labor force and a low consumption of a raw material. Some definitions are required in the following, for a better understanding of KET's. All these definitions are supplied by The European Commission (2010).

The main characteristic of nanotechnology is the manufacture of structures at the molecular level having dimensions smaller than 100nm and enable applications where such materials are used, through electrical, magnetic, mechanical, biological and optical procedures.

The electronic micro-systems refer to the highly miniature semiconductor components integrated in products with large physical volume and their feature is defined as miniaturization. The new trend in this field is combining the semiconductor technologies with nanotechnologies by using the silicon structure in dimensions smaller than 100 nm.

Biotechnology means the use of microorganisms in the industrial processes of production of bio-materials, bio-fuels and, finally, the manufacture of textiles, leather and paper products and it has the advantage of being environmentally-friendly by recycling what we usually call "waste" as raw materials for this industry.

Advanced materials are the materials which have an internal structure enabling properties much enhanced than the traditional materials, proving applications in all the industries and helping in the reduction of costs while increasing the performance, which means the increase of competitiveness and finally having a positive impact on the surrounding environment in comparison with the traditional products.

Photonics are defined as a branch of science and technology which uses the photons as carriers of energy and information, thus replacing step-by-step the role which belonged in the past to electrotechnics and electronics. Photonics combine physics, nano-technologies, material science, bio-technology, chemistry, and electric engineering in development of electronics, of laser technologies and of optic fibres.

Advanced manufacturing technologies were defined by European Commission as production systems, processing plants, equipments controlled by high speed communication and information systems. This KET is a direct approach to manufacturing process instead of manufacturing products which are a characteristic of the other KET's.

As one of the European Union reports shows (IDEA et al, 2012, p.33) these technologies are capitalintensive and require substantial investments which often it is a state task. It looks like a paradox that the KET's are promoted mostly by small and medium enterprises (SME's). Since the funding comes mostly from the state, a SME is best suited to handle a one big project in order to get the most out of any technology. The small and medium dimension of the company, together with the flexibility that it is also a need, bring more companies together to cooperate for projects that have a link at the technological level. A small country doesn't have enough capacity to create complex networks, but may take advantage of the new technologies through cooperation at international level.

The conditions mentioned above ask for a high degree of cooperation between universities, private companies and state, that means at the end a certain kind of cultural approach for creating an innovative chain. Not all the parts of the innovative chain have to perform all the tasks involved in research activity. For example, subcontracting activity doesn't need to carry out research projects.

The above mentioned capital intensive characteristics of these technologies drive to specialization of a certain country or a company to only one technology, the so called "smart choice" (IDEA et al, 2013, p.39).

Taking part in an innovation chain it is first of all a decision of the state to support the project or not and less a certain business culture or other cultural features. Also there is no need for a critical mass, the presence or absence for a certain industry to take part in a project funded by the state.

As it is a state choice being or not a part in a project if it has the necessary funding money, the same is the case of the private company that has the money and the availability to be a part in a certain project.

In the following the paper presents one case when the state was involved with success in developing a certain nanotechnology and another example when a private company promoted on its costs another type of nanotechnology.

3.Two nanotechnology case studies

3.1. Nanofibers in Czech Republic

For a better understanding of a micro level, first a general country overview is needed.

One of the main goals of Europe 2020 Strategy is to provide 3% of the GDP for research and development (R&D) (Czech Statistical Office, 2013). Starting with 2005 until 2012, the Czech Republic allocated a percentage between 1.2 to 1.8% of GDP for R&D sector as it is seen in the Appendix A.

Following the rise of R&D expenditure from 2009 to 2012 the number of R&D performers increased from 2155 to 2578 (Czech Statistical Office, 2013). More the half of the increase of R&D investment come from the private sector (Czech Statistical Office) and industries based on nanotechnology received most of the funds as this niche is growing rapidly in the Czech economy. Combining funds from EU grants, Czech government and the private sector, the Czech Republic is a world leader in the field of nanotechnology.

Starting with 2008 Czech Republic increased the level of investment in the new KET's, probably taking into consideration the Czech presidency of EU in 2009. An important feature of this country is a certain harmony between the policy of the KET's actors, the policy of the state and the target of Europe 2020.

Regarding the share in the country total exports at the level of the year 2010, the nanotechnologies represent about 0.5%, while the country's share in total exports by KET is again 0,5% (IDEA et al, 2012, pp128-pp130).

Between all these KET's, the nanotechnology has a long tradition in Czech Republic, as Czechinvest (2012) a government agency shows, starting with 1949 when Professor Armin Delong presented the first electron microscope. Then its production created an advantage for this country when only five other countries in the world were able to produce such a device.

