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MODERNIZATION OF THE AGRICULTURAL PRODUCTION BASED ON INTENSIFIED INNOVATION PROCESSES

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Abstract. The level of the economic development as well as the intensity level of social and political processes in the crisis and post-crisis period is very closely related to the increased research activity almost in all economic sectors. At the same time, intensified technology and innovation processes in agricultural production are vital for the sustainable economic growth of the Republic of Moldova under the existing conditions of globalization. The aim of the study is to validate the need for agricultural production modernization based on the intensified innovation processes and to develop recommendations on improving the evaluation of innovation technology effectiveness. The normative legal acts and regulations of the Republic of Moldova, official data of state institutions, as well as the methods of statistical analysis and mathematical modeling were used in this research.

Key words: Agricultural production; Economic development; Innovation process; New technologies.

Rezumat. Nivelul de dezvoltare al economiei precum şi nivelul intensificării proceselor sociale şi politice în perioadă de criză şi postcriză se află în legătură directă cu sporirea activităţii de cercetare practic în toate ramurile economiei naţionale. În aceste condiţii, intensificarea proceselor tehnologice şi inovaţionale în producerea agricolă are o importanţă majoră în dezvoltarea durabilă a economiei Republicii Moldova în condiţiile actuale de globalizare. Scopul cercetării constă în argumentarea necesităţii modernizării procesului de producţie în agricultură în baza intensificării proceselor inovaţionale şi elaborarea recomandărilor cu privire la perfecţionarea evaluării eficienţei tehnologiilor inovaţionale. În procesul de cercetare au fost utilizate actele legislative şi normative ale Republicii Moldova, datele oficiale ale instituţiilor de stat, precum şi metodele de analiză statistică şi modelarea matematică.

Cuvinte-cheie: Producţie agricolă; Dezvoltare economică; Proces inovaţional; Tehnologii noi.

INTRODUCTION

The fierce competition in international markets of economic resources leads to the fact that the innovative component is enhanced at all economic production levels. Taking into account this trend, there is the need for a productive innovation policy, which enhances the competitiveness of the economic sector, has a significant impact on the efficient functioning of the national economic system and leads to the highest level of its openness, strengthening the development of modern integration processes in such sectors as agriculture.

The investment and the use of production factors are just possibilities and means, rather than implementation of the objectives of science-based innovation in agricultural production. Therefore, priority should be given to the development of the country based on the innovation activity in the most important knowledge-intensive and high-tech economic sectors, which represent the most significant and progressive engines of the national economy development.

MATERIALS AND METHODS

The studies are based on the regulations of the Republic of Moldova in the field of scientific and technological development and innovation: the Code on Science and Innovation of the Republic of Moldova no. 259-XV of July 15, 2004; the Innovation Strategy of the Republic of Moldova 2013-2020 – "Innovation for Competitiveness" no. 952 of November 27, 2013. The basic information is provided by statistical reports and information of national institutions (State Agency for Innovation and Technology Transfer - AITT, State Agency on Intellectual Property of the Republic of Moldova - AGEPI, the National Bureau of Statistics - BNS).

The research methodology is based on the use of tools for both analytical and mathematical analysis. In order to validate the provisions of this article there were applied the methods of dialectical, systematic, functional, statistical (correlation and regression) and comparative analysis; also, the methods of mathematical modeling of innovation technologies performance indicators.

RESULTS AND DISCUSSIONS

Currently there are 3 scientific and technological parks and 7 innovation incubators in the Republic of Moldova that enhance the effectiveness of the research results implementation into production, provide consumers with competitive industrial products, works and services based on innovation. They include 39 resident companies, selected on the competitive basis and approved by the Supreme Council for Science and Technological Development of the Academy of Sciences of the Republic of Moldova. The Agency for Innovation and Technology Transfer of the Academy of Sciences organizes annual competitions on innovation and technology transfer projects, funded from the state budget which is up to 50% of the total project cost. Studies show that the number of projects varies from year to year. In 2007 and 2010 there was a maximum number of completed projects, but, by 2013, there has been noticed a gradual decrease, which is due to the reduced funding for innovation projects, as well as to the unstable economic and political situation in the country and abroad. There were awarded 40 innovation and technology transfer projects in 2013, 22 of them being funded and implemented in the amount of 6.82 million MDL from the state budget and 9.58 million MDL were provided by private funds (Ganea, V., Iliadi, G. 2011).

