THE KNOWLEDGE TRIANGLE IN MOLDOVA

Contents:

1. Introductory aspects of the knowledge triangle in Moldova

This study has been produced as part of the "Fostering the Knowledge Triangle in Belarus, Ukraine and Moldova" *(FKTBUM)* project, which aims at developing the so-called target specifications or project plan of the knowledge triangle (Pflichtenheft) in partner countries – Belarus, Ukraine and Moldova – in order to contribute to speeding up the development of the three sides of the knowledge triangle (education, research and innovation) and their integration into knowledge-based economy development policies.

a) Specific objectives of the TEMPUS-FKTBUM project:

- Establishment of a system of knowledge for the leaders of higher education in Belarus, Moldova and Ukraine concerning modern approaches to the organization and management of the knowledge triangle;
- Analysis and identification of challenges in the process of efficient integration of higher education, research and innovation in partner countries;
- Development of measures for long-term use of the project and for support of the knowledge triangle by Belarus, Ukraine and Moldova;
- Initiation of national processes in order to establish a legal framework to speed up the process of integration of higher education, research and innovation in Belarus, Ukraine and Moldova.

Project objectives that coincide with the topics and priorities of the Tempus program also include:

- Promoting modernization of education systems in partner countries;
- Promoting improvement of the quality of higher education in partner countries;
- Broadening the education opportunities of universities in partner countries and in the EU, international cooperation, capacity to modernize;
- Promoting human resources development;
- Creating contacts between education and research institutions in partner countries and the EU;
- Promoting understanding between different cultures from the EU and partner countries; etc.

b) Abstract scheme of the knowledge triangle

The contribution of higher education to employment and economic growth, as well as its attractiveness at international level, can be increased by means of establishment of **close and efficient ties between education, research and innovation** – the three sides of the "knowledge triangle".

The knowledge triangle is a priority in the process of creation of globally innovational society on the basis of development and integration of the three elements of the knowledge triangle (education, research and innovation), as well as capital investment into human resources, development of professional capacities and support of scientific research, ensuring modernization of education systems, etc., so that they become more relevant for the needs of a knowledge-based global economy.

The theoretical model in figure 1 (which is a basic model of the knowledge triangle promoted by FKTBUM coordinators) coincides with the perfect abstract scheme of the knowledge triangle.

Figure 1. Theoretical model of the knowledge triangle

The abstract scheme of the knowledge triangle (KT) reveals the indispensable need and vitality of the interdependence between KT stakeholders for the country's competitive development and knowledge transfer to society and economy. The interaction between KT stakeholders is realized via 3 channels, each of them being double-directional:

1. *Relation/interaction between research and higher education.* In this relation, the functions of the stakeholders involved in research activities consist in transfer of new knowledge and results of the research process to higher education, development and provision of scientific and methodological knowledge and new methods of its application, etc.

Meanwhile, the role of the stakeholders involved in education is to define qualifications for researchers, identify research areas for graduates and coordinate their research projects, etc.

2. *Relation/interaction between research and innovation.* This relation involves several stakeholders, with distinct functions each.

For example, research and its stakeholders should provide to companies the newest inventions, know-how for using them, as well as provide services of expert examination and feasibility in various fields, etc.

In their turn, companies determine and define directions for research, determine the economic parameters for application of research results, and apply the results that promise to be profitable, etc.

On the other hand, the institutions promoting technology transfer perform the function of intermediary between research and real economy.

At the same time, organizations that provide support to companies create and ensure the necessary conditions for the development of a healthy business environment and provide legal and economic advice to companies, especially newly created.

3. *Relation/interaction between innovation and higher education.* In this relation, the private sector (companies) formulate to the academic environment requests for the professional and social competences of future specialists and managers, while universities integrate them into university curricula and prepare professionals and managers according to the modern requirements of the labor market and of real economy. Also, universities contribute to the development of entrepreneurial culture, collaborate with the institutions that promote technology transfer and participate in the communication platform (cluster) between students, scientists and business representatives.

In this context, it is clear that the separate work of each of the KT elements cannot ensure its functionality or, subsequently, benefic effects in the process of establishment of knowledge-based economy at the national level.

c) The notion and elements of the knowledge triangle in Moldova

The knowledge triangle can bring an efficient input into the progressive development of the Moldovan society. It also stands at the basis of ensuring an achievement-based research process, integrated into the international research circuit and oriented towards meeting the growing needs of the national society and economy.

Every element of the knowledge triangle contributes to increasing the level of knowledge, the productive stock of capital, economic development by means of attraction of investment, development of exporting industries, promotion of knowledge-based society, and strengthening of research and development, innovation and technology transfer, oriented towards efficiency and competitiveness.

The knowledge triangle also contributes to creation of the necessary conditions for the implementation of innovation in real economy – key elements for establishment of true knowledge-based society and economy in Moldova.

In this context, we find it opportune to identify the main stakeholders involved in the construction of the KT in Moldova.

Priorities for research and development in Moldova are established by the Parliament.

Research activities in Moldova are almost entirely managed by the Academy of Sciences of Moldova (ASM) and its executive body – the Supreme Council for Science and Technological Development (SCSTD) and other agencies and institutions in its subordination: Center for Fundamental and Applied Research (CFAR); Center of International Projects (CIP); Agency for Innovation and Technology Transfer (AITT); Advisory Council of Expertise (ACE). In addition, research is conducted in 66 institutions, including institutes and

research centers (*including* the 19 research institutes subordinated to the ASM), 15 higher education institutions accredited by the National Council for Accreditation and Attestation and 11 institutions of other types.

The ASM organizes, manages and performs research and development according to the Partnership Agreement between the Government and the Academy of Sciences of Moldova.

The main stakeholders in the education sector are the Ministry of Education and the network of higher education institutions, which in 2014 included 31 institutions (19 public institutions and 12 private institutions).

Innovation activities are performed by local companies and supported by the Organization for Small and Medium Enterprises Sector Development (OSMESD), *AITT*, the State Agency on Intellectual Property (AGEPI), etc.

For the KT to function in Moldova, all stakeholders should perform their functions according to the theoretical model of the knowledge triangle.

2. The current situation of the knowledge triangle in Moldova

In a very short time, economic globalization has changed the world economic order, creating new challenges but also new possibilities. Moldova cannot be competitive in this new context, unless it becomes more innovative and more efficiently responds to consumer needs and preferences. Given that remittances and, therefore, consumption are not able to fuel long-term economic growth of Moldova, we need *a new development paradigm that involves smart growth based on investment, innovation and competitiveness*.

During the 20 years of reform in Moldova, state policies have undergone an essential metamorphosis: priorities have gradually evolved from fundamental science and military needs to key technologies and industry. Currently, a new stage is being shaped, focusing on innovation and societal needs as a whole.

An analysis of the sources of economic growth in Moldova in a classical representation of the Cobb-Douglas production function suggests a very alarming conclusion – without a serious effort to change the development paradigm, the growth potential in the next 10 years is limited to a maximum of 4.5% to 5% per year.

As a way to increase the production and capital stock and the knowledge about its use, the economic growth paradigm should imply attracting foreign and local investment, strengthening research and development, as well as development of export industries. On the other hand, the speed, scale and consistent approach to the broad spectrum of proposed reforms are also important. A change in paradigm cannot be achieved through a set of instant reforms alone. Promoted reforms will serve only as a first step in this new method and an approach to the problems of the Government and the entire society.

This paradigm of economic growth must be placed in the center of the knowledge triangle, whose elements are described above. Only by ensuring conditions for the development of all sides of the knowledge triangle can reliable economic growth be achieved, visibly reducing the gap between our country and European economies and making Moldova a competitive country in Europe in terms of its ability to reform and innovate.

The current knowledge triangle in Moldova is marked by the legacy of a centralized Soviet-style system of research, development and innovation. The massive exodus of skilled workforce, low capacity of the domestic market, low production capacity, various business constraints, etc. determine the relatively low performance of each element of the knowledge triangle (KT) in Moldova. Its defective functionality is also determined by weak interaction between the sides of the KT. In the following compartments of the study, these issues are treated in detail for each side separately.

As it is shown in the first part of this study, the knowledge triangle in Moldova has three interdependent sides, namely: education, research and innovation. The following pages describe the current situation in each of these three fields.

a) **Education**

The operation of the Moldovan education system is characterized by the fact that since 2005 it has been largely determined by joining the Bologna Process and by the authorities' efforts to adopt the university system to the European standards established in this process. Legal relations in the field of education are regulated by the Constitution of the Republic of Moldova and by the Education Code[1] (in force since 23 November 2014), as well as by other legislative and regulatory documents. The Education Code is the fundamental regulatory and legislative act for education at all levels, substituting the old Education Law of 1995.

By means of the new Education Code, the Ministry of Education proposes a new approach to the education process, aimed to modernize the education system in the context of Moldova's European integration, in accordance with the Bologna Process. In this respect, the Education Code will contribute to the implementation of the Education Strategy 2020 by consistently addressing issues of access, relevance and quality of education. The Education Code has several main objectives, namely: promoting lifelong learning; liaising with the labor market; establishing an effective system of insurance, monitoring and evaluation of the quality of education; development, support and motivation of teachers to ensure quality education and rethinking of the education system in terms of quality and cost-effective education services.[2]

The network of higher education institutions in Moldova currently consists of 31 institutions, including 19 public institutions and 12 private institutions (one unit less than in academic year 2013/14). According to the National Bureau of Statistics, two of the public institutions have only Cycle II – education for master's degree.

The universities' participation in the knowledge triangle focuses on training young scientists and researchers in accordance with modern market requirements, introduction of new knowledge and the latest achievements in the field of higher education, etc. Universities are also research units. However, not all higher education institutions are accredited to carry out research and development. Out of 31 institutions of higher education, only 15 are accredited as research and development institutions.

The number of students in higher education has declined significantly over the last two years, by about 13 thousand. At the beginning of academic year 2014/15, there were 89,500 students (excluding foreign students), of which 81% are enrolled in public institutions. The number of students declined both in public institutions (6.4 thousand persons less than in academic year 2013/14) and in private institutions (1.3 thousand less).

