

Is the Expansion of High-Tech Leaders Possible Within the New EU Members? A Case Study of Ammono S.A. and the High-Tech Financing System in Poland

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Abstract—Innovations, especially technological, are considered key-drivers for sustainable economic growth and competitiveness in the globalised world. As such they should also play an important role in the process of economical convergence inside the EU. Unfortunately, the problem of insufficient innovation performance concerns around half of the EU countries. Poland shows that a lack of a consistent high-tech financing system constitutes a serious obstacle for the development of innovative firms. In this article we will evaluate these questions referring to the example of Ammono S.A., a Polish company established to develop and commercialise an original technology for the production of bulk GaN crystals. We will focus on its efforts to accumulate the financial resources necessary at different stages of its development. The purpose of this article is to suggest possible ways to improve the national innovative system, which would make it more competent in generating high-tech leaders.

Keywords—High-tech financing, innovation, national innovative system

I. INTRODUCTION

INVENTIONS and innovation have always played a key role in the development of human civilisation. Even early simple inventions such as bronze and iron resulted in fundamental changes in the level of living and the organisation of social life. However, theoretical analyses regarding the impact of technological changes and innovations on economic growth were developed only in the twentieth century, first by Joseph Schumpeter and later by many researchers, for example: Robert Solow, Christopher Freeman and Paul Romer.

Today, the crucial role of innovations in economic growth is a fact. They are considered key drivers for sustainable economic growth and competitiveness in the globalised world. They also play an important role in the battle against increasing social and ecological problems. Which is why effective innovations' production is one of the objectives included in the EU's new growth strategy, namely "Europe 2020". Due to this strategy the EU is expected to become "...*smart, sustainable and an inclusive economy by 2020...*" [1]. This replaced a more ambitious goal, defined for the previous decade in the Lisbon Strategy, according to which the EU should have become the "...*most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010*"[2].

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Unfortunately today, the EU is far from the aforementioned vision, as it constitutes an organism composed of 27 economies, very diversified in terms of the level of economical and social development. Huge differences can also be observed in the level of innovativeness of the EU members. Amongst them are world leaders such as Sweden, Finland and Denmark as well as some lesser-developed countries such as Latvia and Bulgaria. The problem of insufficient innovation performance concerns around half of the EU countries. This group includes mainly, but not only, countries integrated as new EU members since 2004.

In order to assess why so many countries are not able to cope with the ambitious goals of the European Union, it is necessary to answer the question: what factors decide about a country's capacity to produce innovations. To do this we can refer to the notion of national innovative capacity ("NIC") introduced by Scott Stern, Michael E. Porter and Jeffrey L. Furman in 2000. NIC was defined as "... a country ability to produce and commercialise a flow of innovative technology over a long term..." [3]. Two elements in this definition should be underlined: (i) the prevailing role of technological innovations, and (ii) the necessary continuity of the innovations' production process over a longer perspective. Stern, Porter and Furman also analyse factors, which determine NIC. They stress a key role of the environment in which potential innovators are operating, i.e. so called innovative infrastructure. This infrastructure includes all institutions and conditions, such as legal authorities, universities, suppliers, supporting institutions etc., which might have an impact on companies' activities. An accumulation of the necessary resources by companies and their performance depend on the quality of elements composing this infrastructure and their interconnections [4].

Summarising the above, when we talk about innovative activities we think mainly about companies introducing innovative technologies, products or organisation concepts due to the creativity of their managers, employees or co-operators. However, it is obvious that talented people and brilliant ideas are not sufficient to make a country innovative. To be successful in this field, it is necessary to establish, using a combination of public and private resources, a system of continuing support for development of prospective inventions from their birth in research centres, through product development, until these products reach market maturity.

