TECHNOLOGY TRANSFER AND NEW TECHNOLOGY BASED FIRMS DEVELOPMENTS - POLISH PERSPECTIVES AND CASE STUDIES ON NANOTECHNOLOGY

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Abstract – This paper provides a general overview of the Polish environment for technology development. Some of the specific questions answered in this paper include: What are the specific factors of the Polish innovation environment? How do technology firms emerge from R&D institutes and universities? Are there any new opportunities for Polish high-tech enterprises in the competitive world market?

The final section of the paper presents a case study of a spin-off company in the nanotechnology sector. It is demonstrated that some of the new developments should take into consideration knowledge and technology transfer management.

Key words – Technology Transfer and Innovation, Technology Strategy of Enterprises

Introduction

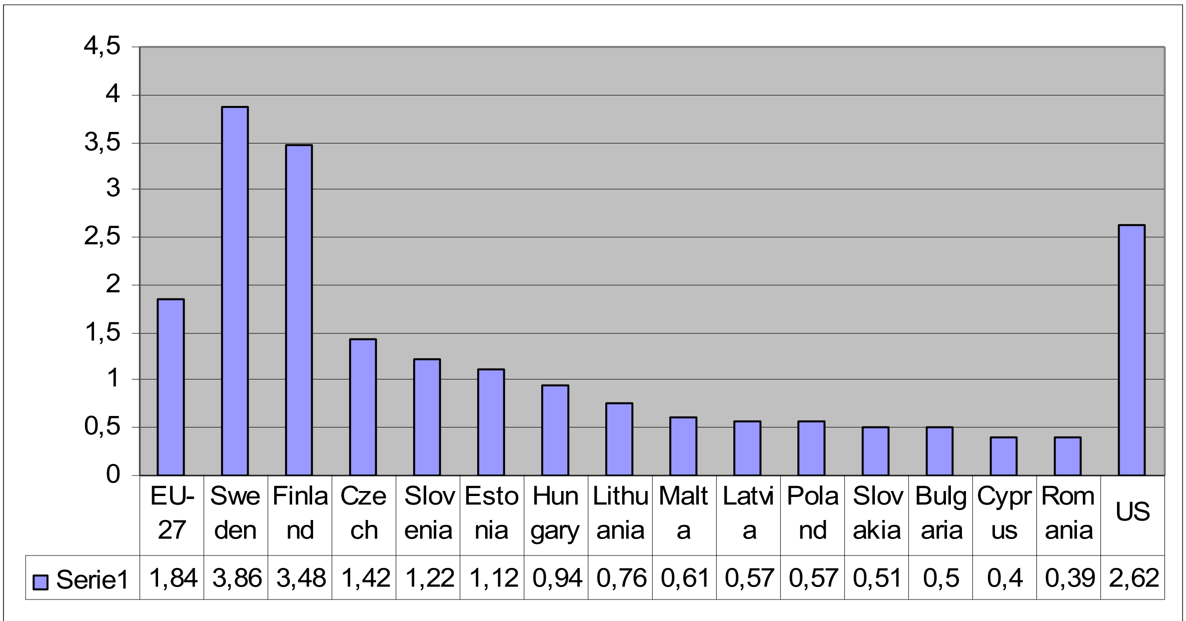
The issue of innovation in national and science and technology management represents the nature of the free market economy. The creation of knowledge is one of the main tasks of higher education. Knowledge needs to be transformed. In the time of globalization and integration of the Polish economy with the European Union tempo of knowledge, technology transfer and implementation of innovation are one of the company competitive advantages. The main focus of this presented paper is technology transfer from universities to enterprises, new technology firm developments, barriers and stimulators for innovative industry enterprises. The expected benefits of implementing of innovation include an increasing ability to generate new products. The purpose of this paper is to provide scientists and entrepreneurs with comprehensive information which will aid in their understanding of the changes on Polish high-tech markets and presents a case study from nanotechnology sector focusing on knowledge and technology transfer components. The text is divided into four parts. The first and second part of the paper begin by outlining the essential aspects of European and Polish innovation markets. The third part focuses on the Polish nanotechnology road map and is aimed at analyzing future perspectives for high-tech companies. The fourth part presents the case study on the spin-off company operating in the nanotechnology sector by providing an example of management of technology development and transfer. The author also provides examples of scientists who have become successful entrepreneurs. The paper allows to draw important insights into the development mechanism by which Polish scientists and entrepreneurs build up their competences and enter into high-tech international markets.

Innovations, New Technologies and Organizations Focused on the Development of Ideas and Business Significant and Context

Achievement of maintainable competitiveness on a global scale by the European Union will require a dynamically developing economy based on knowledge. The development of research, new technologies have become a basic element of European Union strategy (Lisbon Strategy). The initiative to create a common European Research Area (ERA) brought about an acceleration in integration. The creation of common technologies and their development have become a priority in research programs such as, for example, framework programs. Research and Development (R&D) expenditure in Europe remains at a level of

1.6% of GNP, which is lower than in the USA (2.8%) and Japan (3.1%). The prognosis for China indicates that in as early as 2010 R&D expenditure for the country will reach the EU average [Siemaszko, Supel, 2006]. The European goals in research and development, as set by the Lisbon Strategy, are to achieve by 2010 R&D intensity of at least 3%. In 2005, only two Member States exceeded the European Union goal of achieving R&D intensity of 3% of GDP: Sweden and Finland. The average European Union member R&D intensity is lower than in United States [Eurostat Pocketbooks, 2008]. The new members of the European Union have lowered the European Union R&D intensity average because only three countries, namely, Czech Republic, Slovenia and Estonia have higher R&D expenditure than 1% (fig.1). The majority of countries, including Poland, have R&D intensity at 0.5% of GDP that make technology transfer and innovation policy national strategy for the next few years. The Sixth Framework Program for 2004-2006 was successful in increasing industry participation in academic research. The CRAFT program, addressed to small and medium businesses was of particular significance. However structural changes in the external environment pushing for a more proactive role of universities in technology transfer started in Europe in the early 1990s [Baldini, 2006]. The transfer of technology from academia to commerce is key to the commercialization of academic research results. Analyzing results achieved in Europe and USA, it may be stated that Europe is ahead of the USA in terms of licenses and new companies produced, whereas Europe trails USA in terms of income from licenses participating in research [European technology transfer, 2006].

Figure 1 R&D intensity in EU-27 and US



Source: Based on Eurostat Pocketbooks. Science, Technology and Innovation in Europe, European Commission, 2008, p. 10.