Nowadays as a Market Report(2014)about nanotechnologies in Czech Republic shows the nanotechnology activity is organized in two clusters, Czech Nanotechnology Cluster and Nanomedic cluster and a group of researcher named Nano-team. Combining information from the Market Report (2014) and IDEA et al. (2012, p.129) the main companies in this field are NanoTrade LTD, Kertak Nanotechnology, Elmarco,Tescan, Optaglio, Pardam LTD, Advanced Materials JTJ Inc., NANOPROTEX, CONTIPRO, NAFIGATE CORPORATION AND AstavAnorganickuChemie AV. CR.but the main companies are Elmarco, CONTIPRO and NAFIGATE CORPORATION.

As the IDEA et al. (2012, p.129) shows on the Czech nanotechnology market there are two large patent applicants: Elmarco S.R.O. and AstavAnorganickuChemie AV. CR. Next the paper will focus on Elmarco S.R.O. activity. For a more complete picture of the nanotechnology environment, another Czechinvest report (2006-2012) shows in 2006-2012, 38 nano projects were implemented investing about 57 960 000 euro. The statistical data published in the report emphasize a number of 140 subjects operating with nanotechnology, more than 100 subjects from academic environment and 40 subjects from business community.

In the following, the paper will present a case study about Elmarco, the main nanotechnology actor in Czech market and one of the nanotechnology leaders in the world. Most of the information is taken from the company

Elmarco (2014) site combining all the information coming from press releases and company presentations.

Elmarco S.R.O is a private company providing technology and equipment for the production of nanofibers, which are engineered textiles made of fibres less than 500 nm that mean thousand times thinner than human hair. The headquarter is in Liberec with two sales offices in Morrisville, NC USA and in Tokyo, Japan, having a number of 80 people employees, including 35 R&D specialists.

The activity started in 2000 as a manufacturer of industrial solutions for semiconductor industry. In 2004 entered into a license agreement with the Technical University of Liberec. Following this agreement the first Nanospider line was unveiled in 2005 and in 2006 they sold the first line. The Nanospider technology represents an electrospinning process for the production of nanofibers which are used for the production of nanofiber membranes. The area of application of these nanofiber membranes are very large, starting with health care, liquid filtration, performance apparel, air filtration and solar cells.

In 2008 Elmarco opened its research, development and production centre investing 190 million Czech Crowns, out of which 75 million Czech Crowns were provided by the structural funds of the European Union. The facility in Liberec covers 3000 square meters and is a unique centre for nanofibers technology.

Starting with 2008, Elmarco took advantage of government support for investing in the global development and playing a key role in the international nanotechnology market.

It is important to emphasize how an increasing worldwide activity had an impact on decreasing the number of people employed in the company, from 250 persons in 2008 to 80 people in 2014. One of the explanations could be found in the management change, when Ladislav Mares, the founder and co-owner of the company left Elmarco and started a new company Nafigate Corporation, a new leader in the industry.

Acting in a very high specialized technological industry it comes as an obligation to be active in international cooperation. Elmarco established offices and partnerships around the world. At the academic level cooperation started with famous world universities, science-research workplaces as Technical College Liberec, Academy of Science Czech Republic, Chemical-Technological College, Charles University, American North Carolina State University, Massachusetts Institute of Technology, Stellenbosch University in South Africa, Commonwealth Scientific and Industrial Research Organisation Australia, Kyoto Institute of Technology, National University of Singapore, University of Akron-Ohio.

At the commercial and sales level, Elmarco established an office in Tokyo-Japan and Morrisville-USA, coordinating the Asian and American markets.

In 2007 Elmarco signed a cooperation agreement with OerlikonNeumag, Austria, a global player in the field of industrial solutions and innovative technologies for textile manufacture. The starting point was a joint development of projects regarding acoustic applications. The advantage of this partnership is the Oerlikon presence in 35 countries around the world and its project Rusnanotech Initiative that aims promoting nanofiber technology.

Another partner is CEZ a.s. from Czech Republic and together tested successfully in 2009 the solar panels of nanofibres made of titanium dioxide (TiO_2) as an alternative to silicon panels.

Another breakthrough partnership started with HemCon Medical Technologies Inc., from Portland, Oregon, USA to open a market estimated at 5.5 billion dollars, the wound care market.

The American company is known for developing the chitosan-based HemCon dressing used by military and civilian first responders and wound care practices in hospital, dental and clinical settings.

The nanofiber materials enables the creation of complex layered dressings in a single product that offer more surface exposal of active ingredients enhancing efficiency of the product.

In January 2013 started cooperation with Ahmedabad Textile Industry's Research Association (ATIRA), the largest Indian research association for textile industry. ATIRA installed one Nanospider production line for research of nanofiber applications and commercialization of nanofiber integrated products on the Indian markets.

