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THE NATIONAL INNOVATION SYSTEM OF THE REPUBLIC OF MACEDONIA

Abstract: This paper reviewed the current status of the National Innovation System (NIS) in the Republic of Macedonia, its key elements and inter-relationships. There are interacting groups of actors defined in terms of the public and private sectors and their roles as „knowledge creators" or „knowledge users." Each sector is also characterised by a dominant issue in STI, such as: (a) The supply of and demand for qualified human resources (Social and Human Capital); (b) The knowledge base (Research Capacity); (c) The ability to innovate (Technology and Innovation Performance); and (d) The capacity of markets to absorb and diffuse innovations (Absorptive Capacity).

Author assessed government strategies and policies that are targeting above-mentioned NIS elements, furthermore they detailed picture „key players" from „knowledge creator" area in the Republic of Macedonia. Mayor weaknesses that are recognized for relatively limited NIS performances are: (1) lowest government investment in research and development (R&D) ever (only 0.18% of GDP in 2007); (2) very narrow interest and investments by business sector for R&D activities (less than 6% of overall investment for R&D); and (3) decreasing interest for youngsters to study science and engineering, even the number of universities, faculties and programs are growing.

The paper culminates in a series of recommendations for policy intervention that can be considered for strengthening NIS, with a focus on: increasing investment in R&D, strengthening educational system with focus on science and engineering area, introducing technological/industrial development zones, establishing science parks, promoting of R&D benefits to SMEs, strengthening the science-business interface, developing R&D human capital and reducing the „brain drain", intensifying international cooperation, increasing technology dissemination, promoting intellectual property rights and creating R&D tax incentives.

Key words: *National Innovation System (NIS); Science, Technology and Innovation (STI); Research and Development (R&D); Small and Medium-size Enterprises (SMEs); Knowledge based Economy.*

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INTRODUCTION

It is now widely acknowledged that Science, Technology and Innovation (STI) are key factors in building competitive, knowledge-based economies. The creation, diffusion and exploitation of scientific and technological knowledge are key means of enhancing economic growth and productivity, thereby contributing to enterprise competitiveness. Moreover, „science" and „technology" are different but mutually reinforcing bodies of knowledge, created by very different institutions and actors. Although they share features such as a dependence on imagination and creativity in the solution of problems and cumulative accumulation of knowledge, they are also different (Metcalf, 2000).

In reality, however, modern science and technology are becoming increasingly interdependent. New developments in science open-up new opportunities for technology and vice versa, with the consequence that many firms are increasingly involved in pure scientific research. This is increasingly encouraging public-private partnerships.

Turning to the issues of „innovation," this involves more than just knowledge of science and technology *per se* and requires us to distinguish an invention (formulation of a working idea for a product or process) from an innovation (application of that idea to the economic process). Innovation is the successful application of a new idea, often involving new technologies or applications. Among other things, it delivers better products and services, cleaner and more efficient production processes and better working models. For firms, it means higher growth and greater profitability. For society, innovation is critical to greater productivity, competitiveness and prosperity.

For innovation to take place, it is necessary to know what potential users demand in a product and how much they are willing to pay. The production process must be organised, the inputs must be acquired and the activity managed. In other words, „entrepreneurship" is required to bring together the market opportunities with the scientific and technological opportunities. Innovations tend to be incremental improvements in current practices and products, however, a small sub-set are „radical" in nature, opening-up new fields or opportunities. The wider application of an innovation happens through a process of „diffusion" so it is essential for firms to sustain their innovative trajectory, rather than simply seek one-off innovations. In this context, the target of policies designed to unleash innovation is opportunities, incentives, resources and management capabilities.

Finally, the „absorptive capacity" of SMEs is of importance, as it influences economic growth and employment. The absorptive capacity refers to the ability to create new knowledge through investment in such new knowledge and the ability to identify the most appropriate technology to be assimilated from existing ones available to firms. It is especially important to both countries and firms that may be lagging, such as small countries such as the Republic of Macedonia that generally do not produce the technology that they exploit. For the absorptive capacity to be effective, it is necessary for firms to i) have an existing capacity for change (a stock

of knowledge within the firm) ii) integrated research organisations (mobilisation, coordination and integration of knowledge between firms, research institutions and universities) and iii) human capital (adequate quantity and quality of scientists and engineers engaged in research engaged in production of goods and services).