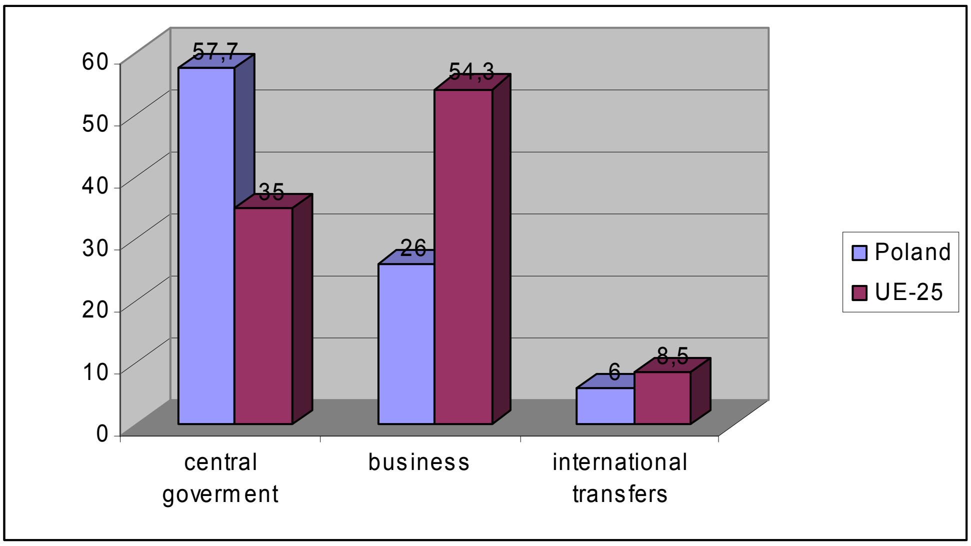
Innovation and new technologies have always been under development in Poland. Poland has got many inventors and entrepreneurs who have made names for themselves through their ideas and undertakings. In Poznan in the 1980s the idea to create a technological park appeared. Undoubtedly, it was only the system reforms following 1989 which gave the basis for comparatively free infrastructure development for the development of innovation, technology transfer and commercialization of research results. K. Matusiak [2006] notes five periods of commercial innovation development in Poland: the pioneers (from the Solidarity revolution to 1993), solution of labor market problems (1993-1996); stabilization of the system and new ideas (1998-2000), pre-accession period (1997-2004), first experience in EU (following 1st May 2004). A sixth period may surely be added – dynamic development and inclusion of Polish institutions in European and global networks for innovation and development of new technologies. At present a significant commercially competitive advantage of Poland and Eastern-European countries is low labor costs coupled with a large consumer market. This situation will not continue indefinitely and therefore an essential element of continued company development may be the building of company competences in innovative operations, including operations in the field of R&D [National reference framework strategy, 2007].

Poland is among the group of catch-up countries (with Bulgaria, Croatia, Hungary, Latvia, Lithuania, Malta, Romania, Slovakia Turkey), with an above EU27 average rate of improvement. Relative strengths, compared to the EU country's average performance, are in human resources, firm investments and economic effects and relative weaknesses are in finance and support, linkages & entrepreneurship and throughputs [European Innovation Scoreboard, 2009]. A further indication of institutional development supporting development of innovation and technology transfer is the fact that the survival rate for companies in Poland in their first year of operations for the years 2001-2004 was 63%. This means that an average of 40% of companies ceased operations in this period. The decisive majority of companies financed innovative operations with their own resources (94%). Two out of five companies financed innovative operations with external funding. Polish companies utilize academic and developmental body resources to a limited extent. Only every thirtieth company between 2001-2003 has cooperation agreements concerning research and development with academic and developmental institutions engaged in the development of new technologies. Companies tend not to engage in research and development as a source of new technological solutions or products as such activities are deemed highly risky and to bring no competitive advantage. Nine out of ten companies introduce above all product innovations and almost ¾ manufacture new technologies based on their own resources. Sources of an external nature are of little significance to companies. In this case technology transfer leads to the copying of foreign solutions without legal or financial consequence. In the case of one quarter of companies technology transfer leads to the purchase of research results, whereas one in one hundred companies declares the purchase licenses allowing for use of patents, or consumer and industrial designs. [State of the sector report, 2007]. The development of new technologies in Poland is becoming more and more dynamic. As recently as 2002-2003 software accounted for the largest share in investment expenditure. The second investment group was new production lines. It is particularly worth noting that the level of investment in new technologies was highest in the "gazelle" segment. Almost every second company invested in new technologies in 2002-2003, which is a result twice as high as that noted in the SME sector of companies not belonging to "gazelle". The main new technology investments were directed at the production industry. These companies were in good financial condition owing to steady growth in GNP in Poland from the beginning of 90s. The increase of gross domestic product per capita was the one of the highest in Europe and significant in the world. Indices of GDP between 1995 and 2007 was 72,6%.

On the other hand, there is a visible relationship between investment and increased long term debt. This indicates that a necessary condition for investment in new technologies was external funding in the form of bank loans [State of the sector report, 2004].

A strategic aim of Polish innovation policy for the years 2007-2013 is to increase company innovation for the maintenance of an economy on a path of rapid development and to increase financing of R&D results by business (finance structure of R&D work in European Union and Poland presented in fig.2). A condition for the effective implementation of innovation policy is the creation of an efficient institutional system and the development of mechanisms to coordinate activity of central and local levels. A significant potential, conditioning company innovation is R&D potential [Gulda, 2005].

Figure 2 Financing of R&D in Poland and UE-25

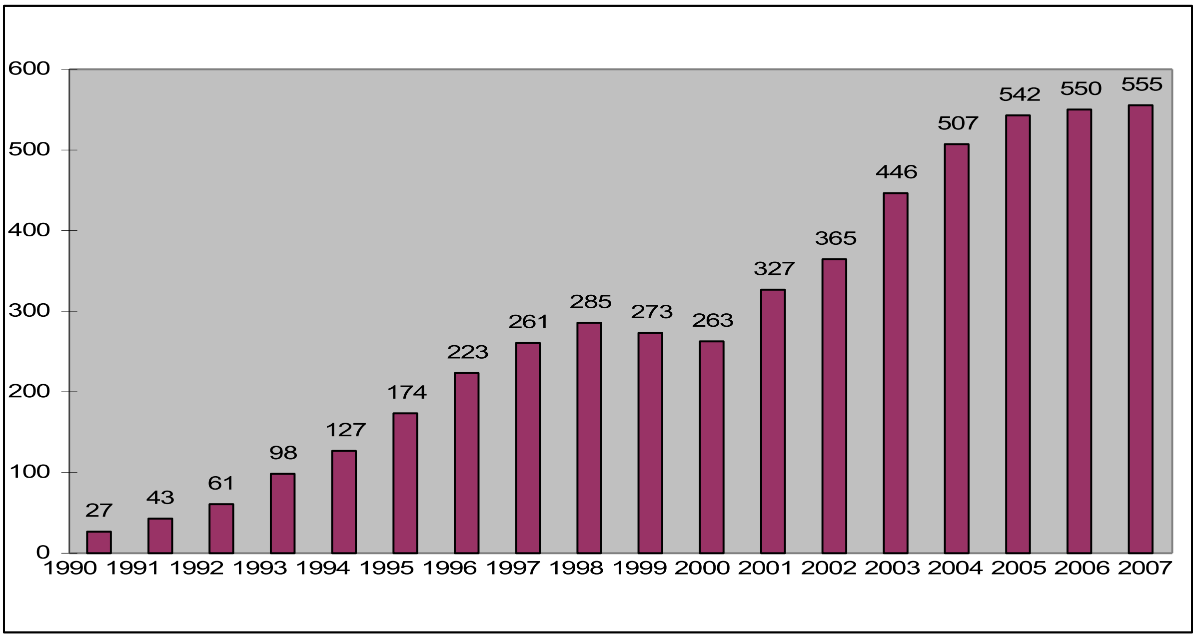


Source: Innovative Economy Operation Program. National strategic reference framework 2007-2013,Ministry of Regional Development, Warsaw, October 2007.

The problems with commercialization result from many factors such as: the minimal cooperation between small and medium businesses and the research sector, low awareness of the opportunities to make use of academic and developmental institution resources for company development, the domination of the purchase of new machines and equipment [Mazurek, 2008] and low effectiveness of patents. The dominating model for knowledge transfer in Poland is personnel development, consulting service systems, access to information and knowledge transfer system organization. This allows for increased scale of the transfers of technical and experimental achievements to national and global circulation. As Jasiński writes, Polish companies show too little interest in technology transfer and the scale of the diffusion process for technology is too small [Jasiński, 2005]. From this the models for technology transfer account for changes in innovation infrastructure, and know-how and best practices transfer.

In recent years centers supporting transfer and commercialization of research results and technologies, such as technological parks, technology transfer centers, technology incubators, have become particularly popular (fig.3).