In 2011 the global revenues for nanofiber products were 382 million USD and the estimation for 2017 is 852 million USD. Until now Elmarco sold worldwide more than 130 equipment units, thus became the world leader in this field.

Concluding the Czech company has a number of competitive advantages like owning a technology for producing nanofibers, unique in the world, has the government and European Union funding, a strong cooperation and international activity, the offer can be put in accordance with customer needs and the capacity to cooperate with domestic companies. Nevertheless nanotechnology is a tradition activity in the Czech Republic.

3.2. Bamboo nanofibers in every day clothes

As the Bamboo Innovator (2014)site shows, the United States is a top leader in nanotechnology research. Between 2000 and 2013 the Congress allocated 18 billion dollars for R&D in nanotechnology. In 2014, 1.7 billion was budgeted that means 8% lower than two years ago. Besides this Congress support, the private sector invested about 3.5 billion a year in nanotechnology. Despite of this effort, the Government Accountability Office, GAO, an independent agency working for Congress, following the way of spending government taxpayer money, believes that America may lose its first place in the nanotechnology race. The main explanation for that is the money goes mostly for basic research and production at laboratory scale. The first place in the international race can be lost since China and Russia invest heavily.

As McLaren (2006) shows GreenYarn is a nanotechnology company producing eco-friendly alternatives to conventional fabrics. As advanced materials which are antibacterial and deodorized this company uses nano-particles come from selected natural bamboo dried and heated at 800 Celsius degree. After it becomes bamboo charcoal, fine nano-particles are processed and then added into cotton, polyester or nylon fibers. This technology was invented years ago by Japanese researchers.

The Organic Clothing Blog (2007) shows there are two ways for bamboo processing in classic manner. One is mechanical through crushing and combing which is labor intensive and costly, the other one is chemically using poisoning substances and creating health problems. The chemical procedure is similar to rayon or modal manufacturing uses chemical solvents as sodium hydroxide known as caustic soda and carbon disulfide. A long exposure to these substances can cause tiredness, nerve damage and headache. The advantage of the nanotechnology for processing bamboo is the absence of chemicals in the manufacturing process and new properties of the final product. In 1882 Thomas Edison discovered that carbonized bamboo was ideal as filament for his first electric light bulb. The bamboo plant is the most sustainable plant. In fact this isn't a tree, this is the fastest growing grass and after harvesting do not need replanting. The products made of bamboo are smooth, flowing and these properties are obtained at easy price. The finesse of a product made of bamboo is similar to silk and cashmere.

All the information bellow is taken from the GreenYarn(2014) site and from other sites recommended by the company where there are published some of its press released.

The company started eco-fabric sport socks production in 2004. These products had the anti-bacterial, anti-fungal, aid blood circulation, deodorizing, thermally regulating and static free properties.

TheGreenYarn started to sell from 2005 Eco-fabric and Eco-fabric garments as high performance outerwear, jackets, gloves, hats and footwear (in Asia to Taiwan, Korea, Japan, Singapore,Thailand, Malaysia, Hong Kong and China through Advenz, its distributor from Taiwan. On the US market, GrennYarn organizes its own distribution. In 2006 it was invented a facial mask stimulating healthy metabolism and blood circulation. Its name was Moist+ and it was distributed on Singapore market through Dart-win Shipping&Enterprises and on the China market this was available in 1400 stores (Clickpress, 2006).

After selling more than 1000 000 pieces in 2008 imitations were found so GreenYarn recalled the stock. Until 2010 the effort was concentrated on a new product, Moist+2, that could not be easily copied.

In 2013 the Moist+3 was launched being more absorbent and comfortable.

In 2006 a report of Project on Emerging Nanotechnologies at the Woodrow Wilson International Center for Scolars mentioned about more than 200 nanotech-products could be found in stores. The main garment producers using nanotechnology were DuPont Teflon coating and GreenYarn. Even these two companies are the most important players on the market they aren't in competition since their offer has different characteristics. For example DuPont's fabrics are repel liquids, breathable while GreenYarn's fabrics eliminate odors, static free and kill bacteria. Having different type of products these two companies focus on different clients and segments of market, the only link between them is the technology used.

The initial investment was about16 million dollars and supported by Advenz, Taiwan and consisted in 25 sock manufacturing machines. In 2006 the company had almost 10 employees and a level of sales estimated for 2007 about 1 million dollars which means 100 000 number of pairs sold since a unit price is about 10$ per pair as two different Press Releases (2006) show.

In 2008 new product was launched, a smart underwear sold initially on Singapore market and the GreenYarn was looking for American stores interested in. As a Press Release (2007) shows the particularity of this new product is the combination of bamboo nano and bio-ceramic particles. This ceramic particles transfer far-infrared energy that is a form of light that deeps and massages the cells from the skin layer.