Innovation systems theory defines „systems" in terms of a number of „actors" and stresses that the relationships between them and system performance is often determined by the weakest link in the chain. This means that policy interventions should focus on the weaknesses. Systems theory also suggests that individual policy instruments applied in isolation are unlikely to have a dramatic impact on overall system performance. In complex systems there are likely to be many weak links and accurate targeting of an individual weak link will only produce incremental improvements unless other weak links are also addressed. The policy implication is that there is a need for a broad range of policy instruments, rather than a focus on any one aspect. This also suggests the need for frequent experimentation and evaluation of single instruments and combinations of instruments, with the results continually feeding into the policy formulation process. Figure 1 presents a simple innovation system comprising four interdependent sectors, taken from Guy and Nauwelaers (2003). There are interacting groups of actors defined in terms of the public and private sectors and their roles as „knowledge creators" or „knowledge users."

– The supply of and demand for qualified human resources (Social and Human Capital).

– The knowledge base (Research Capacity).

– The ability to innovate (Technology and Innovation Performance).

– The capacity of markets to absorb and diffuse innovations (Absorptive Capacity).

There has been a shift in our understanding of the relationships between STI and their link to economic development, while there is up-going discussion of National Innovation Systems incorporating the key actors and activities in the knowledge production and absorption processes necessary for innovation to take place. It is also increasingly acknowledged that economic growth and competitiveness are founded on well-functioning NIS in which all actors, both market and non-market institutions, need to perform well. This applies to research and higher education institutions, businesses, the public sector, as well as households as consumers of sophisticated goods.

Such innovation systems exist at different levels: global, regional and local networks of firms and clusters of industries. These systems may or may not be confined to a country's borders but national characteristics and frameworks play a key role in shaping them. The concept of NIS is thus a tool for analysing country specificities in the innovation process in a globalised economy, as well as a guide for policy formulation. It highlights interactions and interfaces between various actors and the workings of the system as a whole, rather than the performance of its individual components. NIS thus focuses on three complementary approaches: micro, meso and macro level.

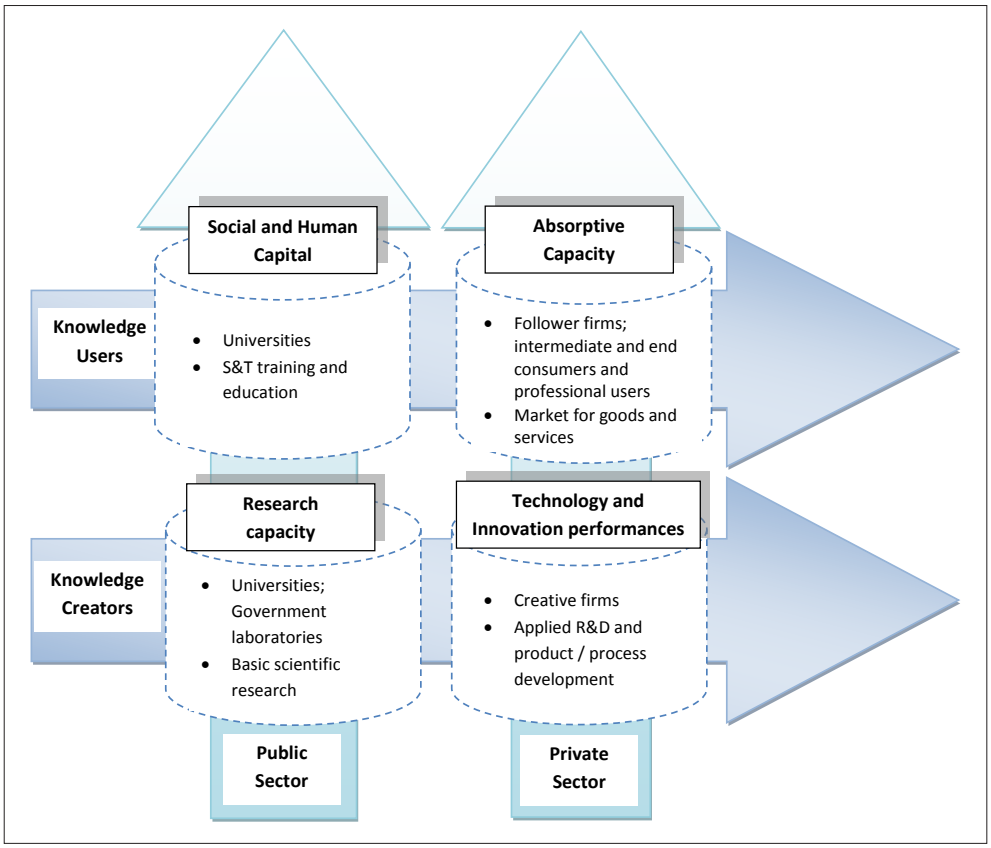

Figure 1. Issues, Actors and Activities in a Simple NIS System
[Source: Guy and Nauwelaers (2003)]