Figure 3 The growth in the number of innovation and business development organizations in Poland



Source: Matusiak K. B, Development of commercial support systems – indicators, policy and institutions, Institute for Sustainable Technologies Press, Radom – Łódź 2006

In Europe academic – technological parks are seen as entities creating places of employment and the intellectual property market. The concept of a crossbreed as proposed by Laffitte is very much alive – collect in one place operations characterized by advanced technologies, and financial institutions. The structures supporting the development of technological commerce (centers of innovation, technology transfer, technology incubators) have the task of caring for the company. A significant element in Poland are the Special Economic Sectors (SSE) - (companies locates in SSEs are exempt from income tax for ten years, and pay only half for a further five [Jaśkiewicz , 1999]. One third of parks are actually projects, that is, at the market entry stage. One fifth of parks are at a very early stage in development. In Polish academic – technological parks in 2008 guarantee funds, raised risk capital funds were not in operation [Fabrowska et all, 2008].

Technology Access Keys and Limitations in Technology Transfer and Commercialization and Polish Perspectives

Stawasz [2006] highlights that the realization of resource allocations by SME is more significant in more economically developed nations. The SME sector is not only a source of invention, but is also more effective [Simon, 2008] In Poland SME sector companies are decidedly weaker when compared with other European Union members (employment in Polish companies is ¼ lower than the average in the European Union. The market research has indicated [Dzierżanowski, 2007] limited investment of SME into new technologies. 3% of SMEs invest in R&D and 2% declare cooperation with academics and plans to purchase the results of academic activities. The SME sector invests in lower risk assets such as machinery, plant equipment, software. Every second SME argues that machinery and plant equipment is its last activity in new technology development. Every third SME has invested in IT software in recent years. A few main factors stimulate the increase of technology transfer and R&D expenditure in Poland. The most significant are:

- competition
- market sector - production companies have the highest expenses

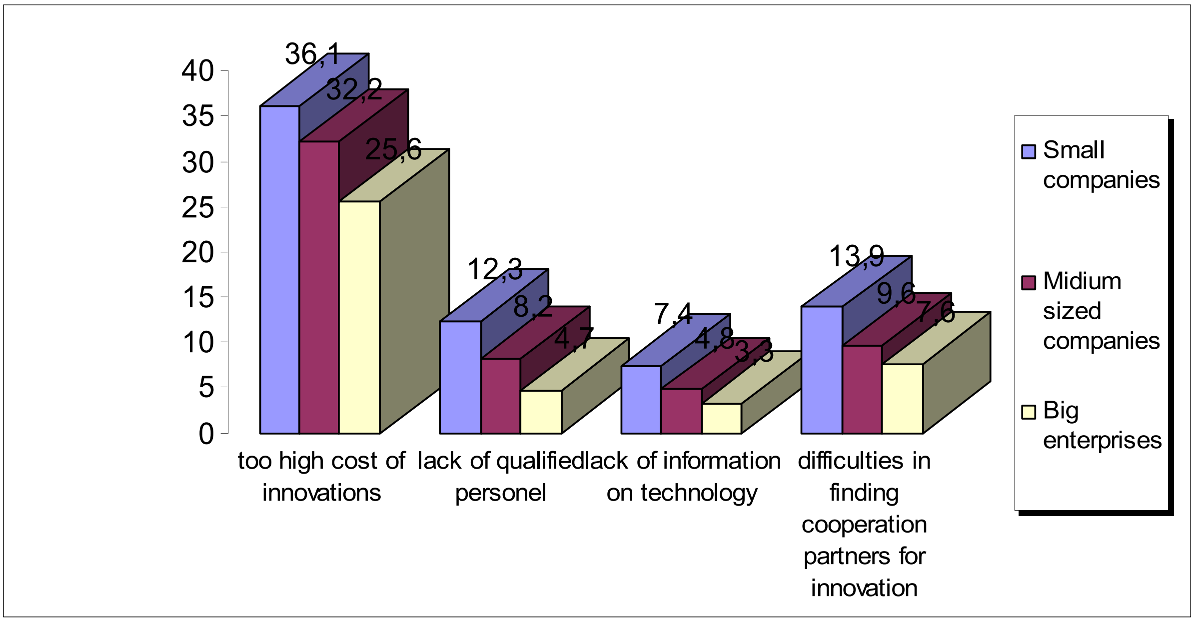
- identification of weaknesses in relation to competitors
- quality of human resources
- identification of development strategy in company
- potential for innovation as: the possibility to introduce new products and new production lines, production capability, the chance to enter new markets and elasticity of production,

Technology transfer is cooperation "means active participation with other enterprises or non commercial institutions in innovation activities" [Eurostat Statistical Books, 2008] Benneworth [2006] argues that there are different models of spin-off development. Some universities focus on supporting entrepreneurial professors (Newcastle University), others encourage students to create their own business after graduating, providing a loan, advisory services, access to laboratories (The University of Twente). Universities can have a strong impact on spin-off incubation when they lead mentioned companies to be involved in core research activities. Universities are more supportive of their daughter companies where they have entrepreneurial infrastructure (e.g. technology incubator) on campus. It is easier for them to establish new business exploiting their academic knowledge. Benneworth and Charles [2004] identify the main value of spin-offs as high-technology firms. The most successful economies are dominated by high-tech companies which is why spin-offs generate added value for the economy. Kondo [2007] defines spin-off companies as those commencing operations based on their relationships with the academic world. These companies use the technologies, human resources, and even capital resources of universities in their incubation phase and in later operations. With this in mind, it may be said that such companies are academic companies. Spin-off companies develop because they often enter niche segments. Robers and Malone [1996] provide a wider interpretation of companies generally referred to as splinters, and add that such companies are formed not only on the basis of relationships with universities, but also R&D institutes and government laboratories. Splinter companies are formed with the aim of implementing research results in industry. The industrial application of research into new technologies is therefore key in the formation of spin-off companies. Izabelle [2004] identifies three types of so-called new technological company (NTBFs – new technology-based firms) taking into consideration the type of body on the basis of whose operations the splinter company is formed and the relationship between the new company and the organization providing know-how or know-who. These are: companies formed on the basis of license received from a mother body (so-called spin-off companies), companies formed by university graduates or employees, not associated by license or patent to a mother body (so-called spin-out companies) and companies formed on the basis of knowledge transfer (also on the basis of license received) from a public research agency (spin-in).

To create and develop innovative firms, business infrastructure, science and technology parks, R&D centers and high-tech incubators the principal goal is the generation and transfer of knowledge and technology. The national and regional strategy has to be the attraction of scientific projects, laboratories and the strengthening of the universities. University and industry must evolve appropriate coalition and play a key role in innovation policy. The creation of new enterprises logically indicates the development of incubators and research laboratories with the support of the university or R&D organization [Bugliarello, 200]. Technology transfer can be specified as product and process oriented effects of innovations. The main innovation effects seen by companies in Poland improved quality of products and services. Two out of five small and medium sized enterprises indicated improvement quality as a high degree of importance relevant as percentage of active innovation enterprises during 2004-2006 [GUS, 2008]. Enterprises employed more than 249 people focused on increased range of products as the significant effect of innovation. The situation on the Polish market concerning innovation, technology development, science transfer characterize factors hampering innovation policy in industrial enterprises. They are cost and market oriented. Lack of funds within the enterprise and the high cost of innovation were dominating barriers to innovation and implementation in 2004-2006. These factors prevent above all SMEs from introducing innovation strategy. Polish enterprises suffer from uncertain demand for innovation and companies dominating in the sectors. Knowledge and technology transfer barriers that influence the innovation activity of Polish firms were difficulty in finding cooperation partners for science and technology commercialization. These mentioned factors make the development of the science and technology parks and center for technology transfers at universities important. Market research on determinants stimulate international cooperation of beneficial organization within National Coherent Startegy shows that organizations as science and technology parks and high-tech incubators intensively seek international partners for their clients (spin-offs, spin-outs and other innovative firms) . Innovation policy and international cooperation have been one of the goals of science and technology parks managers [ProAcademia, 2008]. They work on the stimulation of cooperation between industry and academia. The formal and informal linkage between firms and science and research organizations produce information flows conductive to innovation or lead firms and universities and R&D institutes to science and technology transfers. Technology and science transfers for the most part depend on organization of intellectual assets, which creates innovation and makes commercialization of innovation possible. Market value of inventions, new technologies and new products significantly concentrate on intellectual capital components as people capital (as a combination of knowledge, skills and experience of scientists, firm managers and employees), structural capital (as an organization's ability for transferring of know-how, know-why outside organization), partner capital (as the relations between partners used for exchanging the knowledge and improving their qualifications), innovation capital (which refers to creation and implementation of new technologies and products to the markets) [Mróz, Rogozińska-Mirut, 2007]. Analyzing the Polish enterprises' innovation activity we can argue that qualified personnel, which is a component of people capital, is one of the weaknesses of Polish innovation markets. The lack of qualified personnel is a factor hampering the innovation activity of industrial enterprises but it is not the main barrier in implementing company innovation strategy.