In this article we will try to analyse the system of financial support for new technology-based firms in Poland. Poland is the seventh largest economy in the European Union (based on its GDP in 2011) and the largest among its twelve new members. According to the latest Eurostat data for 2011, it accounts for around 3% of the EU's annual GDP [5]. Poland has quite recently survived a transformation of its economical and political system. Costs and side effects of these radical reforms are still a heavy burden on its economy. Today, Poland is one of the least innovative countries in Europe. Its Summary Innovation Index amounted to 0.296 in 2011, which was far below the EU's average [6]. Alternatively, Poland has a rich tradition in engineering science, which gives it a good background for the development of new technologies. The question is how to improve the Polish national innovative system ("NIS") to take advantage of this knowledge and its human resources. We will focus on the financial aspects of the NIS, since weaknesses in this area seem to be the main obstacle for expansion of technology-based firms in Poland. We will analyse this question with a case study of Ammono S.A., a Polish company established to develop and commercialise an original technology for the production of bulk GaN crystals. We will use Ammono's experience in accumulation of financial resources at different stages of its development to identify its strengths, weaknesses and possible improvements of the Polish high-tech financing system.

II. PRESENTATION OF AMMONO S.A.

A. Background

Ammono S.A. was established in 1999 to amplify its founders' research, related to gallium nitride (GaN) crystallisation, carried out at the University of Warsaw, Institute of Experimental Physics. Today, Ammono is a producer of GaN monocrystals, the only material working as a substrate for blue and green lasers. It uses its own proprietary, a highly innovative technology, based on the ammonothermal method of GaN crystallisation. This technology allows them to obtain the best quality GaN crystals in the world, with a very limited number of defects in comparison to materials provided by its competitors. The usefulness of Ammono's GaN has been proven by a number of devices built on these substrates by reputable clients, including a green laser and a world-record-power violet laser. In 2012, Ammono won the prestigious Compound Semiconductor Industry Award for the best product in the category of substrates and materials.

Ammono is successfully building its position in the international scientific and innovation society. Its achievements have been appreciated by the Institute of Electrical and Electronics Engineers (IEEE), the world's largest professional association, dedicated to advancing technological innovation. The IEEE's prestigious magazine, "Spectrum", published an article entitled "The World's Best Gallium Nitride: a little Polish company you've never heard of is beating the tech titans in a key technology of the 21st century". Ammono was said to be "...the greatest success story in materials science..."[7].

B. Development Stages

We can divide Ammono's development so far into three stages characterised below.

1. Stage 1 – Research at the University of Warsaw (1992-1999)

The idea to develop a new method for GaN crystallisation, inspired by the hydrothermal method of mass-producing synthetic quartz crystals, was raised during the PhD studies of one of Ammono's future founders. The development of this innovative concept required exploitation of advanced chemical and physical knowledge. Therefore a special team, which included researchers from both disciplines, was established in order to verify the feasibility of this project. Experiments carried out during this stage proved that the ammonothermal method was able to synthesize a high quality of GaN microcrystals and possibilities for larger crystal growth. As such this method has valuable potential for industrial applications. This resulted in eleven publications and one patent application.

This stage was fully financed from the public budget. Several grants in the total amount of around €120,000 were provided by the Committee for Scientific Research for the project.

2. Stage 2 – Technology development at Ammono sp. z o.o. (1999 – 2010)

Further development of this method directed into industrial application needed substantial investments, which exceeded the capacities of the national public grant system. This forced the project team to find external financing, which required a prior spin off from the University structure. In 1999, the team members decided to establish a limited liability company and actively promoted this project amongst potential investors, i.e. industrial firms with strong R&D orientation. In June 2000, Ammono Sp. z o.o. started a joint research project with Nichia Corporation, a Japanese chemical company and world leader in light emitting diode and laser production. During these 10 years, Ammono Sp. z o.o. managed to achieve the following goals:

- 1) The ammonothermal technology of GaN production was optimised which allowed the company to offer its pilot products on the market. The sale of AMMONO-GaN wafers began in 2009.
- 2) Due to the continuing improvement of the AMMONO-GaN quality, the company's clients achieved spectacular results in laser production.
- 3) The company successfully developed ammonothermal technology in terms of GaN crystals' bulk. The milestone was achieved in 2008 when the company made first 2-inch diameter GaN crystal (the standard size for mass device production).
- 4) The Company obtained several dozen worldwide patents.
- 5) Ammono acquired facilities, which were necessary for its long-term development, which included modern, purpose-designed buildings of 2500m² and 4 hectares of land for further expansion.