[1] Education Code of the Republic of Moldova no. 152 of 17.07.2014, published in Official Monitor no. 319-324 of 24.10.2014. Available at: http://lex.justice.md/md/355156/

[2] http://edu.md/ro/evenimentele-saptaminii/codul-educa-iei-a-fost-aprobat-de-guvern-15969/

Table 1. Students in higher education per forms of education and forms of ownership, in academic years 2013/14 – 2014/15, persons

	2013/14			2014/15		
	Total students	of which:		Total students	of which:	
		female	pay for studies		female	pay for studies
Total	**97,285**	**55,067**	**69 187**	**89,529**	**51,496**	**62,059**
full-time	64,352	36,852	38 223	57,940	33,993	32,426
part-time	32,933	18,215	30 964	31,589	17,503	29,633
State-owned institutions	**78,919**	**45,586**	**50 821**	**72,474**	**42,345**	**45,004**
full-time	53,656	31,084	27 527	48,417	28,515	22,903
part-time	25,263	14,502	23 294	24,057	13,830	22,101
Private institutions	**18,366**	**9,481**	**18,366**	**17,055**	**9,151**	**17,055**
full-time	10,696	5,768	10,696	9,523	5,478	9,523
part-time	7,670	3,713	7,670	7,532	3,673	7,532

Source: National Bureau of Statistics. *Higher education institutions in academic year 2014/15.* Available at: http://www.statistica.md/newsview.php?l=ro&idc=168&id=4588

On average, there are 252 students in higher education per ten thousand people, compared to 273 students in the previous academic year. Reduction of the number of people enrolled in undergraduate studies is also felt in distribution per areas of study. Thus, compared to academic year 2013/14, there has been a decrease in the number of students enrolled in the first cycle in all 8 core areas. In cycle II, there has been an increase (of 0.3 thousand) in the number of students enrolled for studies in the education field, and small positive changes in such fields as natural sciences and exact sciences, humanities and arts. At the same time, in Cycle II there has remained an increased demand for social sciences, economics, law (3,700 persons enrolled), although the number of students enrolled in this field decreased by 6.3% compared to academic year 2013/14 .

When referring to graduates' distribution per general areas of study, we notice a higher percentage of graduates in such fields as economics (27.3% of total graduates), education (14.8%), law (12.4 %) and engineering (8.8%). Among receivers of the Master's degree, 27% studied economics, 20% – law, and 15% – education.

The entire education process was provided by 5,400 people (basic personnel), or 6.4% less than in academic year 2013/14. Teachers with a scientific degree made up 2,700 persons, including 2,300 with PhD and 400 with Habilitated Doctor degree. The share of women among the teaching staff is over 54%, and even higher in the case of assistant professors, lecturers / senior lecturers – more than 60%. (National Bureau of Statistics, 2014)

The downward trend in the number of students is determined by the current quality of the education system, as well as by other shortcomings, including poorly developed education infrastructure, exodus of teachers because of low wages in the education sector, non-compliance of the university curriculum with labor market requirements, etc.

These shortcomings are expected to be overcome by implementing the new Education Code. In this context, it is important to note that the proper application of the Education Code will require additional financial resources, and public spending on education will reach 7-8% of GDP. The extension of the duration of compulsory education alone will cost, according to

estimates, around 400 million lei annually, and measures to support young specialists will require about 61 million lei per year.

So, the expected results are determined by a multitude of other factors that contribute to the gross domestic product (such as a viable business environment, etc.) and by political will.

There is a general consensus that education is a prerequisite for innovation, while research is usually focused on providing a link between higher education and the national innovation system. Equally important is the relationship between formal education and its impact on national innovation systems. In general, to participate in and benefit from the opportunities of the knowledge-based society, one needs to have certain basic skills associated with a high level of innovation, especially ICT and entrepreneurial skills.

The goals of Moldovan universities do not differ from those of European universities: greater visibility of specific outcomes in the public space, a more active and relevant presence in the public space, transparency, accountability and comparability, a better relationship between higher education, research and innovation; promotion of diversity in the university sector; development and implementation of appropriate measures of human resource management; encouragement of life-long learning; strengthening of links with the non-academic sector; improvement of conditions for funding and promotion of competitive and sustainable models.

However, higher education institutions are facing many problems in the realization of their goals: lack of transparency in high-level decision making, lack of quality standards and strong political commitment in this area, lack of sufficient funds to ensure an exchange of good practices in higher education institutions abroad, lack of medium- and long-term common goals with the private sector in certain directions that produce positive structural effects, such as economic growth, improved quality of life, etc. All of the above, and not only, create serious barriers to the organization, operation and development of the education system in Moldova.

b. Research

Moldova's innovation policy was initially designed according to the Soviet-style research and innovation pattern, in which the Academy of Sciences of Moldova (ASM) had extended political rights[3]. Over time, it underwent a series of reforms. In 1992 (on 30 October), a new charter of the ASM was adopted, according to which the Academy is "a public institution, the highest scientific forum in the country" and it is responsible for the implementation and coordination, within its competence, of the policy in the field of fundamental research. On 29 July 1999, Law no. 557 on state policy in the field of research and development was adopted, but it was later diagnosed with some "gaps" in terms of the possibility of co-financing by the state the research and development activities of companies and the funding of research in higher education institutions. Given these shortcomings and the role of politics in this respect, the 1999 law failed to reach the goal proposed by authorities ("stimulation of growth in the field of research and development through diversification of types of ownership and legal forms of organization of research and development stakeholders"). Thus, in 2004, the state policy in the field of research and development was fundamentally revised: previous laws were repealed and the *Code on Science and Innovation* was adopted by Law no. 259 of 15 July 2004, according to which the ASM became again the main authority responsible for all stages and elements of policy (development, implementation, monitoring, reporting) and for determining research priorities. Almost all public programs for the funding of research, development and innovation are managed by the

[3] Interim charter of the Academy of Sciences of the Moldovan Soviet Socialist Republic (MSSR) of 12 December 1990, approved by the MSSR Government at the Academy's General Meeting.

ASM in its executive body, the Supreme Council for Science and Technological Development (SCSTD), and its management agencies and institutions: Centre for Fundamental and Applied Research (CFAR), Centre of International Projects (CIP) and the Agency for Innovation and Technology Transfer (AITT). The Advisory Council of Expertise (ACE) provides evaluation for these three funding agencies. With 19 research institutes under its supervision, the ASM is the leading research organization in the country.

The Parliament adopts legislation regulating the organization and operation of science and innovation; approves strategic directions for science and innovation; approves the funds to be allocated for science and innovation; and ratifies international cooperation treaties in the field of science and innovation.

It should also be noted that the Code on Science and Innovation in Title II Chapter IV contains an article (Article 69) which refers to public functions and duties in the field of science and innovation, regulating general "rights of the central specialized bodies and other authorities." Given these provisions, it is possible to conclude that ministries, departments and other authorities have limited powers in this area, despite the fact that the Code specifies that they participate in promoting the state policy in the field of science and innovation, develop proposals on strategic directions of activity in the field of science and innovation and state programs.

The regulatory framework for the research field can hardly be separated from that of innovation. Regardless of this, it underwent considerable reform in recent years.

Table 2 refers to the most important legislative and regulatory acts governing the activities of research, development and innovation in Moldova.

Table 2. The main laws governing the activities of research, development and innovation in Moldova

N/o	**Law**
1	Code of Science and Innovation of the Republic of Moldova, Code no. 259 of 15.07.2004;
2	Partnership Agreement between the Government and the Academy of Sciences of Moldova for 2013, Government Decision no. 714 of 12.09.2013;
3	Law on science and technology parks and innovation incubators no. 138-XVI of 21.06.2007;
4	Law on Informatization and State Information Resources, no. 467-XV of 21.11.2003
5	Law on the State Agency for Intellectual Property no. 114 of 03 July 2014
6	Law on Protection of Industrial Designs no. 161-XVI (adopted on12.07.2007, in force since 01.12.2007)
7	Law on Protection of Trademarks no. 38-XVI (adopted on 29.02.2008, in force since 06.09.2008)
8.	Law on Protection of Plant Varieties no. 39-XVI (adopted on 29.02.2008, in force since 06.09.2008)
9	Law on Protection of Inventions no. 50-XVI (adopted on 07.03.2008, in force since 04.10.2008)
10	Law on Copyright and Related Rights no. 139 (adopted on 02.07.2010, in force since 01.01.2011)

Source: Produced by author based on official websites of ASM, AITT, AGEPI, etc.

In addition to the laws in Table 2, a number of development strategies has been elaborated and adopted, including:

- **Innovation Strategy of the Republic of Moldova for the period of 2013-2020 "Innovations for Competitiveness"** approved by Government Decision no. 952 of 27 November 2013 (Innovation Strategy), developed by the Ministry of Economy and approved by the Government in September 2013. It stipulates five general objectives: adoption of a model for open management of research and innovation (R&I) that would enable formation of entrepreneurial spirit and innovation skills, orientation of companies towards innovation, application of knowledge to solve global societal problems, stimulation of demand for innovative products and services, etc.
- **Strategy for Research and Development of the Republic of Moldova until 2020** (R&D Strategy) drafted under the guidance of the ASM and approved by the Government in December 2013, aiming at increasing investments in research and development to 1% of GDP by 2020.

None of the strategies clearly identifies thematic priorities (for example, in the Research and Development Strategy the six societal challenges of Horizon 2020 are mentioned as priorities).

- **National Strategy for Information Society Development "Digital Moldova 2020"** (September 2013) aims to create a foundation for the development and widespread use of the potential of information technology and electronic communications by public institutions, the business community and society in general through optimum intervention of the state.
- **National Strategy for Intellectual Property until 2020** aims to strengthen the legal and institutional framework conducive to the creation, protection, management and full use of the potential of intellectual property (IP), which should become a fundamental element for the development of sustainable economy based on knowledge and innovation and a source of national wealth for Moldova.

Also, the Concept for the Development of Industrial Clusters in Moldova was approved in August 2013. It aims at obtaining the following potential effects on the activities of R&I: increase in companies' demand for R&D, increase of researchers' qualification, promotion of personal scientific technology transfer, development of research centers per sectors, provision of scientific institutions' access to new sources of funding, etc.