The facility to apply academic research in practice is possible with the stimulation of Polish academic research institutions, companies, public sector entities, and non government organizations, which can benefit from transferred technologies and know-how, and can also offer their own achievements in order to commence commercial operations [Gontar, Trzmielak, 2005]. A network of associations is a key element in the transfer of knowledge to business. Further to Mason and Rohner we may state that the network of associations that exists in contemporary business has led to easier than ever gain of ideas for new technological solutions external to the organization. Organizations wishing to obtain innovative knowledge place an emphasis on research development or transfer of results.

Figure 4 Main barriers in industrial enterprise activities during 2004-2006



Source: On the basis on GUS, Innovation Activities of Enterprises in 2004-2006, GUS, Warsaw 2008: 153

Polish governmental organizations, such as Polish Agency for Enterprise Development did a lot to stimulate and encourage companies, R&D institutes and academic organizations to be active in commercialization fields. The Polish Agency for Enterprise Development under the honorary patronage of Polish Ministry of Economy organizes an annual competition for innovative organizations "Polish Product of the Future". The competition is held in categories for: product and technology of the future at the pre-implementation stage and product and technology of the future at the implementation stage. The competition has excellent promotional goals. Several of the best technologies were presented and awarded with medals, cups and financial rewards at International Innovation, New Technology and Products Exhibition in Geneva. The best granted technologies are presented in table 1.

The effective technology transfer of the awarded technologies depends on the ability to transform the added value into potential partners or clients needs, asset turnover and return on sales. Unfortunately the grants and awards are only a promotion tool of technology and knowledge management. Companies, R&D institutes and universities step by step improve their targets, measures of technology added value and value drivers which lead to technology transfer and commercialization.

In terms of protection of intellectual property rights, the commercialization of research results in Poland has been burdened with the stereotype that the invention itself possesses some added value which should be implemented in the company. Polish law dictates that an invention is a technical solution which is new, is at the invention stage and is appropriate for industrial application, regardless of technical field[1].

[1] Art. 24, *Industrial Property Law,* Zakamycze Press, Zakamycze 2003, p. 19.

Table 1 Granted Polish technologies and products at International Innovation, New Technology and Products Exhibition in Geneva

2008	2007
Multi-directional Recycling of Sewage Sludge and Proteinaceous Offal Polluted with Chromium and Other Heavy	Screening audiometr 'Kuba Mikro AS
Integrated 3D Measurement System ScanBright	Series of frequency converters MFC-710 of rated power up to 315 kW
, PCP – technology of polycarbonate cards personalization	Measuring system for quality inspection of resistance welded joints
Experimental complex for investigation of high temperature properties of molten metals and alloys	SKZ-81 haulage assembly with a dual power system
Technology for purification of crude nickel sulphate	Ophthalmic applicators with monolithic active core for eye cancers brachytherapy
The personal bullet-proof suit.	

Source: Polski Produkt Przyszłości, Polish Agency for Enterprise Development, http://ppp.parp.gov.pl/druk.php?proc=538, 30.04.2009

The word "industrial" has given rise to controversy, as the fact that there is a possibility for industrial application does not necessarily mean that the invention can be implemented in the form of technology or a product on the market. Polish academics can boast many inventions which have received various types of awards, however there is no interest in their implementation in the market. The reasons for this should be sought above all in three areas: system for academic promotion, economic function, and economics. There is little support for entrepreneurial individuals to enable them to realize the value of their inventions. One of the dominant criteria in the assessment process for research grant applications is still academic achievement. Those with past academic achievement have greater chances of receiving funding from the Ministry of Science and Higher Education. Through receiving funds they increase their chances of receiving further grants. Funds for implementation purposes are transferred above all to institutions which already possess experience, that is, those having been in the market for several years. In practice this means that the best ideas will not necessarily receive support if it is not backed by a state institution. This system barrier impedes the best and maintains a market presence of bodies that are no longer competitive following accession to the European Union. Another reason for relatively low effectiveness of implementations is the economy's structure. Large companies are the property of overseas investors which already possess R&D departments in their mother countries, often belong to once monopolies which still have large market share, and innovations appear out of necessity rather than market needs and demands. The number of strong, dynamic Polish companies ready to implement academic research results and high-tech solutions is relatively small. Mazurek indicates that there is a universal belief that the offers of research and development bodies do not cater for the needs of the SME sector [2008]. Market research confirms this hypothesis, but it should be added that the level of development in the SME sector does not allow for the purchase of research results or new technologies (the NewConnect stock market has functioned since 2007). Three out of five

MSE sector companies consider the purchase of machinery and equipment to be more effective. Only every tenth company recognizes the effectiveness of joint research work with other companies or the validity of implementation of such [Mazurek, 2008]. The third and last factor impeding the transfer of academics and commercialization of research results and new technologies is the lack of financial benefit to the academics. Economic benefits are provided by publication, which often prevent the further transfer of research results into industry. Implementation into the market involves the process of commercialization, which begins with an estimate of market chances and ends with the sale of a product or service. The commercialization process is sometimes difficult and may last several years. During this time of working on the implementation of new technologies or products, financial, personnel and marketing sources must be ensured. On the other hand, the product and technology creators need to seek consultation in the scope of management. These and other problems are uncovered by the wide scope of work that has to be performed in educational and research institutions or centers for transfer of technology. And then the product or technology creator must be aware of the barriers that must be overcome to proceed from an idea to the commercialization of a product. However the number of business oriented institutions such as academic technological parks, technology incubators, centers for technology transfer being developed provide a sound basis for further change in the R&D sector.