A key issue in the STI debate is the necessity to monitor and evaluate the performance of specific countries in terms of their STI progress. In this context a key development has been the creation of benchmarking tools, such as the scoreboards (see OECD, 2005; EU, 2009). The *European Innovation Scoreboard* (EIS) is an instrument developed by the EU to evaluate and compare the innovation performance of the member states. The latest EIS report (EU, 2009) includes innovation indicators and trend analyses for the 27 EU member states, as well as for Turkey, Iceland, Norway, Switzerland, Croatia, Serbia, US and Japan. The revised list of indicators and the methodology capture additional dimensions of a country's innovation performance. Macedonia in 2010 for a first time conducted extensive survey and analysis of relevant sources in order to be included in the EIS 2010 report (Polenakovik et al, 2010).

EVALUATION OF THE NATIONAL INNOVATION SYSTEM IN THE REPUBLIC OF MACEDONIA

Public Sector „Actors" for STI Issues

There are two types of actors in the public sector:
• Those responsible for STI policy creation such as:
– Government.
– Ministry of Education and Science (MoES).
– Other Ministries (Economy (MoE), Agriculture, Information Society, etc.)
– Macedonian Academy of Science and Arts (MANU).
– Others (such as universities, professional associations, etc.).
• Those responsible for implementing STI policy (e. g. MANU, public scientific institutions, higher education institutions, innovation and technology transfer centres, State Office of Industrial Property, etc.)

Institutions responsible for STI policy

Governmental bodies currently do not take sufficient account of the importance of the scientific and R&D sector during the processes of making key decisions. With the exception of the MoES, and to some extent the Ministry of Economy and Ministry of Agriculture, ministries rarely seek to use the full scientific and R&D potential available.

The *MoES* is responsible for policy development and monitoring of implementation of activities relating to science and R&D, however, it is evident that it has failed to assist the Government of the Republic of Macedonia to recognize that science and R&D as being among the key strategy priorities essential for to long term economic development of the country. Regarding the legislative issues, MoES passed:
– Law for scientific-research activity (2008);
– Law for the Macedonian Academy of Sciences and Art (1996/2009)
– Law for encouraging and facilitating technological development (2008);
– Law for encouraging and assisting the technical culture (2000).

While programming function of MoES are determined by:
– Programme for scientific research.
– Programme for technological development.
– Programme for technical culture.
– Strategic documents in the state related to science (and education).

The MoES's activities are currently largely restricted to co-financing activities such as:
– Developmental and innovation projects (up to 30% of total cost).
– 45 scientific journals per year.
– Publication of ca. 200 scientific books per year.
– Participation in ca. 50 domestic scientific conferences.
– Participation in international conferences, seminars, etc. (500 people).
– International study visits for ca. 100 young scientists.

– Budget funds (~ 1.000.000 EUR / year for scientific projects.

The effects of these scientific and R&D-related activities on the national economy are not clear since there is no direct relationship between investment and economic impacts, hence the reason for independent evaluation.

In the last several years *Ministry of Economy* started to play more significant role in the NIS. Through its sectors for (a) Industry and (b) SME development and competitiveness, in the last few years several important strategies/programs were introduced

– Industry policy 2009-2019,

– SME strategy 2010 – 2013,

while process of development of national innovation strategy (2010 – 2020) started at the end of 2010 (with OECD support). MoE, also supports applied project for clustering, business incubators, introduction of ISO, HASSAP, and other standards, etc.

MANU is the primary national institution to promote the development of science, research, innovation and new technologies, both in the country and internationally. However, MANU is facing serious problems such as lack of funding, low level of human capital, outdated equipment, etc. with the consequence that it is not in a position to fulfill its role satisfactorily.