The quality of research institutions depends on the quality of equipment, quality of researchers and quality of management in the field. Since 2005, several research institutions have received funding for renovation of equipment or for equipping new laboratories. However, in most cases the chosen solution was renovation of existing equipment rather than purchase of new equipment. The Court of Accounts has found a number of serious violations in the spending of funds intended for the purchase of scientific equipment (e.g. equipment being paid for several projects at the same time or the money being used for other purposes).

In 2014, R&D activities were conducted in 66 institutions, including 40 institutes and research centers, 15 higher education institutions and 11 other institutions. Out of all institutions, public institutions make up about 77%, which is less than in 2013, when their share was 83%.

At the end of 2014, 5,038 people (of which 51.4% women) worked in research institutions, which is 1.1% more than in 2013. Of the total number of employees, 70% worked full time.

According to the National Bureau of Statistics (NBS), out of all employees, 3,935 persons had higher education (78.1%), 376 persons – special secondary education (7.5%), and

727 persons had other levels of education (14.4%). Per categories of occupations, most employees engaged in R&D were researchers (65.8%), followed by auxiliary personnel (15.0%), other categories of employees whose functions were related to the institution's work in general (13.6%) and technicians (5.6%).[4] (Table 3)

Table 3. Employees engaged in research and development per categories of occupation, in 2013-2014

	Persons				Structure - % -			
	2013		2014		2013		2014	
	Total	including women	Total	including women	Total	including women	Total	including women
Employees – total	**4,981**	**2,592**	**5,038**	**2,588**	**100.0**	**100.0**	**100.0**	**100.0**
Researchers	3,250	1,559	3,315	1,586	65.2	60.1	65.8	61.3
Technicians	304	231	282	205	6.1	8.9	5.6	7.9
Auxiliary personnel	750	386	758	402	15.1	14.9	15.0	15.5
Other categories	677	416	683	395	13.6	16.0	13.6	15.3

Source: National Bureau of Statistics. *Research and Development Activities in 2014.* Available at: http://www.statistica.md/newsview.php?l=ro&idc=168&id=4728

Reduction in the number of researchers in Moldova is caused by the massive exodus of workforce abroad, which has been caused by precarious economic situation and low salaries of the personnel engaged in R&D. Moreover, besides the fact that low salaries encouraged professional researchers to go abroad, they do not motivate young researchers to continue their careers in research. Although the situation with the remuneration of researchers has slightly improved (average salary of a researcher in 2013 was 3,870 lei[5]), the analysis of the structure of researchers by age in 2014 reveals that 43% of researchers are older than 54, more than one third of researchers are 35-54 years old (34.8%) and 22.2% are young researchers (under 35 years old). At the same time, every fifth researcher was older than 64 years old. (Figure 2)

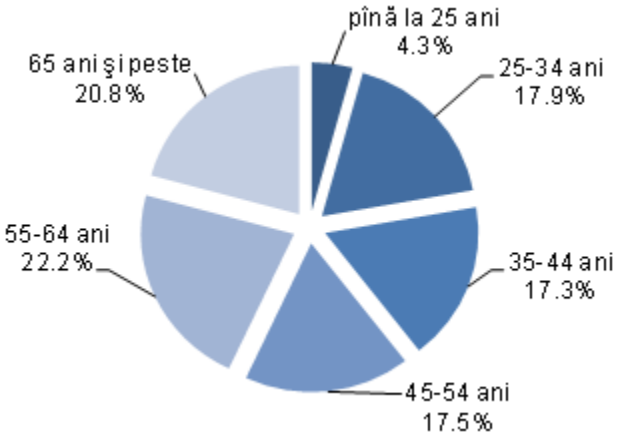
The disaggregation of data by gender reveals that in 2014 there was an average of 92 women researchers to every 100 men researchers, the same as in the previous year.

According to the National Bureau of Statistics, the highest share of researchers worked in the field of natural sciences (36.1%), followed by those in social sciences with a share of 15.0%. Compared with 2013, the structure of researchers per scientific fields has changed; particularly, the share of researchers in the humanities field has decreased (by 1.7 p.p.), while the share of researchers in social sciences has increased (by 2.4 p.p.).

[4] National Bureau of Statistics. *Research and Development Activities in 2014.* Available at: http://www.statistica.md/newsview.php?l=ro&idc=168&id=4728

[5] ASM. Report on the work of SCSTD and main scientific results in the field of science and innovation in 2014 and in the period of 2011-2014. Available at: http://asm.md/administrator/fisiere/rapoarte/f172.pdf, p. 28

Figure 2. *Structure of researchers per age groups, in 2014*

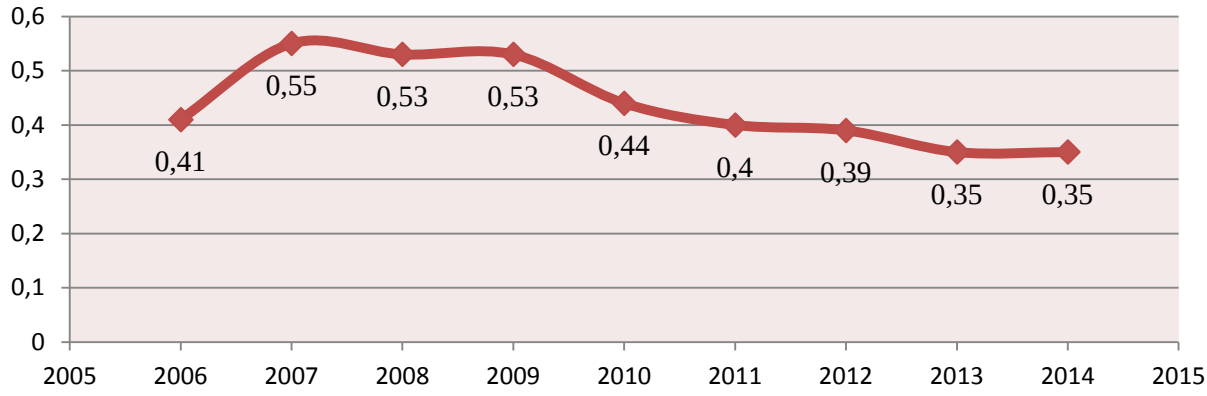


Under 25 y.o. – 4.3%; 25-34 y.o. – 17.9%; 35-44 y.o. – 17.3%; 45-54 y.o. – 17.5%; 55-64 y.o. - 22.2%; 65 y.o. and more – 20.8%

Source: National Bureau of Statistics. *Research and Development Activities in 2014.* Available at: http://www.statistica.md/newsview.php?l=ro&idc=168&id=4728

Although the funding for science and innovation in the period of 2011-2014 grew, it did not help fully stop the exodus of researchers from science, renovate technical and material resources or restore the prestige of science and innovation. Moreover, the share of this funding in GDP has been decreasing in recent years (Figure 2), constituting only 0.35% of GDP in 2014. This performance is much lower than the average performance of the EU countries, which aim through the Europe 2020 Strategy to direct 3% of GDP towards research and innovation. (Figure 3)

Figure 3. Dynamics of the share of expenditure on research and development in the GDP



Source: Developed by author based on *WB. World Development Indicators* (available at: http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS) and *ASM. Report on the work of SCSTD and main scientific results in the field of science and innovation in 2014 and in the period of 2011-2014* (available at http://asm.md/administrator/fisiere/rapoarte/f172.pdf)

According to the National Bureau of Statistics, the structure of current expenditure per components reveals predominance of expenditure on personnel – about 72% or 278.8 million lei (32.3 million lei more than in 2013). Material expenditure made up 63.7 million lei (2.5 million lei less). Expenditure in the "Other" category was 45.8 million lei or 17.8 million lei more than in 2013. (Table 4)

Table 4. Structure of public expenditure in the field of research and development

	2011	**2012**	**2013**	**2014**
Total expenditure on research (million MDL)	333.5	368.2	356	415.2
Current expenditure (million MDL)	312.9	368.2	340.7	388.3
• Expenses on personnel	70.1 %	71.2 %	72.4 %	71.8 %
• Material expenses	20.0 %	18.6 %	19.4 %	16.4 %
• Other current expenses	9.9 %	10.2 %	8.2 %	11.8 %
Capital expenditure (million MDL)	20.6	14.1	15.4	26.9
• Capital expenses on equipment	92.7 %	97.2 %	86.4 %	91.4 %
• Other capital expenses	7.3 %	2.8 %	13.6 %	8.6 %

Source: Developed by author based on the data of the National Bureau of Statistics.

Capital expenditure amounted to 26.9 million lei, having grown by 11.5 million or 1.7 times compared to 2013. Expenses intended for equipping the units/institutions that conducted R&D activities totaled 24.6 million lei, having grown by 1.8 times compared to 2013.[6]

Capital investments are very important for the research process if they involve the acquisition of new equipment and technology, which can then increase return on investment. But these expenses, despite making up over 90% of total capital expenditure, represent 27.7% of total spending on R&D and are quite modest when compared to needs. (Table 4)

The funds for science and innovation have been used both for the maintenance and development of scientific institutions in the field of health, agriculture, education, culture, and for the implementation of state programs, staff training, etc. According to SCSTD, of the 1,185.8 million lei allocated from the state budget for science and innovation in the period of 2011-2014, 986.3 million lei were allocated for scientific research, which represented 83.2% of total funding. (Table 5)

Of the total funding, 316.9 million lei were allocated for fundamental research (26.7% of total funding for scientific research) and 669.4 million lei, or 56.5%, for applied research[7]. (Table 5)

[6] National Bureau of Statistics. *Research and Development Activities in 2014.* Available at: http://www.statistica.md/newsview.php?l=ro&idc=168&id=4728

[7] A*SM. Report on the work of SCSTD and main scientific results in the field of science and innovation in 2014 and in the period of 2011-2014.* Chisinau, 2015, p. 37. Available at: http://asm.md/administrator/fisiere/rapoarte/f172.pdf

Table 5. Dynamics of execution of basic expenditure per priority activities in 2011-2014 (million lei)