With this in mind the laws for protection of intellectual property rights are highly significant. These rights are widely understood, further to academic, literary, or artistic property, as being also industrial property, the subject of whose sale are patents on inventions. Codified knowledge in patent and spin-off company formations are science and technology transfer factors usually encouraging commercialization of new developments arising out of university research The management of intellectual property at educational institutions leads to assessment of the market value of research work, analysis of strategy for the protection of intellectual property, planning of the patenting process, or definition of the scope of sales of know-how, and decision making in the scope of or know-how and know-why transfer [Landfall, 2004]. We can highlight several categories associated with the taxonomy of technological licensing in academic institutions:

1. There is cooperation between an academic research institution and a company, and the academic believes he has the rights to the results of research and development work
2. Academic institutions possess the patent, patent application and other research results which may be of value to the company
3. The academic institution seeks a business partner to provide certain resources such as market access, funding for research, a concept for new technologies or products, marketing etc. for further research work.
4. The academic institution has a team which, based on the results of research results, may form a new academic company (spin-off), which will commercialize the results of research work.
5. A company seeks a partner for R&D activities and offers funding of research and/or cooperation
6. The company has a team which, based on the results of research work performed within the company, may form a new company (start-up) within the structure of the business oriented educational institution

In analyzing the six situations above which force the management of intellectual property, it is important to define what may be sold and what is of value to the company and academic institution. It should be emphasized here that education associated with the commercialization and transfer of technology aims to provide academics with knowledge, which allows them to differentiate academic value from market value, which Razgaitis names value and price

[2003]. Value is the minimum sum of costs borne in the development of technologies, which may be increased by the sum of the academic research institutions outlay, rate of invested capital return, anticipated profit, sum of resources allowing for further research on the transaction subject. Price is the value (market value), allocated to or negotiated by the parties to the transaction. Schuh et all [2008] indicate four kinds of value, which we may refer to as property transaction value – historical value (costs borne by the research body), present value (costs which may presently be incurred preparing and conducting similar research), trade value (the monetary equivalent that can be received from the buyer) and future value (which comprises future income generated through the implementation or use of intellectual property rights). The last two values are dependent on the construction of the purchase phase [Simon, 2009]. Property transaction value may comprise:

1. patent rights, know-how
2. technology transfer - know-why – documentation associated with technology (process descriptions, research results) access to academic research institution experts, who can advise in the implementation of technology or work for the buyer
3. rights to equipment used in the R&D phase
4. guarantee that the patent or other intellectual property exists and is not in breech of the rights of a third party
5. the right to represent the research body where the research results or patent are associated with another academic activity or other technologies
6. the right to information or first option to purchase future research results associated with the transaction subject, which the research body may generate in other research work
7. the right to sublicense

The first and second situations are an example of the passive activity of academic institutions, and these are dominant in the Polish market. This passiveness results from, for example, the isolation of patent authorities from the process of commercialization. The commercialization process may begin only when a patent has been granted, and in many cases this may place limitations on the sales of research results and cooperation with business. However a developing infrastructure and the entering of R&D activities into the national development program force the third and fourth activities. Scenarios five and six are a beginning of market orientation on the path of R&D product generation. Companies recognizing a strengthened position through development or purchase of research results seek partners for cooperation. This may cover only the ordering of research or participation in joint research projects, or inclusion, for example, in a technology incubator and though this, access to academic institute resources. The stimulation of joint development projects between academic institutions and research development bodies is two-way. The business oriented infrastructure in the form of technology incubators and technology transfer centers and the financing of business projects based on research results attracts business to educational institutions and simultaneously forces the academics to take an active role. They are included in business projects by the companies themselves as companies are offered public funding for cooperation with academics. Thus changes are made in what academic institutions have to offer, bringing about market benefits...

A basic problem which arises in the management of intellectual property at academic institutions are the rights and obligations resulting from intellectual property created within the institution, share of the intellectual property stakeholders in the commercialization of research results (for example, inventors, laboratory, company, faculty, department, institution, region, business, industrial sector etc.) Each academic conducting academic projects within the scope of academic institutions creates prototypes, produces research results which may be commercialized or from which intellectual property rights (material and economic) may arise, is bound by contract of employment with the institution. Thereby research results are the property of the employer. The motivation system does not always consider benefits from the creation of research results suitable for commercialization, other than academic benefit. Research institutes in which new technologies or potentially beneficial innovations are created, in their own interest, and in response to market changes, are starting to clearly define the complete process of intellectual property management, including share in rights, for example economic rights, of research results. A significant number of intellectual property management models in academic institutions in Europe and the United States clearly highlight the share (at least economical) of inventors, research result authors in the rights to intellectual property. European countries have recently reformed their intellectual property laws to grant intellectual property rights to universities echoing the landmark U.S. Bayh-Dole Act. In Polish academic institutions the arising models are aimed at including patent authorities in the commercialization process for research results and transfer, in part, the economic rights to intellectual property to academics. Changes in the intellectual property protection system have begun in all leading academic institutions. The Jagellonian University has gone furthest with such changes, giving not only economic rights (50% of income from commercialization) but also internal university regulations allow for transfer of ownership rights to the invention.

The modernization of the technology transfer processes from academics to business through assistance in protection of intellectual property in potential markets is a priority in the development of science and high-tech sectors for the Polish Ministry of Science and Higher Education for the next several years. New policies will allow the university for the first time to maintain a comprehensive record of Intellectual Property and the commercialization of its intellectual property, which is likely to have a positive effect on the allocation of university sources. It will also facilitate the funding of patent applications with the patent authorities in accordance with World Intellectual Property and/or Organization, European Organization procedures[Santarek et all, 2008].

Nanotechnologies, Nano spin-offs and European Roadmap

Eloy [2008] indicates that a wide range of possible functions, easier integration and more affordable pricing create the potential market for nanotechnologies. The nanotechnology market is very fragmented and few products have reached high volume. However, general investment in nanotechnology has increased several fold. The value of sales of products employing nanotechnology in 2004 reached approximately 9.5 bln Euro, which accounts for 0.1 global industrial output [Wawrzyński, Karsznic, 2007]. The sale of products containing elements resulting from research results in the nanotechnology sector is forecast to reach 15% of total industrial output by 2015 [Independent working group, 2005].

Nanotechnology research has experienced rapid growth in knowledge and innovations. The European Union has recognized nanotechnology as a critical research domain which allows technology transfer from science to business and an increase in a wide range of fields of application. Huang et all [2006] indicate that concentrating the analysis only on the rate of number of patent increases in nanoscale science and engineering, significant growth can be observed (the percentage of USPTO nanoscale science and engineering patents increased between 2001-2004 from 3,8% to 4,9% if patents are keyword searched by "full-text"). Europe made significant process between 2002-2006. Expenditure in research, development of science and nanotechnology reached in Europe 2006 1.9 bln Euro (for comparison USA spent 2.7 bln and Japan 2.1 bln) [Supporting SME share, 2007].

Between 2004-2006 the global sum of public and private sector expenditure in nanoscience and nanotechnology was 24 bln Euro. Europe accounted for over one quarter of this amount