Other organisations, such as the Association for Popularization of Technical Culture, Independent Union for Education, Science and Culture, etc. possess neither the interest nor the capacity to handle STI issues. The Associations for Popularization of Technical Culture lack both human capital and facilities. Although they organise competitions at the primary and secondary school levels, they are unable to nurture talented young people.

Institutions responsible for implementation of STI policy

MANU implements its activities through five departments (Linguistic and Literary Sciences; Social Sciences; Mathematical and Technical Sciences; Biological and Medical Sciences; and Arts) and five research centres (Research Centre for Genetic Engineering and Biotechnology, Research Centre for Energy, Informatics and Materials, Centre for Strategic Research, Centre for Linguistics and the Lexicographical Centre). The first two centres are internationally recognised for their research, but there is an overlap in the focus of the other three centres and other scientific institutions such as the Institute of Economics, Institute for Sociological, Political and Juridical Research, Institute for Macedonian Language and Institute for Macedonian Literature. MANU's difficulties are compounded by the fact that researchers and scientists are not always allowed to apply for MoES research projects.

On the level of higher education in the Republic of Macedonia there are:

– State universities (5) with 60 faculties.

– Public research institutions (7).

– Private universities (18) with 79 faculties, and

– Independent researchers (21).

The public research institutions are members of the public universities but, with few exceptions, are unable to provide graduate and postgraduate education since their main activity is research. Only the Institute of Earthquake Engineering and Seismology and to some extent the Hydro-biological Institute have been able to establish themselves at the international level. The institutes in the biotechnology area (Institutes for Veterinary Science, Agriculture and Tobacco) have met some success in developing new products and processes but because of low level of support from the Ministry for Agriculture for their work, the results remain unsatisfactory. As it can be seen from the Table 1, the significant number of researcher is coming from Higher education institutions. Main reasons for the low number of R&D staff in the business sector include the fact that the majority of businesses are in very bad shape and have limited financial muscle to devote to R&D investment and research staff. To this must the added the belief by managers that they can make do without R&D staff. They fail to understand the nature of the relationship between R&D investment and company competitiveness and profitability

Table 1. Number of R&D related staff in the Republic of Macedonia [Source: MoES (2009)]

R&D staff \ Year	2003	2004	2005	2006	2007
Business sector	67	136	158	78	79
Government sector	829	754	754	671	668
Higher education	1693	1662	1730	1624	1647
Total	2589	2552	2642	2373	2394

Five public universities educate some 60,000 students. Although they combine education with science and research, the level of contact with industry is insufficient. Research and scientific papers are used by the scientific and research staff primarily for the purpose of career development. The weak link between the universities and the economy has been noted in the past and continues to be an issue. In the preceding twenty years, universities have been seeking to offer education programmes that are integrated with the needs of the high technology industry as well as the wider socio-economic environment. Furthermore, universities are aiming to take a lead role in relation to the economic development of the country. This is difficult to achieve. Universities continue to struggle with many basic problems such as outdated curricula and old fashioned teaching methods that are still not in line with the requirements of the Bologna process; there is insufficient coordination between faculties; they have redundant equipment and facilities; the salaries for teaching staff remain unattractive; there are limited employment opportunities for young teaching and research staff, etc. The lack of linkage between universities and the business sector, combined with an absence of employment opportunities for qualified staff intensify the ongoing brain-drain (Polenakovik & Pinto, 2010).

The State Office for Industrial Property (SOIP) is responsible for the IP protection system in the country. Analysis by the SOIP shows that the industrial property rights are improving (see Table 2). The SOIP is promoting creativity and inno-

vation through initiatives such as the International Intellectual Property day, the Patent of the Year, Makinova, participation in international exhibition of ideas/inventions/new products, etc.

Table 2. Intellectual property rights (2006-2009)
[Source: State Office for Industrial Property (2010)]

Industrial Property Numbers / Year	2006	2007	2008	2009
Total number of patent applications	462	528	440	422
National	53	145	34	39
Foreign	409	383	406	383
Total number of trademark applications	1290	979	1822	1433
National	322	278	620	791
Foreign	968	701	1202	642
Total number of registered industrial design applications	42	37	42	30
National	32	34	26	23
Foreign	10	3	16	7
International registrations according to the The Hague agreement for registration of industrial designs	773	979	1022	729

In the Macedonian R&D sector, 53.4% of researchers are female, however, a pressing issue is the fact that this human capital rapidly ageing. Although data are scarce, the fact that those defending their PhD theses are typically in their 35 s and 40 s, combined with the very low level of young scientists entering R&D institutions because of Government budget restrictions and the process of external (leaving the country) as well as internal „brain drain" (leaving R&D institutions because of low salaries, prospects and equipment), are some of the indicators of the maturity of scientific human resources. Significant numbers of the brightest and most able young researchers are leaving country in the hope of finding better work and living conditions. Young scientists should be encouraged to exchange experiences with their international colleagues, but they should also have an incentive to remain/return to their country of origin. Incentives a required to achieve this whilst at the same time recognising that the freedom to travel should not be restricted.