Types of research	Realized				Total
	2011	2012	2013	2014	
Fundamental scientific research	**74.5**	**77.2**	**76.4**	**88.8**	**316.9**
Institutional projects	69.5	73.8	72.5	84.8	300.6
State programs	0.6	0.6	0.5	0.4	2.1
Projects for young researchers	1.4	0.9	1.1	1.5	4.9
Bilateral topics and projects	3	1.9	2.3	2.1	9.3
Applied scientific research	**164.3**	**171.1**	**157.1**	**176.9**	**669.4**
Institutional projects	138	147.6	142.6	157.9	586.1
State programs	7.5	6.9	1.6	3.2	19.2
Projects for young researchers	2.1	2.1	1.9	1.5	7.6
Bilateral topics and projects	3.6	2.5	3.8	4.4	14.3
Technology transfer projects	8.6	8	7	9.9	33.5
Other expenses	4.5	4	0.2	–	8.7
Total scientific research	**238.8**	**248.3**	**233.5**	**265.7**	**986.3**
Staff training	13.1	14.6	2.6	2.7	33
Institutions and actions for science and innovation not attributed to other groups	20.6	31.5	37.5	43.4	133
Administrative bodies	5.8	6.6	7.1	7.7	27.2
Total. basic expenditure	278.3	301	280.7	319.5 1	179.5
Capital investment	3	3.2	–	–	6.2
Total science and innovation	**281.3**	**304.2**	**280.7**	**319.5 1**	**185.7**

Source: A*SM. Report on the work of SCSTD and main scientific results in the field of science and innovation in 2014 and in the period of 2011-2014.* Available at: http://asm.md/administrator/fisiere/rapoarte/f172.pdf

The funding of activities in the field of science and innovation according to the priorities of science development approved by Parliament Decision no. 150 of 14 June 2013 is done in an institutional and competitive system: for institutional projects, state programs, projects for young researchers, bilateral topics and projects and innovation and technology transfer projects selected via competition, subsidies for publishing of monographs, subsidies for organization of scientific conferences and PhD scholarships, etc.

According to the ASM, in 2014 public funds were allocated to the following strategic directions: “Innovative materials, technologies and products” – 97.0 million lei (36.6%); “Biotechnology” – 70.6 million lei (26.4%); “National heritage and the development of society” – 52 million lei (19.4%); “Health and biomedicine” – 41 million lei (15.3%); “Energy efficiency and use of renewable energy” – 6.8 million lei (2.5%).

Despite these strategic directions, most policy measures in the field of research and development in Moldova are generic and the procedures and instruments for funding, assessment, monitoring and reporting are identical for all thematic priorities. Of all the instruments used for funding research and development, only state programs are thematically

focused[8]. However, topics within programs are still rather broad and the funding allocated for this measure is modest.

It is also appropriate to note that in recent years the trend has been to increase the share of institutional funding to the detriment of other funding instruments. In 2014, over 90% of public funds were distributed for institutional projects. (Table 4)

According to the current legislation, in the creation and funding of research, universities are directly dependent on the Supreme Council for Science and Technological Development (SCSTD) and institutional projects.

Under the Partnership Agreement, SCSTD duties include: to distribute budget allocations according to strategic directions of science and innovation; to organize elaboration of state programs, international scientific and technical programs and mechanisms for implementing them; to develop mechanisms for monitoring and stimulating the implementation of results of the state programs in science and innovation, as well as the creation of markets for the products of that field; to promote innovation and technology transfer. The SCSTD consists of 17 members, only three of whom are from the university sector. In addition to these three members, only two others are from outside the ASM (representatives of the National Council for Accreditation and Attestation and AGEPI), so the ASM has 12 representatives in the total 17 members of SCSTD.

Unlike the ASM, which has institutions eligible for full funding of projects from the state budget, public universities can only claim field-specific eligibility, allowing them to receive partial funding from the state budget, based on competition, while private universities can claim only affiliate membership, which enables them to benefit from budget funding up to 40% of the total amount of the winning project. In recent years, the share of expenditure on research, development and innovation in GDP has fallen from 0.7% in 2008 to 0.35% (385 million lei) in 2014[9].

At first glance, these schemes appear to be competitive, but analysis showed that their results and effects on the economic development of the whole country are insignificant. According to studies developed by Popa A., "the main form of promotion of the state policy in science and innovation, under the Code, is state programs. Despite the importance conferred on them, because of the lack of allocated funds, they failed to become the main tool for the implementation of state policy."[10] According to the same author, about 8% of total allocations for research, development and innovation are funding based on state programs. Experience from other countries shows another situation in this respect. In most countries with a developed and high-performing RDI field, funding based on state programs exceeds funding on institutional basis; in some cases it even reaches the ratio of 70%/30%, with only military institutions or institutions unique in their fields being funded on institutional basis.

The author's main conclusion about funding for research and innovation in Moldova is that the ASM distributes funds without a clear strategy in this area. In addition, the lack of a set of indicators for the evaluation of research results and their impact on achieving national objectives leads to assessments of poor efficiency of funding, accompanied by the risk for budget resources to be directed to activities that are not national priorities.

At the same time, because of high political costs and the difficulties that universities would face in case they undertook research responsibilities, RDI decentralization appears to be a premature model for Moldova at this stage. However, in the long term, it could be the

[8] CUCIUREANU. G, ERAWATCH Country Reports 2013: Moldova 2014, p. 10-11. Available at: http://erawatch.jrc.ec.europa.eu/erawatch/export/sites/default/galleries/generic_files/file_0527.pdf

[9] A*SM. Report on the work of SCSTD and main scientific results in the field of science and innovation in 2014 and in the period of 2011-2014.* Available at: http://asm.md/administrator/fisiere/rapoarte/f172.pdf, p. 36

[10] Ana Popa "Cercetare, Dezvoltare și Inovare în Republica Moldova probleme și opțiuni", Expert Grup, Chișinău 2011

best solution, assuming that universities cardinally improve the quality of education services and strengthen their capacities of research programs management. (Popa A., Prohnitchi V., 2011)

An important feature of R&D spending efficiency is its dependence on the implementing institutions. Motivation and financial possibilities for research and innovation vary between public and private institutions. While the private sector in Moldova is more oriented towards the market, increase of productivity, reduction of production costs and enhanced applicability of innovation, the financial possibilities of the private sector are usually relatively low or nonexistent. International experience, however, shows that fundamental research is performed in public institutions and universities, while applied research is more often done by the private sector.

Therefore, the private sector's access to public R&D resources is very important. This statement becomes quite important in the situation when the private sector in Moldova has a limited access to public funds for research and development.

In recent decades, the trend in developed economies is to encourage public research and development organizations to engage more in applied research, usually in cooperation with private companies. These collaborations provide potential additional sources of funding for public research and development organizations, but in order to catalyze the emergence and development of such partnerships, several favorable conditions need to be created: the legal system, the status of organizations, the tax system, the national system of intellectual property protection, etc. Although direct funding of the private sector is not common practice in the EU, it can be used to set aside the market failure of R&D in Moldova. However, Moldovan legislation limits private companies' access to public funds for research and development.[11]

In response to the criticism concerning the system of funding research and innovation in Moldova, the *Centre for Fundamental and Applied Research Funding* was created in 2012. This center was created as a subdivision of the ASM and its objective was to improve the competitive allocation of public funds for R&D and to separate funding from the ASM's political and executive bodies.

But we should mention that this center is still a subdivision of the ASM and that no essential changes in the funding of research were made upon its creation.

c. Innovation

In Moldova, innovation is regulated by the Law on science and technology parks and innovation incubators no. 138-XVI of 21.06.2007 and other legislative acts listed in Table 2 and by strategy papers on research and innovation at national level.

The main institutions responsible for planning, organization and management of innovation in Moldova are the Agency for Innovation and Technology Transfer (AITT), the Ministry of Economy and its subordinated institution, the Organization for Small and Medium Enterprises Sector Development (OSMESD), and the State Agency on Intellectual Property (AGEPI).

As for the innovation funding mechanism in Moldova, it is appropriate to note that the general public budget or the budgets of organizations in Moldova do not include a specific funding line intended for innovation. The National Bureau of Statistics does not calculate an indicator on funding for innovation. It is therefore difficult to estimate the amount of funding for innovation and to assess the balance between funding for research and innovation.

Only the AITT budget is intended for promotion and funding of innovation. However, AITT funding does not exceed 5% of the total funding for R&I from public sources.

[11] POPA, A. Research, Development and Innovation in the Republic of Moldova, problems and options; Chisinau, 2011, p. 12-13

It funds innovation through two main instruments:

• Technology and innovation projects – the budget is about € 1.2 million per year, half of which is used by the private sector;

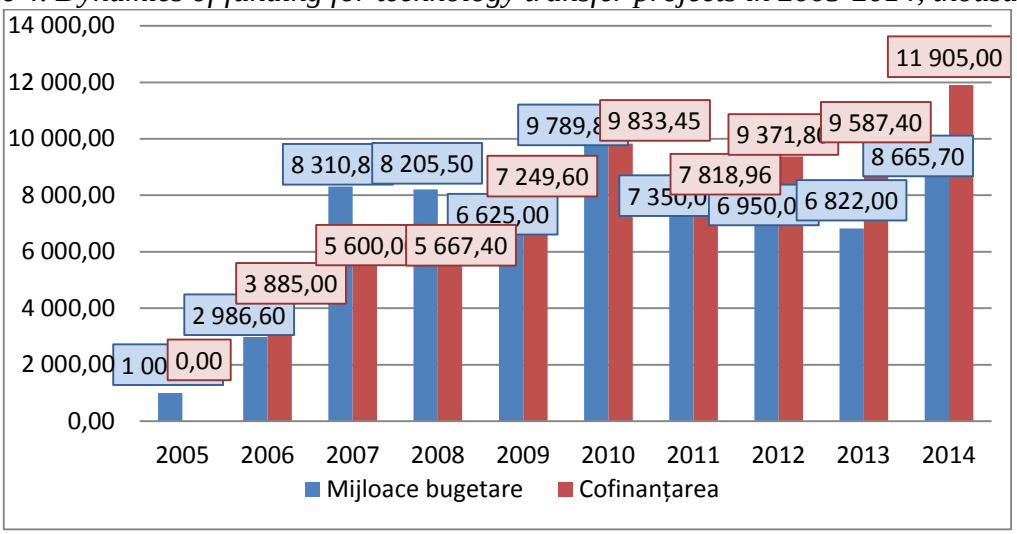
• Science and technology parks and innovation incubators, which form the innovation infrastructure.