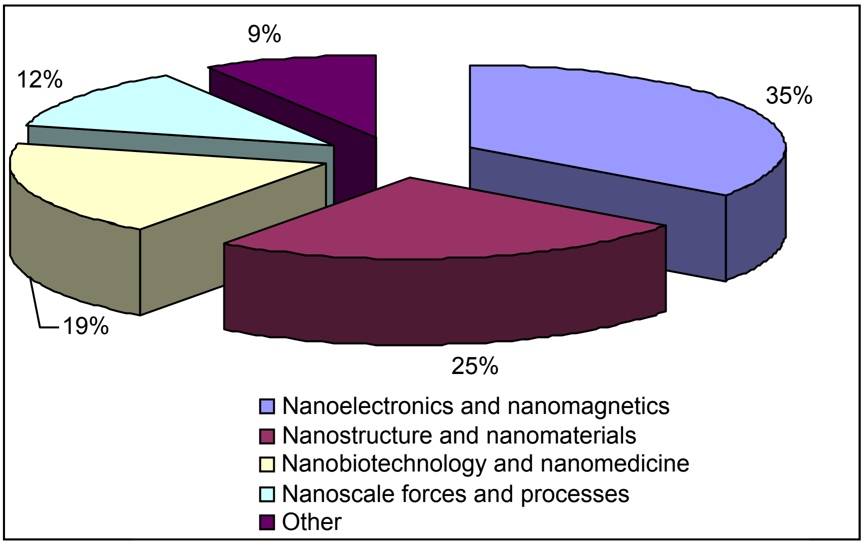
[European Commission, 2007]. USA, Japan and the European Union hold the leading places in research into nanotechnology. China is also a significant player, where the Chinese government invested approximately 195 million Euros in nanotechnology including Beijing, Hong Kong and Shanghai, the latest of which established the Shanghai Nanotechnology Center [Michelson, 2006] in the USA work is underway in the following areas: nanoscale forces and processes, nanostructure, nanomaterials, nanoelectronics and nanomagnetics, nanooptics, nanoscale equipment, nanoanalytics in nanoscale, nanbio, nanomedicine, and production machinery and processes. In the European Union, particular emphasis is placed upon the development of nanoelectrocics and nanomagnetics, nanostructure and nanomaterials, nanobiotechnology and nanomedicine, as well as nanoscale forces and processes (fig. 5). Japan is the leader in Micro-ElectroMechanical Systems (MEMS). In 2005 the Japanese MEMS market reached approximately 2.9 bln Euro, where the greatest application value was in: innovation processing and communication equipment, automotive, precision equipment (the value of nanoscience and product is presented in fig. 6). More than 70 Japanese companies involved in MEMS development and manufacturing have their own clean room and production facilities [Eloy, 2008].
The transfer of nanotechnology research results to market practice occurs in most developed and developing countries. The leading position of the USA in number of applications of industrial products employing nanotechnology results from the commercially stimulated use of innovation. Japan and the European Union are powerful players in the implementation of implementation of research results from the area of nanotechnology. However, both regions vary in developing market trends. Japan approaches the commercialization of nano sector research results obtained by large companies. In the European Union activity is concentrated also on the transfer of research results to the market via the SME sector. The commercialization of nanotechnology is a dynamic process incomparable to other sectors because it concerns almost all aspects of the creation of a market product [Poteralska, Zielińska, 2007].
In Poland research into nanotechnology is conducted primarily by academic institutions, Polish Science Academy institutes and research and development institutions. Together with the development of science, an increasing number of small and medium companies, including spin-offs, are created, which make use of large research institute laboratories, order research, or seek assistance in company development. There is very significant development and progress in nanotechnology. In 2000 the Ministry of Education and in 2006 there were 40 [Ministry of Science and Higher Education, 2006]

Nanoscience and nanotechnologies are the future direction for scientists and business but they lead to many problems named by Petersom „Valley of Heath" [Peterson, 2006] such as:

- conflicts in similar patents – broad area of science
- from technological discovery to prototype and business plan is a huge leap
- potential negative effects on health and the environment
- export restriction of the country

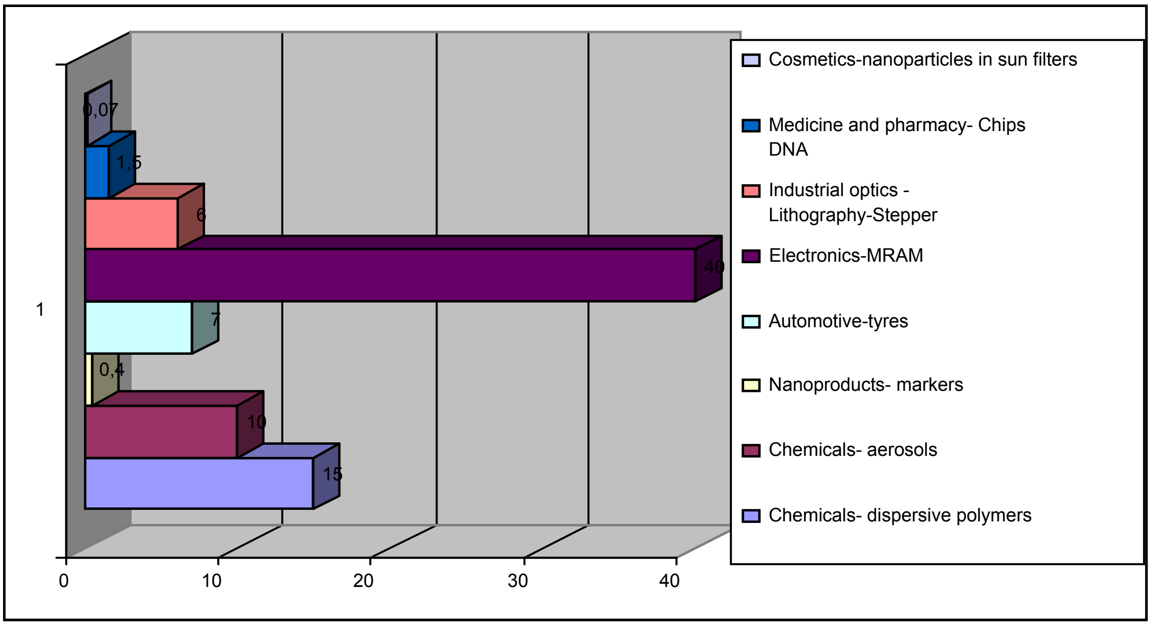
difficulties in finding funds for this highly speculative and hard work

Fig. 5 European Union investment in nanotechnology sectors



Source: Some Figures about Nanotechnology R&D in Europe and Beyond, Unit G4 Nanoscience and Nanotechnologies, European Commission, Research DG, 2005, December. – National strategy for Poland

Fig. 6 Market value of nanomaterials and products based in nanotechnology, in bln Euro



Source: Wawrzyński R. Karsznic W., Applications of nanotechnology, [in:] Science and nanotechnology. State and perspectives for development, ed. Mazurkiewicz A., Institute for Sustainable Technologies Press – State Research Institute, Radom 2007 in W Luter, N. Malanowski, Das wirtschaftliche Potenzial der Nanotechnologie, VDI Technologiezentrum GmbH, Dusseldorf, 2004

The above mentioned threats bring opportunities for the best projects, scientists and business plans. The broad area of work gives the chance for many scientists and companies to find their niches for future perspectives. Nanoscience and nanotechnologies can repair the damage already done by industry. Nanoscience cares about the environment, biosphere, water etc. It raises recycling efficiency, building sustainable systems. The high risk of investment also makes it interesting because of the potentially higher rate of return on investment. Nanoscience and nanotechnologies give opportunities for small and medium sized companies, emerging and developing countries because of the fact that nanoscience and nanotechnologies construct new industries, create niches on the markets, make SMEs potential partners for large companies. Kanama [2007] argues that the technological and economical risk involved with research and development for the nanoparticle area depend on market trends and growth. The highest risk and relative market growth, in 10 years, are in hydrogen storage, pigments, fuel cells and medical discoveries. The smallest market growth may be expected in cutting tool bits, antibacterial applications, automotive catalysts, rubber and new dental composites. However these areas of nanoscience and nanotechnologies involve relatively low level of financial risk. Nanotechnology applications are pushing the boundaries in a number of sectors e.g. research in the field of microelectronics the manufacture of nanodevices at the molecular level based on the use of generic material [Nanotechnology makes use of biotechnology, 2006]. Nanoelectronics, nanophotonic and nanoinstrumentation are three areas that have received the most funding based on dollar investment. There are founded by or associated with leading researchers at top-tier academic institutions [Leff, 2006]

Polish scientific and technological research is concentrated in universities and R&D public institutes. New segments such as biotechnology and nanotechnology provide strong opportunities for new companies. Present research indicates that spin-offs companies, start-ups are the best prepared to stimulate innovation transfers in biotechnology and nanotechnology. Polish innovation based on patents is developed in universities and R&D public institutes, however a change in attitude among researchers in universities is the decisive factor determining the success of technology transfer to the private sector. Polish public and European Union money went to support the building of infrastructure in 2002-2006 (The number of technology incubators, science and technology parks was doubled figure 1). The new period of finance supporting focus on developing laboratories and stimulating the scientific researches which would be transferred to high-tech companies. The study of Countinho et all [2003] based on Mexico, Costa Rica, Colombia, Brazil and Chile problem analysis shows that additional support with economic evaluation of technology and products, training of researchers about basic aspects of intellectual property plays a crucial role in stimulating research institutes to carry out technology transfers and management functions. The transformation of the science and R&D sector is the main focus of new European members states but it is known that new members of European Union also have a lower number of R&D employees and their enterprises have a low demand for patents [Vaněček, 2008]. Other major work has to be undertaken to change companies' preferences in cooperation and innovation policy. Data from Eurostat