Assessment of private Sector „Actors" for STI Issues

The private sector is the key driver of economic development. Unfortunately in the last 20 years (from its independence) the link between R&D and the business sector has been tenuous at best. Private companies have failed to show an interest in participating in the creation of STI policy, although in reality neither Government nor academia have provided a challenge to the business sector to get involved in STI policy development.

Total number of Macedonian companies (end of 2009) was 101323**,** while number of active companies was 70710 [Source: Central Registry of Republic of Macedonia, 2010]:

– Micro (<9 employees): 59398.
– Small (10-49 employees): 3706.
– Medium (50-249 employees): 1159.
– Big (>250 employees): 204.

Business sector (companies) are organised in 4 main Chambers:

– Economic chamber of Macedonia.
– Association of chambers of Macedonia.
– Economic chamber of Northeast Macedonia.
– Chamber of small businesses.

The most active business association are the Macedonian Economic Chamber of Commerce and Association of Chambers of Commerce, however, neither has yet to initiate a project in related to R&D and innovation. Some activities, such as standardization, quality improvements, clustering, etc., are primarily donor-driven and designed to enhance the competitiveness of domestic firms, but these have not had a specific STI focus. On the company level, unfortunately, only few companies have their R&D departments (Alkaloid, Stobi, Skovin, Tikves, Mikrosam, HI-Tech corporation, Plasma, Veda …). R&D expenditure by firms is typically considered a cost without due consideration of the long-term effects of innovative products, processes and services resulting from R&D activities. According to data from recently conducted CIS 4 (community innovation survey) only 18 % of surveyed 2000 companies had introduced innovative products or services in the last 3 years (Polenakovik, et al., 2010). This figure illustrates low awareness for innovation, as well as low priority currently accorded to R&D by the business sector.

Macedonia boasts many professional associations, such as various engineering association, physicians' association, etc. These frequently deal with issues relating to science and its application in practice. The most notable body in this respect is the Association of Inventors, an organisation that is directly involved in STI issues by promoting innovations, organising manifestations and workshops on STI topics.

Private universities also form part of the private sector „actors". Private faculties and universities started 10 years ago and are growing rapidly. But, their common characteristic is the fact that they are primarily oriented towards education rather than R&D. A notable exception is the University of South East Europe, where the Centre for Business Development is seeking to close the gap between academia and business by transferring know-how from the university to the local economy.

Research and Development (R&D) expenditures

The overall conclusion of the current status of STI in the Republic of Macedonia is that it has been largely marginalized in the twenty years since the country became independent. The percentage of Gross Domestic Product (GDP) devoted to the R&D in 2003 was only 0.22%, compared with neighboring countries such

as Serbia 0.32%, Bulgaria 0.5%, Croatia 1.10% and Slovenia 1.53%. Moreover, although in above-mentioned countries this percentage has been constantly increasing, the equivalent figure in the Republic of Macedonia was only 0.18% of GDP in 2007 as illustrated in Table 3.

Table 3. R&D expenditure as a percentage of GDP
[Source: Ministry of education and science annual report (2009)]

Costs \ Year	2003	2004	2005	2006	2007
% of GDP for science, research and development	0.22	0.25	0.24	0.21	0.18
Participation of the business sector for R&D / GDP	0.003	0.015	0.03	0.03	0.04
Funds from the state budget for R&D / GDP	0.14	0.12	0.11	0.10	0.09
Participation of the higher education for R&D / GDP	0.08	0.11	0.10	0.08	0.05

Of greater concern is the fact that R&D expenditures are primarily coming from either the higher education (28%) or governmental sector (50%), with only 22% coming from the business sector compared with the EU practice where the latter participates with ~ 65%. But, it is positive that this percentage is increasing in the last few years (only ~ 2% in 2003). This low level of investment in R&D by the private sector is explained by the fact that after 1990 there were significant losses in the Yugoslav and East and Central European market, and numerous large industrial complexes disintegrated, leading to large numbers of bankruptcies and layoffs. Many of the largest companies, often with their own R&D departments, disappeared and their technical staff had to carve out new economic roles for themselves.