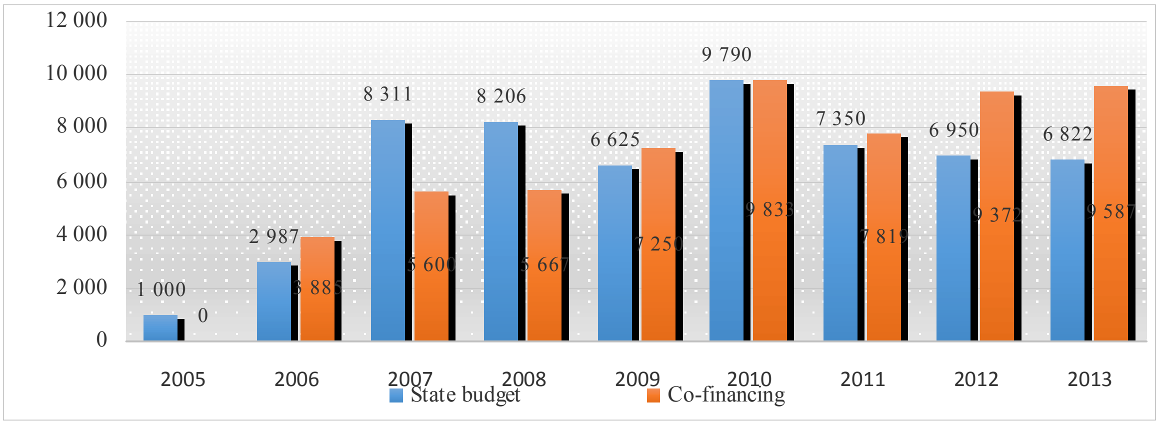

Figure 1. *The funding dynamics of innovation projects in 2005-2013, mln. MDL*
Source: developed by the author based on the AITT and BNS data

Based on the structural indicators, one can have a structural general idea about the overall situation in the sphere of innovation development funding in the country. During the analyzed period one can notice an increase of private funding with the highest indicator in 2010. At the same time, the funding of innovation and technology transfer projects from the state budget was significantly reduced. The largest share of the innovation and technology projects funding is observed in the agricultural sector, where the average amount of funding exceeds 50% of the total funds in 2005-2013:

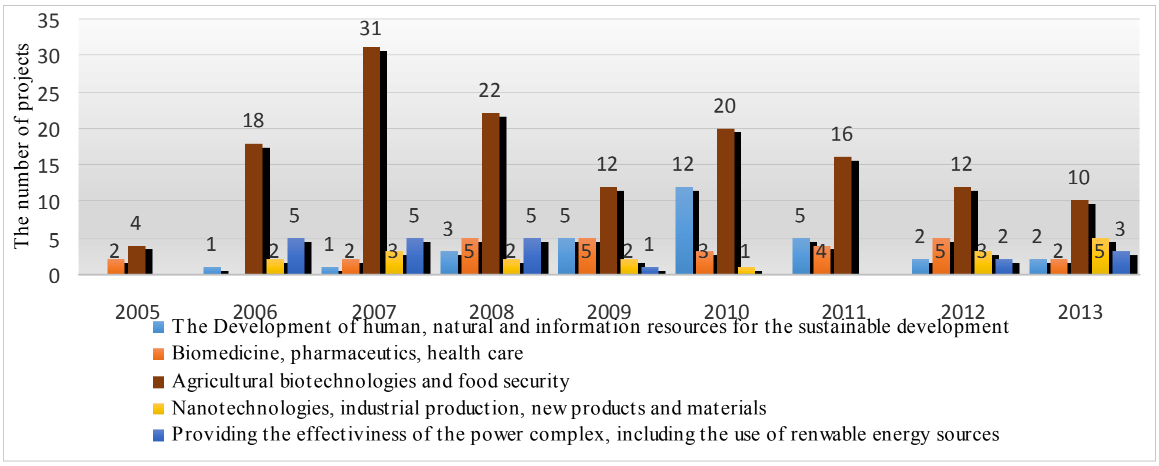

Figure 2. *The dynamics of the implemented innovation projects in the Republic of Moldova by industry sectors in 2005-2013, units*
Source: developed by the author based on the AITT data

In 2013, 45% of total funds were allocated for this sector (Government of the Republic of Moldova). The results of project funding and implementation are represented by the innovation products introduced into the market and affecting the level of socio - economic development of the country. Despite the decreased public funding for innovation projects in 2010-2013, the volume of production and sale of innovation products in the country is constantly growing throughout the analyzed period. At the same time, the co-funding of the innovation activity increases annually, although the government involvement in this type of investment activity in the Republic of Moldova is more stable so far:

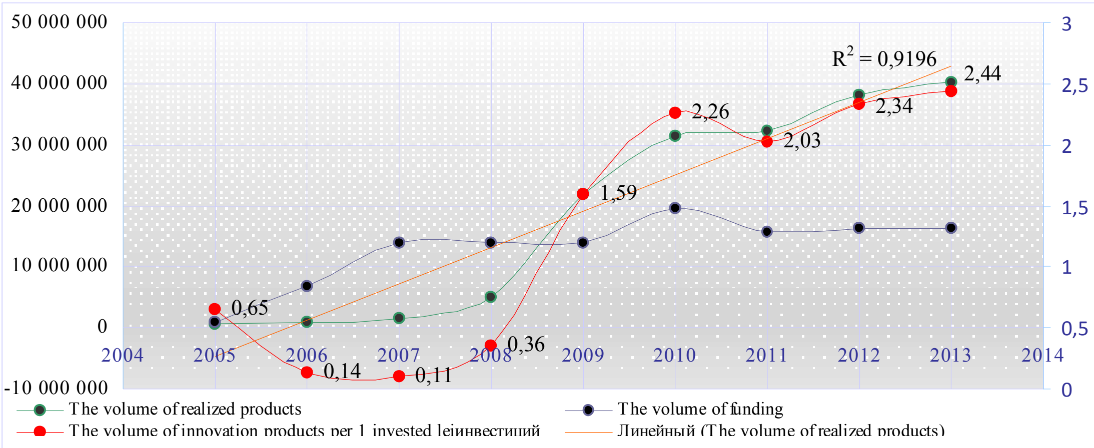

Figure 3. *The dynamics of public funding, implementation and performance of innovation products, MDL*

Source: developed by the author based on the AITT data

The ratio between the amount of funding for innovation processes as a result of the project implementation and the income from innovation product sales is about 92%. In order to determine the increase of revenues from investment, we'll use the following regression dependence: $y^p = 7{,}44 + 2{,}052x$

A well-developed linear regression equation, if necessary, makes it possible to predict the level of production and costs of the innovation activity. Moreover, one needs to determine the elasticity change value of the studied parameters based on the linear regression equation:

$$E_x\left(y^{(p)}\right) = \frac{dy^{(p)}}{dx} \cdot \frac{x}{y^p} = \frac{2.052x}{7.44 + 2.052x}$$

This elasticity factor shows that if index *x* is increased by 1%, than index $y^{(p)}$, is increased by $\frac{2.052x}{7.44 + 2.052x}$%. In order to calculate the elasticity factor we transform this equation as follows:

$$\frac{2.052x}{7.44 + 2.052x} = 1 - \frac{2.052x}{7.44 + 2.052x} = E_x\left(y^{(p)}\right)$$

$$. If x = 0, E_x\left(y^{(p)}\right) = 1 - 1 = 0; If x \to 0, E_x\left(y^{(p)}\right) \to 0$$

The obtained results lead to the conclusion that index $y^{(p)}$ is not elastic with reference to index x, i.e. there is no alternative to public funding of the fundamental research and innovation products in the Republic of Moldova at this stage of economic development.