Technology Transfer between Universities and Enterprises - The Polish Nanotech Start-up, Approach to Competitive Advantage

Poland has got a very young story of high-tech development following the second war. Step by step Polish companies have been trying to enter international markets and compete on R&D Generation markets. Promising high-tech ventures in biotechnology, nanotechnology and clean energy sectors are actively seeking partners, business angels and promising scenarios, the transfer of knowledge from high-level universities and R&D institutes to the business world [Trzmielak, 2005]. The University of Łódz Technology Incubator is one of the many examples which can be found where organizations carry out innovations as an answer to changes in their external and internal surroundings. Two Polish start-ups (incubated in University of Łódź, Technology Incubator) look for a way to solve problems that consequently lead to an increase in their existing processes, product productivity and competitive advantage. They have a interaction with University of Łódź which, as argue Dalamu Porta (et all), consequently has lead to technology transfer and enterprise development.

The Amepox Ltd and Amepox Microelectronics Ltd, strategic challenges with nanotechnologies

Poland for entrepreneurial venture, formed on the basis of university knowledge and R&D activity was demanding and challenging at the end of 20th century. Amepox Ltd and Amepox Microelectronics Ltd (AXMC) are typical spin-out companies formed by academic institution employed on the base of his extensive academic experience, but not associated by license or patent to the mother body. Companies use several technology transfer mechanisms and ways to commercialize research and innovations. They are forcing research to seek outside funding and university research to find new competitive advantages on the market. Technology transfer, defined as process of transformation of research and development results into marketable products [The Paxis, 2006], takes place in Amepox Ltd and Amepox Microelectronic Ltd into two dimensions: internal and external. Successful innovation was based on strong knowledge including a R&D capacity and well educated staff. Additionally, collaboration was a necessary element of new product developments.

Company growth and development

Amepox Ltd based its development mainly on former Technical University scientists. The owner had been fascinated permanent electronic interconnections, adhesives which conduct heat, electricity and magnetic current, and decided to establish his own firm in 1988. The fundamental assets of the new company were the scientific background and university knowledge and laboratory experience of the new company staff at Łódź Technical University. The electronics market was unattained for micro companies at the end of 80s because of Polish law and the monopoly of big electronic companies (many of which collapsed in the early 90s, where Poland went free market). The company examined the human resources and diagnosed the market conditions necessary for sustaining a competitive advantage and focused its activity on manufacturing special chemical resistance materials and applications for the construction industry. The company defined the market in three areas: customer function, technology and customer segments. Customer function provides benefits and satisfies the needs of the company's clients. The needs of the market were recognized at the beginning as: safe exploitation of plastic floors, floors and antistatic usable area due to tightened safety and fire requirements. The technology dimension recognized that the physicochemical parameters of prime coat materials should give access to easy penetration into close to surface layers of porous concentrate ground floor, binding weaker fractions, closing micropores in concentrated structure and with high resistance to different typical chemical substances and exploitation factors. Basic technology determinants for competition were the novelty of presented solutions and their technical parameters, high quality, compliance with standards. The last dimensions were identified as new industry branches which demand surface charge free environments – e.g. for production of electronic elements, computers or in computer control rooms. Analysis of the broad segment was important to understand and compare direct competitors and other participants. It supported technical staff with knowledge on how to create added value products for the market and for company

technology. Innovation in this area required not only competence in regenerating plastics, polymers but also in antibacterial action of materials.
Amepox Ltd progressed in the market with very difficult applications for industrial purposes such as “reinforcing” flooring materials for the highest mechanical resistance to abrasion and chemical treatments, thick type flooring with anti spark and anti slip properties. Their production was based mainly on the highest quality raw materials, epoxy resins, curing agents and modifiers.

After many years of activity on the Polish market, Amepox Ltd was one of the biggest manufacturer of floor materials in Poland with the highest quality. It has highly qualified scientists with PhD degrees, technical staff and Research and Development Laboratories.
The several years of the company’s owner working at Technical University of Łódź had deep influence on Research and Development activity. Highly motivated staff started research programs on different types of silver powder and flake with the highest metallic and ionic purity. The implementation of Amepox R&D results gave the base for new a company, Amepox Microelectronics Ltd. (AXMC) established in 1991.
AXMC grew to become one of the best known and one of the profitable nanoscience companies in the Lodz region and Poland. The Lodz local government awarded the firm with a prize in Łódź high-technology products competition in 2006, 2007 and 2008. The company’s most widely known product was nano inkjet glue. Revenues doubled each year following the technology research in 1998. Nano inkjet glue was typically sold to the electronics industry. The buyers considered first of all the quality of the product. In most cases, product quality was more important than price because it allowed users to get a competitive advantage in the sector. Because of the fact that the development process was long, costly and risky, the company applied for European Union grants. The milestone was made by AXMC in Five Framework Program participation. It offered special incentives to encourage companies to work on new products.

R&D and competitiveness

From the beginning of 90s, AXMC was very attractive for cooperation in scientific fields. Its intellectual potential and R&D activity made the knowledge and experience of company employees very important for the production of R&D Generation products. AXMC development has been based on production of materials for electronic applications. It has unique achievements and technological solutions in e.g. electrically conductive formulations with nano silver additive, electrically conductive ink for Ink-Jet technology, thermally activated electrical conductivity with very small particle size formulations, extremely flexible electrically conductive ink, electrically conductive formulations with very high temperature resistance, silver powder with the highest purity and nano size particles.
AXMC developed its research, invested in laboratories and implemented technology of producing atomic sized silver powder grains. These achievements have been possible because of cooperation with Polish universities and within European Union Framework Programs. These have allowed to invent new products. Silver powder with the smallest possible dimensions 3-8 nanometers is produced by only a few companies in the world. Only two companies in the whole world were able to get silver powder dimension 3-8 nanometers in 2006.

AXMC technology and knowledge transfer came into two directions: from business to academia and from academia to business. The unique scientific research made by AXMC and its close relationship with the best Polish known universities such as Wrocław Technical University, Łódź Technical University and Łódź University gave the possibility to work on new technologies with industrial application. AXMC and Biochemistry Institute of Łódź Technical University focused on the research and technical data included in professional literature and evaluating the precise size of nano silver powder. AXMC and its industry implementations afforded a lot experience for scientists at both Łódź universities. They could develop new projects based on technical data gathered during continued cooperation. The results of the cooperation made it possible to assess the requirements for silver concentration to have effective Gram-plus and Gram-minus bacterium growth inhibition. The scientific organizations which cooperate with AXMC have double results: scientific and market oriented. The best known area of cooperation was in the range of scientific research and the implementation of nanosilver as a bactericidal additive. Cooperation programs were practically unique for universities because the basic and applications research continued towards the newest scientific trends. AXMC was a developing company based on R&D Generation product and cooperation with academic and R&D institutes. It was the one of AXMC market strategies put into practice in recent years. The many new possibilities of nanosilver research and implementation are in medical applications, plastic sections etc.

Because of ten years' experience in manufacturing and the technical university background of the company owner and his staff, AXMC could successfully formulate a nanotechnology manufacturing strategy. A clear understanding of the impact of nanotechnology on the final products characterized the AXMC cooperation offer with scientists. Low material costs and having their own laboratory provided the opportunities for the company to experiment with nanotechnology innovation. Key competitive advantages could be achieved based on human resources and additional cooperation with university R&D departments.