Summary of the Macedonian NIS

The Republic of Macedonia is experiencing constrains in relation to STI policies which are similar to those of other SEE countries since gaining independence. The country has a very high rate of unemployment (36%), experiences a massive level of emigration, is undergoing a process of industry restructuring, runs major trade deficits and attracts very low level of investments, both foreign and domestic in nature. To illustrate the situation, the Republic of Macedonia has yet to attain the same level of GDP that existed prior to gaining independence. In 2003, the level of GDP was a mere 78% of 1989 level (EBRD, Transition Report, 2004).

Another obstacle for low level of investments (especially from business sector) is not well developed financing sector. Currently (situation in 2010) there are 18 commercial banks and 8 saving houses (www.nbrm.mk) that are supporting business development. There are also few foundations like, George Soros (Open Society), or Macedonian Enterprise Development Foundation, but main bank that is supporting business development is Macedonian Bank for Development Promotion. The investment funds (14 in total), are not well developed and although have total venture capital of 275.000.000 EUR, they are investing only symbolically in the companies. Macedonia still do not formally have Business Angels Network, but there is national wide consensus among key „players" for establishment

of this type of network. Also, there is no established innovation fund yet, but there are attempts by the Macedonian Innovation Centre with USAID support to establish this fund in near future. Another possibility that must be exploiting in more details and widely promoted are international programs like: CIP, IPA related programs, FP 7, COST, EUREKA, Transnational programs, Bilateral programs (country to country), UNIDO, UNICEF, World Bank, OECD, Donor driven programs (USAID, ADA, GTZ, SIDA, …).

The Republic of Macedonia is experiencing constrains in relation to STI policies which are similar to those of other SEE countries since gaining independence. The country has a very high rate of unemployment (36%), experiences a massive level of emigration, is undergoing a process of industry restructuring, runs major trade deficits and attracts very low level of investments, both foreign and domestic in nature. To illustrate the situation, the Republic of Macedonia has yet to attain the same level of GDP that existed prior to gaining independence. In 2003, the level of GDP was a mere 78% of 1989 level (EBRD, Transition Report, 2004).

Therefore, main problems of Macedonian NIS can be recognized as a:

– Not clear responsibility who will run NIS in Macedonia (there is already established dialog and base between MoE and MoES, but it must be officially structured).

– Lack of national innovation strategy.

– Very small % of GDP devoted to R&D.

– R&D is focused only within few Faculties.

– Only isolated best practices (Institute for Chemistry, Faculty for Agriculture, Faculty for Mechanical Engineering, YES Incubator, BSC Bitola, …).

– Weak links with international R&D partners.

– Lack of innovation network.

– Lack of innovation fund and venture capitalists.

– Business Angel Network is missing.

– Lack of tax incentives for R&D investments.

CONCLUSION AND RECOMMENDATIONS

Better performance in relation to science, technology and innovation would assist the process of transition and attainment of higher levels of economic growth. However, the Republic of Macedonia lacks a well defined NIS with clear and well articulated relationships between science, technology and innovation, and their link to economic development. Since economic growth and competitiveness are partly founded on a well-functioning NIS in which all actors, market-oriented and non-market institutions need to perform efficiently, an extensive evaluation of NIS is needed in order to highlight the interactions and interfaces between various actors and the workings of the system as a whole, as well as how it could be improved.

Summarizing the overall Macedonian NSI, key STI infrastructure, beside MoES, MoE, other Ministries MANU, and Universities is:

– 20 development and research units in the economy.