The total financing provided by Nichia Corporation over 10 years amounted to around €17 million. Nichia became Ammono's shareholder with a 30% stake. The four Polish founders retaining the remaining 70%.

Since 2007 Ammono has also been a beneficiary of public and European grants totalling around €7 million provided by the Ministry of Science and Education (MNiSW) and the Polish Agency of Entrepreneurship Development (PARP).

3. Stage 3 – Launching of production at Ammono S.A (from 2010)

The further existence and development of Ammono depends on a successful transition of its activity from R&D to large-scale production. The company has to increase the number of currently used autoclaves as well as enlarge its industrial equipment. Since ammonothermal technology is based on original, innovative equipment, such as purpose-designed autoclaves, extension of the company's production capacity will be an expensive and time-consuming process. The minimum budget for this stage III is estimated at €10 million to be invested within the next 2 years. The necessary period for accomplishing this project and generation of financial returns for investors is expected to be 5 to 6 years. In 2011 Ammono transformed itself from a limited liability company, to a Joint Stock Company and started to look for financing on the market. Such financing was provided at the end of 2011 by a venture capital fund established by several Polish investors.

C. Ammono's financing structure from 1999 to 2011

By the end of 2011, Ammono's funding comprised of financing from Nichia Corporation of approximately €17 million (provided as capital increase and purchase of research services), grants from PARP and MNiSW – about €7 million and around €1.5 million income from sales, which altogether totaled €25.5 million. Thus, the financing structure of Ammono's activities between 1999 and 2011 was as presented in the Fig. 1 below.

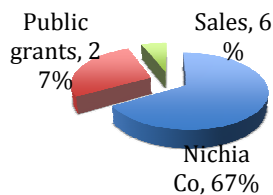


Fig. 1 Financial structure of Ammono's activities in the period 1999 – 2011

Ammono's shareholding structure from December 2011 is: the VC 24%, Nichia 25% and the Company's three founders 51%.

D. Ammono's current situation

Today, Ammono S.A. is an ultra high tech company, whose main characteristics are as follows:

1) They have very innovative products with high renown on the market already, whose unique qualities will only be

fully exploited when used in devices of the future such as versatile laser projectors.

- 2) They possess innovative, complex and original technology protected by several dozen worldwide patents.
- 3) The targeted market is currently estimated at €200 million with a high growth potential.
- 4) Ammono is a relatively large sized company in comparison to typical research-based spin offs in Poland, presently employing 60 people, of which the vast majority are high-level specialists in technology.
- 5) The further existence and development of Ammono depends on a successful transition of its activities from R&D to large-scale production. After three years of investor search and one year in negotiations, the company finally raised financing for the next necessary step in its development.

III. SEARCH FOR FINANCING

The purpose of this chapter is to present Ammono's experience in raising funds for transformation of its activities from R&D to a large-scale production. Since the company's sales are oriented towards the international market, the search for investors was carried out in Poland and abroad. Ammono hired a professional M&A advisor to approach potential financial and industrial investors in Europe, the USA and Asia (especially Japan). We will use Ammono's case to assess the real availability of different kinds of financing for new technology-based firm in Poland.

Theoretically, there are the following main options to raise funding for the company's development:

- 1) Internal financing (founders own capital);
- 2) Debt finance,
- 3) Stock market,
- 4) Strategic/industrial investor,
- 5) Public grants,
- 6) Financial investor, e.g. a private equity and venture capital funds.

A. Internal Financing

As discussed by Murray and Vidhan, according to the pecking order theory, which first appeared in the 1960s and developed in the 1980s, due to lower information costs, companies prefer internal to external finance [8]. For as long as it is possible, founders finance their company's activities with their own capital. In practice, for technology-based firms internal financing is not available, except at a very early stage. In the case of Ammono, high equipment costs required external financing from the very beginning.