Innovation and technology transfer projects is a tool for stimulating innovation in SMEs by partially taking the risks related to innovation. At the same time, they are a form of transfer of new technologies from the institutions of science and innovation to businesses and their application at industrial level, leading to the development and extension of businesses.

Every year, the Agency for Innovation and Technology Transfer under the Academy of Sciences of Moldova launches a competition of innovation and technology transfer projects with funding from the state budget up to 50% of the total project cost. The mandatory condition for submission of innovation and technology transfer projects is implementation of an innovation or a new technology for Moldova. The innovation and technology transfer implementation period is 2 years at most.

According to the AITT, 33 innovation and technology transfer projects were submitted for the 2014-2015 competition of innovation and technology transfer projects, 12 of which were funded in 2014 from the state budget in the amount of 4,785,700 lei. Also in 2014, 7 ongoing projects for 2013-2014 were funded in the amount of 3,880,000 lei from the state budget. A total of 19 projects were funded in 2014 in the amount of 8,665,700 lei from the state budget and 11,905,000 lei from private sources, including 11 projects prepared under invention patents, 2 projects for which patent applications will be filed and 6 projects based on know-how[12]. (Figure 4 and 5)

Figure 4. Dynamics of funding for technology transfer projects in 2005-2014, thousand lei



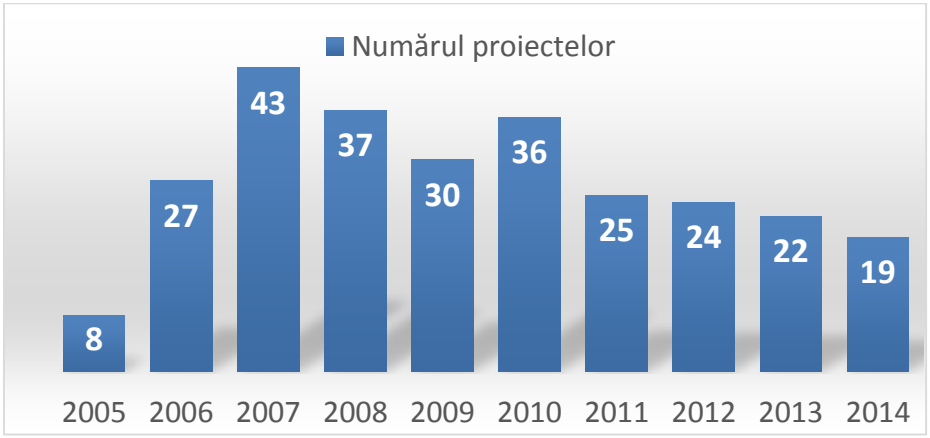
Budget funds Co-funding

Source: AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

The decline in recent years in the number of projects funded is explained by the fact that so far the funds for innovation and technology transfer projects have not been increased. Another reason is the continuously increasing investment costs in projects, which ultimately determine a smaller number of projects funded.

[12] AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

Figure 5. Dynamics of the number of technology transfer projects for 2005-2014

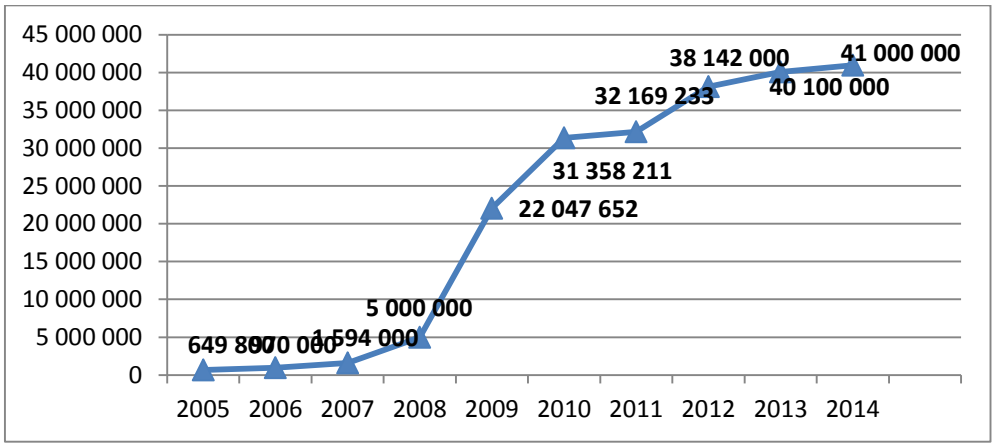


Number of projects

Source: AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

To determine the socio-economic impact of technology transfer projects, it is necessary to assess performance. One of the indicators is the amount of innovation products resulting from these projects. Given the value recorded in 2014, the conclusion is that every leu invested from public and private resources into technology transfer projects yielded 2.0 lei from sales of innovative products. (Figure 6)

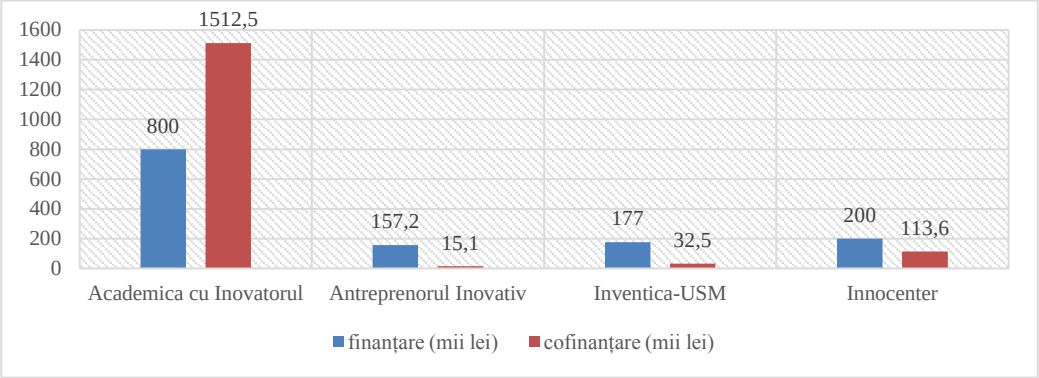
Figure 6. Amount of innovative products from technology transfer projects marketed in 2005-2014, lei



Source: AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

The current innovation infrastructure of Moldova consists of 3 science and technology parks and 7 innovation incubators, which received funding from public sources. Just like technology transfer projects, these entities, in addition to support from the state budget, come with their own financial contribution. Figure 7 shows the amount of public funds allocated in 2014 and co-funding of residents.

Figure 7. Structure of funding for innovation infrastructure in Moldova in 2014



funding (thousand lei) co-funding (thousand lei)

Source: AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

In 2014, 33 companies held the status of resident in 3 science and technology parks and 7 innovation incubators.

The main indicators[13] of the work of residents of science and technology parks and innovation incubators in 2014 are presented in Table 6.

Table 6. Main indicators of the work of residents of science and technology parks (STP) and Innovation Incubators (II) in 2014

N/o	Name of STP / II	No. of innovation objects	No. of new jobs	Attracted investment (thousand lei)	Amount of marketed innovative products (thousand lei)	Number of residents			
						total	new	whose status expired	Potential
1.	**STP "Academica"**	1	18	2,440	9,517	14	4	2	3
	II "Inovatorul"	0	0	0	1,000	0	0	2	2
2.	**STP "Inagro"**					9	0	6	-
3.	**STP "Micronanoteh"**	1	3	2,542.4	0	2	0	1	2
4.	**II "Politehnica"**	0	0	0	0	0	0	-	-
5.	**II "Inventica-USM"**	0	0	0	0	0	0	-	1
6.	**II "Nord"**	0	0	0	0	0	0	-	-
7.	**II "Innocenter"**	2	12	2,467.6	1,078.5	2	0	-	1
8.	**II "Antreprenorul Inovativ"**	0	44	0	5,857.4	6	0	-	2
9.	**II "Media Garaj"[14]**								
	TOTAL	**4**	**77**	**7,450**	**17,452.9**	**33**	**3**	**11**	**11**

Source: AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

[13] The value of some indicators includes the results obtained by the companies whose status of resident expired in 2014.

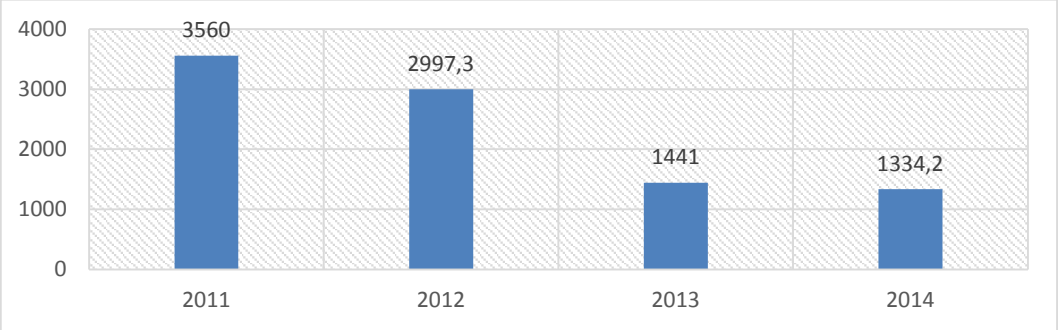
[14] Newly created

In the period of **2011-2014**, 8 new entities of the innovation infrastructure were created:

2011: II "Universcience" and II "Politehnica"
2012: II "Inventica-USM", II "Nord", II "Innocenter" and II "Itech"
2013: II "Antreprenorul Inovativ"
2014: II "Media Garaj"

In this period, state investment into the development of these entities made up a total of 9,332.5 thousand lei (Figure 8).