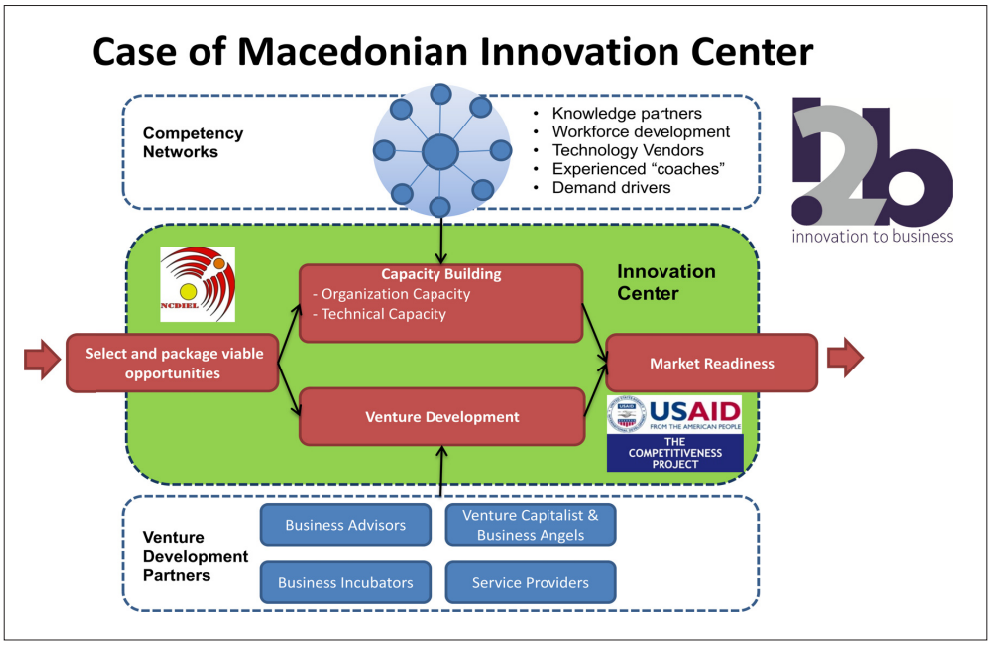

Figure 2. Recently established Macedonian Innovation Centre

– Several Technological cores: Natural Sciences and Mathematics, Mechanical Engineering, Faculty of Medicine; Institute for Chemistry.

– Centers for transfer of technologies: Faculty for Mechanical Engineering, Faculty of Agriculture and Food, Technical Faculty in Bitola and Faculty of technology and Metallurgy.

– NCDIEL – National Centre for Development of Innovation and Entrepreneurial Learning [Funded by Austrian Development Agency in 2009].

– IC – Macedonian Innovation Centre [Funded by USAID in 2010] (Figure 2).

– European Enterprise Network [Funded in 2008 by EU (IPA funds) and Government of Republic of Macedonia (EEN is located at the University Ss. Cyril and Methodius with branches at Agency for entrepreneurship promotion and Economic Chamber of Macedonia)].

– 2 University business start-up centers and 4 business incubators.

– 1 private technology park – SEAVUS company (under construction).

– Plans for several techno – parks: ERA city (science park); MASIT – ICT Chamber (plans for IT park); Faculty Faculty of Mechanical Engineering (technology park).

– R&D centres – only in few companies.

– Association of inventors.

Therefore main challenges for governance of innovation, for development of solid Macedonian NIS are:

– To increase investments in R&D (Facilitate discussions to encourage the Government to adopt a target of 1% of GDP to be invested in R&D by 2015).

– To determine inter – ministerial group responsible for development of innovation policy.

– To prepare efficient ten-year innovation strategy.

– To recognise and finance most proactive innovation drivers (both public and private).

– To strength capacity of public institutions that deals with STI related issues.

– To reverse brain drain of high educated people (stronger relations with wide spreaded Macedonian researchers).

– To establish technology parks, business incubators, entrepreneurial villages, etc.

– To develop tax incentives for R&D investments.

– To be included in regional innovation policies / strategies.

– To allow to younger researchers to apply on EU mobility programs (better promotion of programs in Macedonia).

– To create national and support regional innovation + patent fund.

– To make wider promotion of innovation (schools, media, etc.).

SMEs are at the core of a well articulated NIS and they should be utilizing the benefits of a well-developed system. This is currently not the case in the Republic of Macedonia. The lack of clear responsibilities of NIS actors means that the relationship between them and SMEs are the weakest point in the system. Much more needs to be done to increase the SMEs' role in relation to the NIS. A key issue would be promotional activities designed to raise the awareness level among SMEs of STI issues, combined with the direct benefits to the company arising from R&D activities. Reinforcing SMEs capacities in relation to STI issues should translate into enhanced NIS performance. In order to strengthen the SME sector in relation to STI issues, a number of above mentioned policy recommendations must be implemented.

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