Taking into consideration Ammono's shareholding structure, potential capital increase financed by Nichia would now be treated as internal financing. However Nichia, for which manufacturing of GaN crystals is not its core business, prefers to diversify the financing of Ammono's further developments on the basis of external sources.

B. Debt Finance

Referring to ideas included in the pecking order theory mentioned before, as far as external financing is concerned, firms prefer debt to equity [9]. However, in practice this source of financing has to be excluded in such cases, since at present banks are obliged by law to provide loans only if a company has sufficient collateral, which is not usually the case in start-ups.

C. Stock Market

Technology-based firms are often university spin offs and tend to be smaller companies, which have to start to build their position on the market. Thus, they can be financed only by alternative stock markets such as NewConnect in Warsaw. NewConnect has been operated by the Warsaw Stock Exchange since August 2007. It is dedicated to young companies with high growth potential. There are currently 382 companies listed with NewConnect, which account for a total market capitalisation of around €2 billion [10]. Their breakdown by sectors is presented in the table below.

TABLE I
COMPANIES LISTED ON NEWCONNECT: BREAKDOWN BY SECTORS AS OF 31
MAY 2012

| Sector | Number of companies (%) |
|--------------------|-------------------------|
| Health | 5,5% |
| Technology | 7,9% |
| Real estate | 4,5% |
| Media & telcom | 11,0% |
| Investment | 5,8% |
| IT | 9,2% |
| Commerce | 18,6% |
| Eco-energy | 2,1% |
| Financial services | 8,1% |
| Construction | 7,6% |
| Other services | 19,9% |
| Total | 100,0% |

Source: NewConnect, www.newconnect.pl

NewConnect is dominated by firms providing various services, mainly including: commerce, financial, IT, media and telecommunications. The presence of research-based industrial companies is still limited but is becoming more and more visible.

Financing through alternative stock markets seems to be a good solution for technology-based firms but it also has some disadvantages:

- 1) It greatly depends on the market's fluctuations, which, in a period of crisis, are frequent and unpredictable;
- 2) Due to the lack of track records for ultra high-tech projects on the market in Poland, potential investors are very suspicious with respect to such investment proposals. Using Ammono's experience, they need much more information than required by law, which makes the investment procedures similar to the VC types.

D. Strategic/Industrial Investors

Industrial investors possess technical, commercial and organisational know-how, which could make interesting synergies with the target company. Strategic acquisitions have, however, some characteristics, which might be considered by the founders of technology-based firms as inconveniences. Some of these characteristics are as follows:

- 1) In most cases, industrial investors set out to acquire at least a controlling stake in the target company's share capital or even buy out the old shareholders entirely.
- 2) Strategic investors are often big corporations with a slow decision-making processes.
- 3) A necessity to adopt investor's corporate procedures and priorities would limit the target company's flexibility, which may become a restraint for achieving its own goals.

Specifically in Ammono's case, the availability of funds raised by industrial investors was reduced due to the following facts:

- 1) Very few EU companies are able to acquire high-tech material start-ups.
- 2) Unfortunately, Ammono's situation tends to be in a vicious circle, i.e. potential investors are afraid to acquire an unprofitable business but it is impossible to achieve profitability without investments.

E. Public Grants

Public grants have played an important role in the financing of Ammono's activities, especially during the last few years, when the company was looking for a new investor. However this source of financing should be treated only as a supplement because, in the case of a private company, public grants only cover part of the costs related to the project and are paid to beneficiaries with significant delays.

F. Private Equity and Venture Capital

Private equity (PE) and venture capital (VC) funds are potential financial investors, which could provide companies with funding necessary for their further development. VC, at least theoretically, specialises in the financing of early stage and high risk projects. As stated by Wright, they are considered to be a major solution to bridge the so-called equity gap for new technology based firms, including university spin offs, such as Ammono [11]. Crucially, there are numerous factors, which almost certainly limit technology-based firms' access to venture capital financing. Considered most important of them are:

- 1) Asymmetric information with respect to the technology used by the company, which may result from two main factors: (i) companies are never fully open to disclosing details regarding their technology, (ii) even with the relative frankness of entrepreneurs some technical details might be difficult to understand for potential investors. Consequently, as underlined by Munari and Toschi, the latest face difficulties in the evaluation of the concerned investment opportunities and often tend to overestimate potential risks [12].