Figure 8. Dynamics of state investment into the development of innovation infrastructure in 2011-2014, thousand MDL



Source: AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

Although the number of residents grew in 2013 (due to the creation of the incubator "Antreprenorul Inovativ", which started with 6 residents), other indicators, such as the amount of marketed innovative production and the amount of attracted investments, have been falling. A slight recovery occurred in attracted investments. (Figure 9)

Figure 9. Dynamics of the main indicators of innovation parks and incubators in the period of 2011-2014

Amount of marketed innovative production, thousand lei
Attracted investment, thousand lei
No. of residents

Source: AITT. Report on managerial activities. 2014 (2011-2014). Chisinau 2015

Funding for innovation through venture funds, innovation vouchers or other similar instruments able to stimulate innovation in the private sector are not yet well-developed.[15]

Also, some innovation activities are funded by the Ministry of Economy, most of them through the Organization for Small and Medium Enterprises Sector Development (OSMESD). The main programs of the OSMESD are as follows:

- "PARE 1+1" – a program launched to attract remittances into the economy and mobilize the human and financial resources of migrant workers. The basic principle of this program is that for every invested leu the state offers one more. Thus, the amount of subsidies granted in 2013 through this program was nearly € 2 million and migrants' investments about € 6 million;

- National Youth Economic Empowerment Program – a program launched to support young entrepreneurs in rural areas and facilitate the creation of start-ups. In 2013, funding through this program amounted at about € 5 million;

- Credit Guarantee Fund – an instrument intended to facilitate access to funding for newly created companies, offering them guarantees of 70% of the loan and a warranty period of up to 3 years. By the end of 2013, the amount of investments with the support of this instrument was about € 4.5 million.

The analysis of the principles and mechanisms of these funding instruments allows us to emphasize the fact that they also fund (not exclusively) innovation activities, but there is no separate accounts monitoring for such activities. Moreover, the budget of these instruments does not meet the requirements of the local business environment. We also find that "PARE 1+1" is discriminatory and we recommend competent authorities to consider opening access to this program to all Moldovan citizens. This suggestion results from the consideration that according to this program the State offers one leu from the state budget for every leu from remittances. Contributors to the state budget are the Moldova citizens who work in the country, and so they, who are usually poorer, must fund those who work or used to work abroad, who are usually better off.

At present, national prosperity and high individual living standards, which need to be achieved in a knowledge-based economy, are directly related to the efficient implementation of innovations, which involves using the results of creative activities. In this respect, patenting is an important element of competitiveness and an economic indicator of a country.

Statistics on patents are used as an empirical measure of innovation results. They provide information about the areas of economic interest, about research activities, and can be used for various scientific and economic studies. According to AGEPI, in 2014, 161 applications for various types of intellectual protection were registered and 171 patents were issued, which is 12% more than in 2013. It can be explained by the fact that in 2014 all projects of fundamental and applied scientific research were completed and researchers focused more on the relevance of theoretical and practical scientific results and on their implementation in the country's economy.

The number of patent applications by Moldovan researchers is relatively large compared to population numbers and the size of economy – over 4,500 patent applications in the period of 2006-2012[16]. However, only 28% had a duration of more than 5 years in 2012. The small number of renewed patents is partly explained by return of taxes for a period of five years, which applies to researchers from Moldova. Other reasons for this situation are low

[15] CUCIUREANU. G, ERAWATCH Country Reports 2013: Moldova 2014, p. 10-11. Available at: http://erawatch.jrc.ec.europa.eu/erawatch/export/sites/default/galleries/generic_files/file_0527.pdf

[16] WIPO (2013): World Intellectual Property Organisation. Statistics on Patents, *http://www.wipo.int/ipstats/en/*

applicability of registered inventions (determined by the profile of the Moldovan economy), weak links between R&D sectors and businesses and, in general, a low innovation culture[17].

The situation regarding invention patents obtained abroad is even more marginal. According to the World Intellectual Property Organization, in the period of 2006-2011 only seven patent applications were filed from Moldova to the European Patent Office, and only nine patent applications to the United States Patent and Trademark Office[18]. It can be explained by the high cost of patenting abroad and by the fact that Moldovan researchers who work in collaboration with foreign partners are rarely listed as the first inventor.

Limited human and financial resources have obvious impact on the quality and performance of the knowledge production. According to the ASM, the List of scientific works published and protection titles obtained by the Moldovan scientific community in 2014 includes 10,395 titles, of which 222 are monographs, 369 are articles published in important journals, etc. However, these results are poorly recognized internationally, which is again suggestive of the poor quality of national scientific research. For Moldova, the Hirsch index (h-index, more and more frequently used as a measure of the value of scientific results published by scientists) is 70, meaning that our scientists, the scientific community, have 70 articles with not less than 70 citations each. So, only the scientists with works cited at least 70 times in the specialized literature contribute to the Hirsch index for our country. It is indicative of the visibility of local scientists' works and their recognition by the international scientific community of their fields of study. In this respect, the Russian Federation is roughly at India's level but much higher than Romania or Lithuania. Of course, the results reflect the role of scientific schools, or traditions in scientific research. Armenia, for example, reached a Hirsch index of about 120, comparable to that of Lithuania, which is an EU member state.

One reason of our country's poor performance is insufficient funding from the state budget and insignificant contribution of the private sector to the development of science and innovation. The business community is in no hurry to invest substantially in scientific research, and no such investment into research has come from other countries, either. Another problem is that the scientific results obtained by the Moldovan community are published without considering their applicative value. We publish full theses on the website of the National Commission for Accreditation and Attestation, regardless of the field and practical value of the data. At the same time, possible objects of intellectual property that might have commercial interest for the business community, including Western companies, are not considered, either.[19]

Another reason is the *SMEs' poor innovation capacity*, determined by several factors, such as non-awareness about the effects of innovation on company's development, lack of cooperation between businesses and institutions of research and innovation, limited financial resources, etc. Efficient cooperation between universities and businesses provides a decisive prerequisite for economic development and it has attracted great interest in recent years[20].

These reasons are also identified by the World Economic Forum (WEF) as the main barriers to developing an innovation environment in Moldova. According to the Global

[17] CUCIUREANU. G, ERAWATCH Country Reports 2013: Moldova 2014, p. 10-11. Available at: http://erawatch.jrc.ec.europa.eu/erawatch/export/sites/default/galleries/generic_files/file_0527.pdf

[18] WIPO (2013): World Intellectual Property Organisation. Statistics on Patents. Available at: *http://www.wipo.int/ipstats/en/*

[19] Source: A*SM. Report on the work of SCSTD and main scientific results in the field of science and innovation in 2014 and in the period of 2011-2014.* Available at: http://asm.md/administrator/fisiere/rapoarte/f172.pdf, p. 9

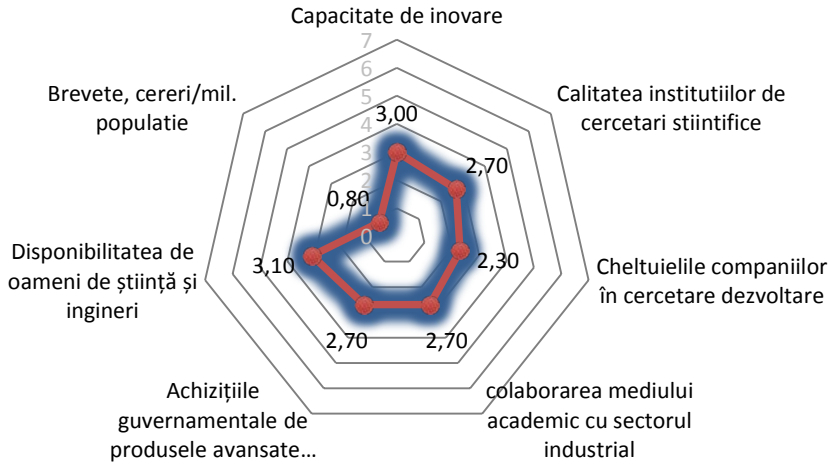
[20] Șerbănică Cristina. O analiză de tip cauză – efect a cooperării universitate – mediu de afaceri pentru inovarea regională în România. In: *Economie teoretică şi aplicată*. Volume XVIII (2011), No. 10(563), Bucharest. pp. 27-43

Competitiveness Index 2014-2015, produced annually by the WEF[21], Moldova is placed 82nd (out of 144 analyzed counties) among the most competitive economies in the world. For the first time in four years Moldova has improved its score up to 4 points out of 7, after it was 3.9 for three years.

The lowest score, 3.0 points, and therefore the worst position, 131st, Moldova obtained for the "innovation" chapter, and the main reasons are as follows:

- Minimum expenditure of companies on research and development (position 135), because the general context in which local entrepreneurs work forces them to think about how to survive in the market rather than how to develop;
- Lack of scientists and engineers in companies (position 128). Businesses have little interest to implement and apply innovations and high technologies within their companies. Most of them have too narrow a vision on how to do business and give little importance to issues such as investing in human resources or attracting qualified personnel;
- Poor collaboration between businesses and academia (position 124) in a situation when in most countries universities are the main drivers of innovation. However, it should be noted that currently local higher education institutions are not sufficiently adapted to a proper innovation framework, either.

Figure 10. Innovation performance of Moldova according to the Global Competitiveness Index 2014-2015



Innovation capacity 3.00 Quality of scientific research institutions 2.70
Companies' expenditure on research and development 2.30
Collaboration of academia with the industrial sector 2.70
Public acquisition of advanced products 2.70 Availability of scientists and engineers 3.10
Patents, applications / million population 0.80

Source: Developed by author based on the WEF report. *Global Competitiveness Report 2014-2015*. Available at: http://www.weforum.org/reports/global-competitiveness-report-2014-2015

Analysis of the data from the GCI allows us to conclude that the KT in Moldova is still fairly poor, and the major problems in the development of a viable KT are not quite related to

[21] The WEF makes an annual assessment of the economic competitiveness of the world's countries under the aspect of institutions (legal and administrative framework in which economic activities are conducted), public policies, infrastructure and other factors affecting productivity and growth potential, including education, health, labor, financial market development, technological progress, macroeconomic stability or market efficiency.

the country's innovation capacity or the availability of researchers and engineers, but to the number of invention patent applications, modest participation of companies in funding innovation activities, quality of scientific research institutions, etc. (Figure 10). Moreover, the synergy potential has been threatened by failures of communication between higher education institutions, the industry sector and other national beneficiaries, as well as by unclear political signals or divergent agendas. In Moldova, the cooperation of universities with businesses has been threatened by numerous barriers. First, the two types of institutions have divergent objectives and priorities (companies seek short-term solutions that universities usually cannot reach; long-term orientation of universities), as well as difficulties in identifying partners. Second, universities are not always interested in the topics proposed by companies, which prefer pragmatic approach over academic. Third, restriction on the publication of research results and possible conflicts related to intellectual property rights may act as a barrier to the involvement of higher education institutions. We can also mention the lack of mutual trust, lack of governmental support programs that would foster interaction between universities and the business community, lack of marketing related to the R&D&I potential.