As another Press Release (2012) shows in 2012 was launched the Greenfeet 3, carbon fiber insoles. Other companies tried before to produce items for medical or athlets needs, but the cost was about 100 USD and was not a mass produced. GreenYarn started the mass production and the cost was much lower. Thus the insoles are de-odorizing, ani-bacterial and wick moisture due to bamboo nano-particles.

In November 2013 it was launched a new advanced men boxer briefs eliminating the use of rubber from the elastic bands (Press Release, 2013).

At the first glance, the GreenYarn case study emphasizes the following conclusions: new products are launched every year, a strong commercial relationship with Asian markets, with agents in all this countries, combines an old technology in a modern way, bringing natural raw material and the latest technologies together. Their products look like classic ones but the difference is at the level of the technology that gives special characteristics and quality.

4.Conclusions

The history of the mankind shows a direct connection between the technological level of the society and the prosperity of life, higher technological level bringing better and longer life.

The prospering societies are more creative in comparison with the poorer economical conditions ones. Today we see cross border interaction among all the sciences, a certain advance in one discipline bringing advances in other fields of knowledge.

In textile industry there are more and more links to research in other industries, especially to the most advanced technologies. The new industry created in this manner is called intelligent textiles industry that uses the results of a wide range of scientific research fields which are multidisciplinary and cover the so called „Key Enabling Technologies" (KET's). Today there are six types of KET's: photonics, nanotechnology, bio-technology, advanced materials, microelectronic systems and advanced manufacturing.

This move created an entire new textile industrial environment by reconsidering its objectives from productivity and flexibility to ones concerning the technological development and targeting high performance of the industry. For the moment there are only a few countries generating and using this knowledge with impact on competitiveness, national development and creating high level paid jobs. KET's are defined as incorporating a high percentage of research and development (R&D), the intensive use of capital and of a highly qualified labor force within extremely fast innovative cycles.

The central point of the KET's are the small and medium sized companies usually organized in clusters, where the entire activity is concentrated on technological and commercial development with impact on the national economy and industrial structure.

The conditions mentioned above ask for a high degree of cooperation between universities, private companies and state, that means at the end a certain kind of cultural approach for creating an innovative chain.

Combining funds from EU grants, Czech government and the private sector, the Czech Republic is a world leader in the field of nanotechnology and Elmarco plays the main role in this field.

After an overview, Elmarco Czech company has competitive advantages by owning a technology for producing nanofibers, unique in the world, has the government and European Union funding, a strong cooperation and international activity, the offer can be put in accordance with customer needs and the capacity to cooperate with domestic companies. Nevertheless nanotechnology is a tradition activity in the Czech Republic.

Looking at the other example of the paper, The United States is a top leader in nanotechnology research. Between 2000 and 2013 the Congress allocated 18 billion dollars for R&D in nanotechnology. In 2014, 1.7 billion was budgeted that means 8% lower than two years ago. And this can create some advantages to Russia and China in the field of nanotechnology.

GreenYarn is a nanotechnology company producing eco-friendly alternatives to conventional fabrics. This company has the following competitive advantages by using the bamboo nanofibers technology: new products are launched every year, a strong commercial relationship with Asian markets, with agents in all this countries, combines an old technology in a modern way, bringing natural raw material and the latest technologies together. Their products look like classic ones but the difference is at the level of the technology that gives special characteristics and quality.

The new industrial era starts to become a reality through continuous spread of knowledge and technologies created by pioneers to all the others that are welcomed into the innovative value chain.

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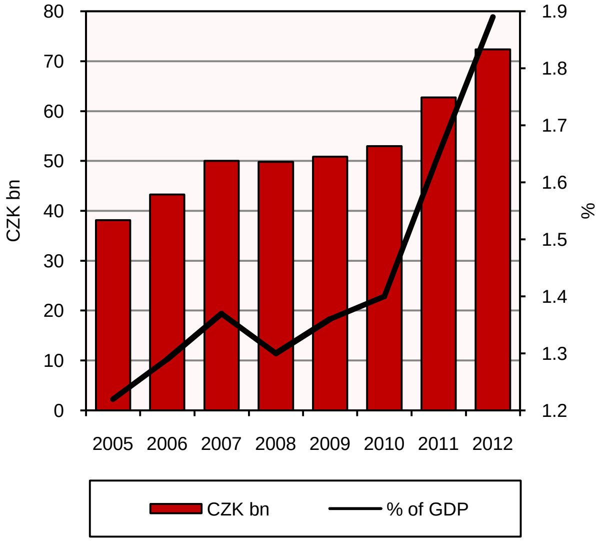
Appendix A



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