- 2) An immature business concept, especially in technology start-ups or university spin offs, which might result in difficulties to estimate the appropriate market position of the spin offs, its production costs and amount of funding required [13].
- 3) Insufficient competencies of company staff in some fields. The new technology based firms are often university spin offs, whose staff includes mostly scientists who have high technological knowledge but very often don't make competent CEOs or sales managers. Furthermore, limited financial resources frequently make it difficult to hire the appropriate specialists on the market.

The above-mentioned obstacles are particularly difficult to overcome when the country's venture-capital sector is not mature enough or diversified. According to the European Private Equity and Venture Capital Association (EVCA) in 2010, the total investment carried out by PE and VC funds in Poland amounted to €656.8 million. Only €2.7 million out of this sum were connected with VC projects, including seed, start up and later stage ventures. Nearly 42% of the invested funds went to the sector of consumer goods and retail [14].

There are only around 40 PE and VC firms operating on the Polish market (members of the Polish Private Equity Association). In comparison, Silicon Valley's Venture Capital Directory comprises of several hundred addresses. The analyses of the portfolios of 35 PE and VC capital funds present in Poland (the author's own analysis based on portfolio data communicated by the funds) discovers the following characteristics of the local market:

- 1) Service companies are more wanted by financial investors than industrial ones. In the analysed portfolios 256 out of 338 companies, which equates slightly more than 75%, represent the service sector.
- 2) As far as the service sector is concerned, activities related to computers and e-business attract in particular the interests of investors. Among 256 service companies mentioned above, 94, nearly 40%, actually represent IT, internet and e-commerce.
- 3) The industrial part of the portfolio is dominated by relatively traditional sectors, such as the production of food, construction materials and metal spare parts.
- 4) Investments in high technology industrial sectors, such as pharmaceutical, biotechnology, electronics and aviation are still very rare cases.

Some steps to stimulate the Polish VC market and increase availability of this kind of financing have already been made. In 2005, the National Capital Fund (NCF) was established to encourage VC investments in innovative SMEs, either through investments in the VC fund's equity or through long-term debt financing. NCF is financed by the state budget and EU structural funds. Its targeted projects are VC investments which do not exceed €1.5 million. Therefore, this programme is dedicated to relatively small projects. There is still an equity gap with respect to the funding of larger, but still early-stage technological businesses.

In such an environment it becomes very hard to find financing for long-term, innovative projects in the area of high

technology, and advanced materials in particular, as in the case of Ammono. This problem deepens with increasing technical complications of projects, as this elongates the project's time frame and exposes it to unpredictable market risks. The case of Ammono also demonstrates that, due to the above-mentioned high complexity of modern technology-based projects, the venture capital investment process becomes very time and cost consuming. It comprises detailed due diligence especially technical, IP and the project's feasibility study as well as hard negotiation with respect to division of responsibilities in case the project underperforms.

Ammono finally found financing for the next stage of its development, which is the launch of its production of 2-inch diameter GaN crystals. In December 2011, the company's shareholders signed an agreement with a VC fund, established by several Polish entrepreneurs. The new partner is expected to invest around €10 million over the next 2 years. Ammono's shareholders were forced to accept tough conditions for this cooperation, including a significant discount in the company's valuation. The search for an investor lasted over 3 years, including one year of negotiations of the final investment agreement. During this time the company came to a near standstill and could not develop. It also risked losing its distinct advantages over its competitors. These delays in the completion of potential investment agreements with VC constitute one of the main dangers for technology based firms. In high-tech sectors, time and quick reactions to its markets' needs and turns often decide about a project's success or failure.

G. Financing of Future Expansion

The recently acquired funds should allow the company to transform its activity from R&D to large-scale production. The company also plans to reinvest all its profits in order to achieve this goal. This is the minimum Ammono has to carry out if it wants to defend its position on the market. However, in order to continue competition with international players in high-tech sectors in the near future, it is necessary to think about the company's development on a larger scale. Ammono would have to launch a new investment project related to the production of its 4-inch diameter GaN crystals as soon as possible, and at least an R&D programme regarding its 6-inch diameter GaN crystals. Therefore, the company will need to increase its funding in the nearest future.