Competences and international projects

Human resources gave AXMC the opportunity to cooperate with world business and academia at the top level. The president of AXMC knew that cooperation with the best was the chance to develop the company and enter new markets. European Framework Programs were the best way to find financial partners for scientific research. The Fifth Framework Program participation was the first stage to European markets. Poland, in association with other European Union countries, started to cooperate in Framework Programs in 2002. AXMC had started to cooperate with Wrocław Technology University and using its network AXMC joined an international team working on new materials and processing techniques for bonding and underfiling of flip chips and bonding of heatsinks in order to realize a step improvement in flip chip technology. The project task would allow a further miniaturization of microelectronic products. The challenges were very ambitious because the small Łódź company with 15 employees had to show a top level of research and high-tech knowledge. The partners in the first project (Nanojoining) were exclusive to AXMC. They became the bridge to international competition. Cybermetix, Boschman Group, Robert Bosch, Microdrop Gesellschaft Fuer Mikrodosier Systeme, Industrial Technology - Eindhoven, Nederlands Organization for Applied Research, Thales Microelectronics targeted at such developments as: new underfill materials containing nano size fillers with superior properties, new electrically and thermally conductive adhesives, a transfer molding process capable of underfiling flip chips in mass volume and an inkjet dispensing technique for electrically and thermally conductive adhesives. Polish enterprise developed its own proprietary method for producing silver nanoparticles with diameters down to 3-8 nm. It was a surprise to partners because only one other company in the world had achieved nanoparticies with diameters down to 3-5nm. It received expressions of global interest from potential customers such as Nokia and Siemens. The lack of experience on the global market was a key factor stimulating AXMC progress in wider implications of project discoveries. The big partners concentrated on the microelectronics market and had not recognized so far the added value of the bactericidal properties of silver. AXMC focused its research on domestic appliances, air conditioning system components and floor cladding materials. It made use of its core business areas, strangeness and past experience with hospital and food factories. Silver nanoparticles were found as extremely effective bactericides and they could be used as polymer fillers in new applications. The main benefits for AXMC in participating in Nanojoininmg European Union project were the new international cooperators sharing they business and scientific know-how and the best practices, new experience on the international R&D markets and references for new clients.

AXMC as a typical spin-off company had strong relationships with universities. It was known also at University of Hamburg, University of Cambridge, University College Cork. AXMC worked with these mentioned organizations on development of novel inorganic nanostructured materials. The company was interested in novel nano-photonic devices based on all inorganic nanostructure with enhanced photoemission activity and thermal stability to be used in transistor light emitting. The new research was also the beginning of the implementation of a new strategy focusing on large consumer markets such as mobile telecommunications, power consumption or automotive. The consumer markets needed not only new high-tech products but also lower prices and higher product effectiveness. The more effective product would be commercialized if producers reduced size, weight, material consumption and power consumption. Nano research goals indicated that various producers of mobile phones, computers, monitors, printers, home appliances or controller units for automotive applications would be the potential clients for the Łódź company. The developments of nanotechnology and products characterized AXMC activity on international markets and demonstrated its strengths as a R&D company.

Cooperation with High-tech Incubator at University of Łódź

AXMC invested in R&D with an eye on future products in the nanosector. It took several cooperation initiatives to find innovative products. Unfortunately building technological strength and its usage for company competitive development had to be synchronized with business management. AXMC presented novelty solutions and new technical parameters of its products but strong competition forced formulation of an implementation and development strategy for every new innovative group of products. However, AXMC experience in technology management was limited. The European Union project gave money, time and partners to develop new technology but the real market characterized higher competitive pressure. The technology and market management needed the forecasting of nano sector development and assessment of market potential for future AMXC products if the company ability of transfer novel technologies and innovative solutions to international companies would be effective and profitable. Recognizing the importance of the management role in creating a market and providing AXMC's technology roadmap, AXMC joined the High-tech Incubator at University of Łódź. It was one of the first companies which entered the new incubator at University of Łódź. The president of AXMC, assisted by the highly educated staff, was able to build a team to run a new project which helped with the implementation of the technologies and "ideas under construction". The incubator program was supported by Lockheed Martin Corporation and the Polish government offset program by having the opportunity to quickly identify pre-qualified strategic partners in US and the European Union provided the developing AXMC a business strategy for high-tech technology, products or services in order to bring them into the international market. The company benefited from the Mining and Matching Program by establishing relations with American companies, spurring the sale of new products to the world market.

AXMC, which worked in the areas of nano technology development and implementation in the market additionally needed:

•assistance in assessment of the market potential of its high-tech product,

•access to information – market and industry sector analysis,

•assistance in preparation of the enterprise business plan,
•financing from outside sources,
•assistance in negotiations with potential partners and investors,
•help with constructing the best possible model of collaboration with a business partner,
•evaluation of Intellectual Property with prediction of the value of technology development with investment of venture capital.
•optimizing the business model of the enterprise for the coming years.

Two years of cooperation with University of Łódź (2004-2006) gave an understanding of the financial markets. There was no doubt that increased nano product sales on the market depended on financial investment in the company. The microelectronic sector needed a larger quantity of AXMC nano silver than the company production capacity. The new nano technology developments and growth of sales of nano silver products versus plastic floors and smooth flooring coating indicated that AXMC required vision to enlarge production capabilities. It would expend the firm beyond the R&D phase. The venture capital would provide the impetus for such a transition. Those venture capitalists who the company met at University of Łódź were a little reluctant to get involved in funding a venture that was not part of an nano industry and only focused on R&D activities alone and with project partners.

The business future of AXMC

It was interesting challenge, starting a business in the nano sector. AXPC started with very little, no cash, no markets, no product for international markets and no business model for international business cooperation. The technology developed in European Union Frame Programs brought the company chance for growth and venture capital investment. The experience with world known organizations, R&D practices and its core assets effected the value of the company. As associated client, AXMC spent two years in High-tech Technology incubator at University of Łódź building business model for R&D generation products. However, one of the crucial approaches was the financial investment into AXMC's new nano silver businesses. The developed model of venture development and potential foreign clients signaled to the investors that AXMC was a business that could partake in venture capital and boom emerging around nanotechnology.

Introducing the new nano product production was time consuming. Fortunately, AXMC received two years from its potential clients for R&D on the nanosilver inkjet products. It was enough to finish VC negotiation and to invest in new laboratory and production assets. The microelectronic industry wanted the new technology which produces silver nanopaticies with diameters down to 3-8 nm. AXMC had never spent millions but created world R&D generation products accepted by e.g. Nokia and Siemens. Nano long term company strategy had to be responsible for production developments and maintaining unique skills and knowledge. The firm invented inkjet technology with nanosilverparticies for the microelectronics industry and nanosilver fort antibacterial actions. The nano products did not require high production costs. Therefore, AXMC as a nanoproduct supplier would give a competitive advantage over foreign product manufacturers.

Conclusion and Caveats

The national strategy created by the Polish government for the period of 2007-2013 aims at creating key organizational structures which will increase prosperity, focusing on firms' new technology developments. Science and technology development can be one of the company strategies to achieve a successful outcome. A successful outcome is defined as the creation of value of new products for the market, competitive advantage for the company, increased wealth for the company owners and investors.

Polish high-tech companies try to find new perspectives on competitive global markets by introducing new products on the knowledge base. We can state that the new sectors are challenging for Polish scientists and entrepreneurs but are closely connected with the chance for international cooperation and innovation industry enterprises activity. Not only do enterprises aim at improving the quality and competitiveness of the product to help the company achieve customer satisfaction, but they also invent new methods and models to help the organization maintain the highest world standards, advance in their activity and prepare themselves for global cooperation and competition. New sectors, cooperation with the best market players are strategic directions in organization development. Collaboration strategy especially in exchanging of organization experiences gives future perspectives for sales growth and revenue.

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