In conclusion it can be said that Moldova needs a *smart growth* based on a reliable knowledge triangle, built and strengthened by well-thought strategies and policies, with priority directions dedicated to research, development and innovation and to ensuring continuous interaction between these components. As efforts are made to control the public deficit in order to redress public finances and as it appears that the workforce is continually decreasing, Moldova faces various challenges related to the future competitiveness of the country, to generation of new growth and to creation of new jobs, as well as to how the Moldovan economy will be relaunched. So, Moldova's competitiveness, its capacity to create new jobs to replace those lost due to the crisis and, overall, the future standard of living depends on our country's ability to stimulate innovation in the field of products, services, social and commercial models and processes and to implement information technologies in various activities of the national economy.

So, the only answer is *smart growth or economic growth that places the priority accent on education and professional training, research, development, innovation, use of information and communication technologies, investment and competitiveness* in all human activities in order to address the major challenges of society today. And this smart growth can be achieved through a competitive "knowledge triangle".

3. Target specification of the future of knowledge triangle in Moldova

The recent years have been characterized by the modernization of the education, research and innovation system. Strategies for the development of the knowledge triangle and other actions that enable the taking over of experience from EU partners are being developed and implemented. Considering Moldova's pro-European vector, all of the currently developed strategies refer to EU strategies in different sectors, such as EU's growth strategy "Europe 2020", which has been the inspiration source for Moldova's National Development Strategy "Moldova 2020[22]" and Moldova's Innovation Strategy for 2013-2020 "Innovations for Competitiveness".

The latter two strategies emphasize the importance of research and innovation development for the sustainable growth of national economy's competitiveness. It is possible only in the context of close ties between education and business, education and research, and research and business.

[22] http://particip.gov.md/public/files/strategia/Moldova_2020_proiect.pdf

In 5-6 years the implementation of the perfect concept of the knowledge triangle will strengthen the current situation in the following sectors:

a) Education and business

Although there is currently no direct relation between the labor market and universities that prepare young specialists, the recent years' higher education graduates (Bachelor, Master) have the possibility to do their internships at any company, depending on their profile. Such internships increase graduates' competencies and give them the possibility of employment.

It should be mentioned that Moldova's Innovation Strategy for 2013-2020 "Innovation for Competitiveness" stipulates as follows: "To strengthen innovation connections between companies, universities and research institutes in order to achieve productive merger of competences and resources required for an innovative economy – financial, human and scientific capital. Their synergy will result in new products and services, or a niche eventually, capable to compete successfully on national and foreign markets."

Given the fact that there is no "National Qualifications Framework, updated professional training and occupational standards nomenclature," professional training at all levels of education does not ensure the skills required by the labor market. In this respect Moldova's innovation strategy suggests the following solution to be implemented in the next 5 years (by 2020):

1) Introduction of elective courses in entrepreneurship and economics in secondary and high school education;

2) Development and implementation of education programs related to innovation in management and engineering departments: law and economics of intellectual property; innovation management; marketing of new products; evaluation and sale of intellectual property objects;

3) Increase by an average of 25% of scholarships for undergraduate students, Master's students, PhD students in exact sciences, engineering and technology and increase by 5% (approximately) per year of the number of undergraduate students, Master's students and PhD students in exact sciences, engineering and technology, from 19,700 in 2014 to 26,500 in 2020, due to redistribution of places for specialties that are unappealing for the labor market.

Also, it should be noted that in January 2013 the Government approved the Strategy for development of vocational/technical education for 2013-2020 and the Action Plan for implementation of the Strategy[23], providing for a comprehensive reform of the structure, content and modernization of secondary vocational and secondary specialized education (this reform is at the initial implementation phase).

b) Education and research

For Moldova, education is one of the most significant factors for human resource development. Education has an essential role in ensuring economic growth, modernization of technological and intellectual components and increase of population's welfare. Only by acknowledging the fact that the quality of education is vital for the formation of the research potential a tighter relation between education and research can be achieved.

[23] Government Decision no. 97 of 1 February 2013 "on the approval of the Vocational/Technical Education Development Strategy for 2013-2020"

In 2014, the Education Development Strategy for 2014-2020, "Education 2020"[24], was approved. The following step in implementation of reforms in education was the approval in July 2014 of the Education Code of the Republic of Moldova no. 152, which contains articles addressing "Scientific research in higher education".

Article 116 of Moldova's Education Code stipulates that "In higher education institutions the research, development, innovation and artistic creation activities are performed for the purpose of learning and professional training of highly qualified specialists".

It should be noted that the new Education Code of the Republic of Moldova, which has replaced the Law on education no. 547 of 21.07.1995, stipulates a larger range of reports, underlining the direct relation between education and research components. A relevant example is Articles 90 and 95 of the Education Code, stipulating that "A Master's degree proves that its holder obtained special academic and/or professional competences, including managerial, research, development and innovation competences." It their turn, the "Postdoctoral programs are organized for the purposes of advanced fundamental and applicative scientific research".

These are only the first steps in the modernization of the education and research segment. Once the entire range of reforms in these fields is implemented in the following 5-6 years, the expected results will be obtained. For example, the emergence of clusters, i.e. education institutions, associations and organizations that carry out education, research, development, innovation and artistic creation activities based on a partnership agreement made according to the effective legislation[25].

The European experience shows that the creation of cluster-type networks, where manufacturing enterprises, education institutions and public institutions interact, boosts the technological performance and productivity, contributing to companies' competitiveness, market extension and increase of visibility.

c) Research and business

Business is a key component needed for the economic development of any country. Entrepreneurs who decide to engage in innovation activities need highly qualified researchers. But the absolute majority of Moldovan companies do not conduct research and technological development due to the increased level of financial risk, though it does not mean that it will not be the case in the near future (in 5-6 years).

In this respect Moldova's Innovation Strategy for 2013-2020, "Innovations for Competitiveness", comes as a fundamental support. The Innovation Strategy provides that "the state will support companies that are committed to using their own resources for developing new promising technologies." In this context, the intellectual potential of researchers, inventors, engineers, patent service workers, etc. will be highly demanded by the business sector, which will lead to its rapid development and will make these professions attractive to youth.

The Innovation Strategy also states that the current regulatory framework governing the activity of entrepreneurs in this sector by prescribing financial instruments that favor small and medium businesses should be brought in line with the requirements and objectives set by our state.

In conclusion, we shall note that in 5-6 years the need to ensure Moldova's development and economic growth will serve as the reason for consolidation of forces of the stakeholders

[24] Government Decision no. 944 of 14 November 2014 "on the approval of Education Development Strategy for 2014-2020 'Education-2020'"

[25] Art.3 of the Education Code of RM no. 152 of 17.07.2014

that are part of the knowledge triangle. The organizations involved in the drafting of reports required for the development of the knowledge triangle will contribute to:

- *Restructuring and reorganization of existing institutional structures of universities and research institutions:* Such structural reforms would allow to increase the global competitiveness of universities, develop strong research environments, boost business ties and better ensure and support cohesion with the EU in the field of academic performance of universities;

- *Improving funding for universities*: The key factors for the success of research funding systems are a mix of appropriate framework conditions. Most European universities are publicly funded. It is also still the most important source of funding flow for Moldovan universities. However, the use of multiple sources of funding could lead to greater stability and greater autonomy for universities;

- *Promoting competitive funding models*: Funding is a key concern for universities worldwide. To get a better quality of research, it is necessary to develop clear concepts and selection mechanisms. In this context, the emphasis on performance and establishment of appropriate indicators are important for successful funding of research;

- *Supporting researchers throughout their careers, focusing on creation of good framework conditions*: Creating an attractive, open and sustainable labor market for researchers;

- *Ensuring better interaction between research, innovation and higher education*: In a knowledge-based society, research should not be isolated from neither innovation nor education. It is important to better integrate aspects of higher education, research and innovation in national strategies;

- *Removing deficiencies from the current regulatory framework*: A real obstacle to the conduct of research and innovation activities by all stakeholders and at all levels;

- *Developing and implementing coherent and comprehensive strategies and policies in the field of "brain circulation":* The required number of young scientists is very high because many researchers retire. Moldova should strengthen its ability to attract and train young people to become researchers and provide nationally and internationally competitive research careers. Also, attracting the best researchers from abroad;

- *Ensuring a closer interaction between universities and the non-academic sector:* Universities must start working with a wide range of private and public sector partners in order to increase the amount of private money invested in research. Major benefits could come from the knowledge transfer from research into new businesses, services and policies.

4. Framework conditions and constraints of the knowledge triangle in the Republic of Moldova

The framework conditions, according to project specifications (see Figure 11), have been described in Section 2 hereto, as the current knowledge triangle situation in Moldova cannot be presented accurately without the description of the regulatory, institutional, organizational and financial frameworks and of human resources availability in all KT-related spheres.

Figure 11. Framework conditions of the Knowledge Triangle

At the same time, it should be reiterated that for efficient operation of the knowledge triangle and qualitative integration of all KT elements for competitive development in Moldova a productive interaction among all four framework conditions is required.

Currently, these four components (regulatory, organizational, human resources and financial frameworks) are often determined by systemic, institutional and bureaucratic barriers. The cross-connection of these barriers has a negative effect on the research potential. The outcomes of these barriers could contribute to an inadequate, inefficient and ineffective implementation of policy documents and development strategies in the field of research and innovation.