A successful launch of the production of 2-inch diameter GaN crystals would enforce Ammono's position on the market and in this way improve the company's credibility vis-à-vis potential investors. However, this project will last for at least two years and the search of further funding needs to start earlier in order to benefit Ammono's technological advantages over other GaN producers. The fact that the production of high quality, bulk GaN crystals is technologically so advanced and complicated it would still classify Ammono's case as a high risk project. Which is why searching for additional financing the company would probably face the same problems, which had happened over the previous three years.

IV. VALLEY OF DEATH IN POLAND

Commercialisation of a new technology is always

connected with high-risk exposure. On one side, the transition from production of test-series to commercial volumes of products requires time and significant investments. On the other, even if a product is appreciated on the market when sold in its pilot series, we still cannot be sure about the true final demand for it. Potential buyers are not ready to commit themselves to the product until they see it on the market [15]. This rule is particularly tough with respect to semi-products dedicated for further industrial use. In such cases, potential buyers must be sure that the product will be available in sufficient quantities before they decide to consider it as substrate to their own production. It is very difficult for small and medium-sized enterprises to share this risk and this fact is considered as a major barrier for the commercialisation of new technologies.

There is the notion of the "valley of death" used to define a difficult situation experienced by technology based SMEs, when their needs for funds rapidly increase but their sales are minimal. Usually this is the period between the moment when public support for R&D ends but the business concept is still not mature enough to be financed by venture capital, mergers and acquisitions or other strategic alliances [16]. In light of the above, two factors seem to determine the length of this valley: (i) the scale and continuity of public support, and (ii) the level of development of the financial sector.

In the case of Poland, this "valley" is much longer than in greater developed economies. There are programmes of grants, sponsored by the Polish budget or EU structural funds, dedicated to innovative projects. Their rules and conditions are structured in a way that allows financing of numerous initiatives at quite an early stage of their development. Such funding is very dispersed and ends relatively quickly. Alternatively, with the development of capital and financial markets some new opportunities of financing are gradually appearing. They generally target small projects with limited risks (e.g. NCF mentioned before) or large, stable and rather traditional businesses (VC and PE). There is still a huge equity gap especially with respect to advanced technology based projects. They are associated with larger investments and higher risks but have potential to develop into truly innovative companies, even worldwide players. They could then contribute to the creation of an ultra high-tech industry. We cannot expect that the still underdeveloped Polish capital market could entirely take charge of the financing of such projects in the nearest future. Hence, there is a strong and immediate need for an active participation of public budgets, national and/or European, to fulfil all of the above mentioned equity gaps.

There are numerous options for the public budget to support development of technology based firms, including

- 1) 100% publicly owned funds or public-private funds, which co-invest directly in companies, with investment policies adapted to larger projects.
- 2) Leverage deals made by privately owned and managed investment funds that use their own capital plus funds borrowed with public guarantees, e.g. SBIC in the USA.
- 3) A guarantee scheme with respect to bank loans for technology-based firms, reducing the risk of loan providers in cases of bankruptcy or low returns.

This last option has been applied even in countries with well developed VC markets. We can use as an example the US Energy Department dedicating a huge budget to loan guarantees for the solar industry in 2011.

V. INNOVATION PERFORMANCE OF THE NEW EU MEMBERS

The innovation performance has a special importance for the new EU members since it is considered as a key driver for their economical convergence within the EU. Unfortunately, in most cases, the achievements of these countries in the field of innovative and technological development are still far from expectations. As presented in Table 2 hereafter, the innovation performance of new EU members, measured by the Summary Innovation Index (SII), which was introduced by the European Commission for comparative purposes, is lower than the average calculated for all the 27 EU countries. In some cases, namely Slovenia and Cyprus this distance is not very long but in others, for example Bulgaria and Latvia, it is huge.

The composite of SII, which refers to financing and support for innovative activities also demonstrates significant differences among the new EU members. In 7 out of 12 countries the value of this index does not exceed 50% of the average calculated for 27 EU countries. As far as VC financing is concerned, in many countries the respective data is hardly available which is mainly a consequence of the fact that the VC sector in these countries is still immature. In other cases, the published data reveals huge distances in terms of VC availability between these countries and EU leaders. The Venture Capital Investment index (VCI), which presents the value of VC financing as a percentage of GDP, amounts to 0.065 in Sweden and 0.059 in Denmark and only to 0.004 in Poland. The above mentioned facts prove that financing systems of innovation activities in the new EU members need restructuring and reinforcing.

TABLE II
NEW EU MEMBERS: INNOVATION PERFORMANCE AND FINANCING

| Country | SII 2011 (*) | Finance and Support (*) | VCI 2010 (**) |
|-----------|--------------|-------------------------|---------------|
| Bulgaria | 0.239 | 0.156 | 0.009 |
| Czech Rep | 0.436 | 0.290 | 0.008 |
| Estonia | 0.496 | 0.677 | na |
| Cyprus | 0.509 | 0.219 | na |
| Latvia | 0.230 | 0.250 | na |
| Lithuania | 0.255 | 0.438 | na |
| Hungary | 0.352 | 0.251 | 0.018 |
| Malta | 0.340 | 0.115 | na |
| Poland | 0.296 | 0.341 | 0.004 |
| Romania | 0.263 | 0.235 | na |
| Slovenia | 0.521 | 0.552 | na |
| Slovakia | 0.305 | 0.229 | na |
| EU27 | 0.539 | 0.584 | na |
| EU15 | | | 0.029 |

Source: (*) "Innovation Union Scoreboard 2011: Research and Innovation Union scoreboard", INNOMETRICS, European Union 2012

(**) Eurostat: http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/main_tables

VI. CONCLUSIONS

There is a stock of technological knowledge and inventions accumulated within universities, high schools, research centres and companies within new EU members. It should constitute a growth factor for these economies and accelerate their convergence with the more developed countries. The important question is how many of these inventions translate into innovative applications. Also, how often will research activities result in valuable commercial products and how far could research based companies develop? Investments in research would have a material impact on economic growth if a country was able to introduce efficient mechanisms of technological knowledge transfer from a scientific sector to industries. These mechanisms should constitute a key part of a National Innovative System and should be based on public and private resources. It is very important to apply systematic and complex solutions to this matter. Market mechanisms should be stimulated and completed by economic policy instruments to secure continuity of the innovative processes from knowledge generation through technology development and industrial application until the products' and companies' expansion.

Various factors determine the efficiency of technology transfer and its spread into the economy. Amongst them a key role is attributed to the high-tech financing system. This is due to the high complexity of modern technologies, which in turn results in an increase in costs of their development. The high-tech financing system in Poland is based on two pillars: public and private. The first one is the distribution of limited resources among a large quantity of beneficiaries, which means that it is adapted to relatively small projects. The second is characterised by still limited openness for risk exposure, which means that it is dedicated to quite safe and traditional sectors. We could say that the engagement of public administrations ends at some point although private institutions are not ready to replace them yet. In consequence, the system is not able to transfer technological knowledge into real economical value and generate "Polish Nokias" - stable, global players in high-tech sectors..

In countries which are still developing, such as Poland, public budgets should play a longer active role in the financing of high-tech projects than in more developed economies. They should use a range of innovation policy instruments, for example loan guarantees, in order to bridge the large "valley of death" for technology based companies, until their market position is mature enough to compete for funds on financial and capital markets. This is a necessary condition to build new development potential for these countries, based on knowledge and technologies.

The lack of solutions for this problem will have the following consequences:

- 1) The stream of new ideas and technologies, which should feed the national innovative systems of these countries, would be too weak.
- 2) Knowledge produced by the scientific sector, and resources invested in its production, would be useless for national economies and risk being relocated abroad.
- 3) The convergence process within the EU would be too slow or even eventually come to a grinding halt.

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