The analysis of the regulatory, organizational, financial frameworks and availability of human resources specific for the Knowledge Triangle in Moldova allows us to sum up structural constraints as follows:

- *Lack of human resources in the field of research and development*. The number of persons employed in R&D in Moldova decreased significantly due to "brain drain", while among the remaining researchers a certain ageing trend can be observed. At the same time, the R&D field is unattractive (from salary and existing infrastructure points of view) for young talents. The level of knowledge obtained in local universities does not meet market expectations, while attraction of foreign students or researchers is difficult due to unappealing conditions. All these factors, and not only, determine poor quality of scientific research in Moldova;
- *Insignificant investment in the KT development*, especially from the private sector. All types of activities related to KT in Moldova are under-funded and rather limited as a result of a low GDP. This is mostly due to a near lack of funding from the private sector. Moreover, it is difficult to identify clear and well defined scientific and technological priorities in the modest governmental funding;
- *Poor interaction of KT stakeholders* (universities, ASM, research centers, regulatory institutions, enterprises, etc.). These stakeholders are not integrated into an efficient and operational KT; each of them work rather separately: research centers yield mostly academic results, universities are oriented mostly towards education, while businesses focus on the market and products with low technological intensity (cheaper products);

- *An inefficient KT management model*. Moldova has a Soviet-type management model, with an elevated level of centralization and a rather "academic" nature. The current system of organization of science and innovation lacks clear separation of authorities responsible for formulation, implementation, monitoring and evaluation of relevant policies;
- *Lack of an adequate innovation infrastructure*. The solution to this problem takes time; it involves additional effort and can be achieved by establishing a regional network of business incubators in all fields of scientific knowledge.
- Although regulation has registered significant progress in recent years (in the form of laws, strategies and development initiatives for every KT element), *the mechanism of evaluation and monitoring of such reforms and of their potential effects on national economy is uncertain and undefined*. Also, *the lack of a set of indicators comparable with regional and international statistics* makes performance evaluation of KT in Moldova even more difficult.

5. Requirements for the functionality of the future knowledge triangle

Non-functional requirements through which the objectives set out in paragraph 3 for the system of education, research and development can be achieved

- Giving a broader meaning to the innovation concept and increasing the role of research and innovation in the country's general development process, referring both to the innovation based on research and research related to commercial models, planning, brand strategies and services that bring added value to users. The creativity and diversity of our citizens and the power of Moldovan creative industries provide considerable potential to encourage development and to create new jobs through innovation, especially for SMEs. The innovation culture in Moldova is very poorly developed. Innovation, although thoroughly discussed in various sources, does not cover all segments of society. At the same time, the economy of Moldova still has no capacity to efficiently absorb scientific results;
- Strengthening the education system through adjustment of education offers to market requirements. Creation and stimulation of business education programs for pupils and students, which would help in the transition from education to real economy;
- Strengthening the innovation potential by increasing the motivation of researchers and innovators, improving education by bringing curricula in line with international market demands, reconciling the education offer with business requirements;
- Encouraging cross-border cooperation among various stakeholders, which involves the use and exchange of knowledge and experience. Recently, it has become one of the more and more used ways to develop successful innovations.

Functional requirements through which the objectives set out in paragraph 3 for the system of education, research and development can be achieved.

- Initiating state programs to facilitate interaction between the business community and universities through creation of: 1. Innovation ***Clusters*** (set as goals in Moldova's Innovation Strategy for 2013-2020) and 2. ***Voucher*** initiatives – granting vouchers to SMEs which would cover the cost of BDS (business development services) package. These BDS packages can be offered as consultancy, feasibility studies, training,

marketing, information, technology transfer, etc. The BDS intention is to improve a company's performance and access to markets and to strengthen its competitive capacity. Moreover, the BDS package can be a mechanism for stimulating further demand for BDS, since the state (or specialized entities) is able to facilitate interaction between the business community and universities by referring potential BDS customers to universities or research centers.

- Involving all stakeholders in the innovation cycle: not only several high technology companies or big enterprises, but also SMEs from all sectors, including from the public sector, social economy and even citizens ("social innovation"), each focusing on their own strengths ("intelligent specialization"), within a partnership. Thus, the development of innovative SMEs by ensuring favorable conditions for organization and development of their activities and decrease of start-up risks is a first step to creating new national innovation networks. Moreover, considering that a true competition and a good functioning of competitive markets are key elements for innovation, strict application of competition rules that ensure access on the market and opportunities for those who enter the market for the first time is a must;
- Creating a national innovation network (science and technology parks, innovation incubators, information technology transfer centers, business incubators, science and innovation clusters) and creating a mechanism for collaboration between science, education, innovation, production and funding;
- Developing an integrated evaluation system (a set of indicators) to assess the innovation capacity and performance of local companies as a mechanism of quality-based evaluation of innovation project results. There is no information on the level of innovation activities within companies and firms due to an imperfect record system of statistics and accounting on innovation activities and their costs;
- Clearly separating competences in the field, which could increase the reliability of the institutions involved in scientific research and innovation and contribute to increasing their efficiency and effectiveness.

Non-functional requirements through which the objectives set out in paragraph 3 for improvement of access of research institutions and enterprises to funding can be achieved.

- Eliminating shortcomings from the current regulatory framework. The regulatory framework must be adjusted to current requirements, which would protect both the national entrepreneurs that intend to develop their business through innovations and the foreign investors that would invest in new risky but promising businesses;
- Supporting researchers and young specialists in their entire career, focusing on the creation of good framework and financial conditions. Encouraging research specialists through attractive salaries;
- Promoting public-private partnerships focused on innovation;
- Further developing the infrastructure of knowledge triangle support in Moldova.

Functional requirements through which the objectives set out in paragraph 3 for the improvement of access of research institutions and enterprises to funding can be achieved.

- Eliminating discrimination in funding research activities (such as the provision that only institutional members of the ASM can be fully financed from budget resources) and opening access to public funding for the private innovation sector;

- Creating a micro-crediting fund for innovative micro-enterprises, aiming at developing a network of incubators as business accelerators in creative industries;
- Expanding the area covered by the Credit History Bureau, focusing on micro-funding institutions, leasing companies and loan and savings associations;
- Strengthening the capacity of the Credit Guarantee Fund and the Deposit Guarantee Fund;
- Reviewing tax policies and the tax system to create a favorable framework for the implementation of various financial instruments;
- Modifying and improving banks' risk assessment procedures and methodologies;
- Creating a mixed fund (funding both from the state budget and private sources) to support new export-oriented innovation businesses (start-ups);
- Applying "venture" and "business angels" type instruments.

6. Requirements to future conditions of the knowledge triangle in Moldova

The emergence of the strong political commitment to make concrete steps for implementation of Moldova's National Development Strategy "Moldova 2020[26]", Moldova's Innovation Strategy for 2013-2020 "Innovations for Competition", Education Development Strategy for 2014-2020 "Education-2020".

Reconfiguration of the regulatory framework is required to optimize and make the governing in the fields of education, research and innovation more efficient. Correct reconfiguration will lead to expected medium- and long-term results.

Also, representatives of higher education institutions and businesses need to develop a common concept, a strategy that will further be included in the Strategy drafted by the Ministry of Education.

It is necessary to develop a mechanism for effective management of innovation and research assets, including modification of funding for innovation projects carried out by SMEs. To create appropriate conditions (at least supplying the necessary and new equipment) for business development within science and technology parks, innovation incubators, research centers/laboratories/facilities of training centers. It is necessary to adopt the law on venture funds. Therefore, these hedge funds will facilitate business development based on innovation.

The development of a common strategic framework between the public sector (representatives of legislative power) and the private sector that will determine specific actions and, as a result, will influence the development of education, research and innovation. The modification of legislation and encouragement of private sector through financial incentives, "tax vacations" for start-up SMEs and other rewards can be a potential solution for the stimulation of public-private partnerships.

It is mandatory to adequately allocate resources (financial, material and human) for all activities related to research and innovation – not only a decent salary to experienced specialists, but also to create conditions that will attract young specialists with innovative ideas, strengthen communication relations and interaction with national and international partners, etc.

7. Problems and risks

Problems that might appear and prevent the achievement of goals set in paragraph 3 and accomplishment of requirements presented in paragraphs 5 and 6:

[26] http://particip.gov.md/public/files/strategia/Moldova_2020_proiect.pdf

Problems:

1) One of the major problems that can persist, and even worsen, is the shortage of funds. Considering the recent events, there is a high risk of continuing financial instability in Moldova. In these circumstances, the following years will be characterized by shortage of funds and, as a result, the knowledge triangle will be unable to receive adequate support. Also, the private sector will not benefit from the possibility of funding from public sources for research and/or innovation projects;

2) Other problems that can appear if the state fails to make concrete steps to fulfill the commitments stated in Moldova's National Development Strategy "Moldova 2020[27]", Moldova's Innovation Strategy for 2013-2020 "Innovations for Competition", Education Development Strategy for 2014-2020 "Education-2020".
- Inadequacy of the legal framework regulating the development of research and innovation;
- Lack of staff capable to perform quality research at world level. The significance of researchers' career will drop even more;
- Continuing lack of interaction between public authorities and the business sector, also between higher education institutions and the business sector;
- Continuing lack of decision-making transparency at senior level in the fields of education, research and innovation;
- Inactivity due to lack of funds can lead to total impossibility to ensure exchange of good practices with foreign higher education institutions;
- Continuing poor competitiveness of the innovation sector due to outdated infrastructure that does not meet requirements. Research and innovation projects will continue being formulated based on existing capacities and less on society needs, needing a close relation with the society's stakeholders.

3) Other problems are suspicious expenses from the modest state budget intended for the development of research and innovation. Examples are the four innovation incubators (II "Inovatorul", II "Politehnica", II "Inventica-USM", II "Nord"; Source: AITT Report on managerial activity 2014 (2011-2014) Chisinau 2015), which have been created and have no residents at this time. No investments are attracted through these incubators and there is no value of the products marketed by residents; however, state budget funds are used for the creation and maintenance of these organizations.

Risks:

1) Reduction of funding for research;
2) Reduction of funds for bilateral subsidy programs;
3) Low participation in international research programs;
4) Reluctance and little interest of the business community in the implementation of scientific results;
5) Low level and poor quality of project proposals submitted for the competitions launched within programs, funds and other national funding facilities;
6) Low attractiveness of researcher as profession;
7) Obsolete research infrastructure.

[27] http://particip.gov.md/public/files/strategia/Moldova_2020_proiect.pdf