The estimated rate of revenues on investment as a result of project implementation is one of the performance indices of innovation projects. Based on the value registered in 2013, we may conclude: we have earned 2.4 MDL for every 1 MDL invested from public funds for innovative projects and technology transfer. Compared to 2005, when the value was 0.6 MDL per 1 MDL of costs or to 2007, when the value was 0,11 MDL per 1 MDL, we can conclude that the production level of innovation products is annually increasing, while the private sector becomes more interested in investing in projects and as a result the innovation potential of the national economy increases.

At present, the main directions of innovation development in agriculture are the following:
· the establishment of efficient production and economic structures;
· the use of innovation technology when planning, organizing and managing an enterprise;
· the development of information and consultancy services;
· the development of highly productive varieties and hybrids of crops and livestock breeds adapted to stressful situations and regional peculiarities;
· the development and implementation of regional innovation technologies that are safe from the environmental point of view.

One of the key elements of modern models used to develop and implement efficient technologies is the interaction between the participants in the innovation processes, with the purpose of exchanging knowledge, ideas, concepts, problems, methods for finding solutions, etc.

The aim of the scientific research is to assess the distribution and interconnection between cost and efficiency according to the type of available and used technology. The studies are mainly aimed to save some money, while new technologies are used to save as many resources required by a particular industry as possible (Lem, S. 2002).

Since the introduction of innovation technologies aims not only to improve the quality of products, but also to save as many production resources as possible, these actions can be directed at saving one or more factors. We would like to consider some possible approaches:

1. The purpose – *to save materials*. The quality of the technology may be represented using the following function:

$$QMT(Quality\ of\ \ Material\ Tecech\ log\ ies) = a\left(\frac{M}{GDP}\right)^{a_1} = a \cdot x_1^{a_1} \tag{1}$$

2. The purpose – *to save materials and energy*. The technology may be represented by the following function:

$$QMT = a\left(\frac{M}{GDP}\right)^{a_1} \cdot \left(\frac{E}{GDP}\right)^{a_2} = a \cdot x_1^{a_1} x_2^{a_2} \tag{2}$$

3. The purpose – *to save three production factors: materials, energy and labour*:

$$QMT = a\left(\frac{M}{GDP}\right)^{a_1} \cdot \left(\frac{E}{GDP}\right)^{a_2} \cdot \left(\frac{L}{GDP}\right)^{a_3} = a \cdot x_1^{a_1} x_2^{a_2} x_3^{a_3} \tag{3}$$

The application of these approaches may be presented, for example, based on 25 enterprises from the Republic of Moldova, such as “Alfa-Nistru” JSC, “Goliat-Vita” Ltd., “Prietenia –Agro” Ltd., etc., the average annual number of employees is 7,845 people, the cost of energy resources is 331 thousand MDL and the total production costs equal 85,137 thousand MDL (AITT, 2014). Based on the available data, we have developed a system of normal equations to construct the regression equation : $y^p = a_0 + a_1 x_1 + a_2 x_2$

$$\begin{cases} 25a_0 + 7845a_1 + 331a_2 = 85137; \\ 7845a_0 + 2870249a_1 + 89368a_2 = 32870355; \\ 331a_0 + 89368a_1 + 5485a_2 = 837963; \end{cases}$$

As one can see from the first equation $a_0 = 3405 - 314a_1 - 13a_2$

$$\begin{cases} 7845(3405 - 314a_1 - 13a_2) + 2870249a_1 + 89368a_2 = 32870355; \\ 331(3405 - 314a_1 - 13a_2) + 89368a_1 + 5485a_2 = 837963; \end{cases}$$

If we transform it, we get the following:

$20361a_2 = -1907537; a_1 = 94;$

$406910a_1 = 4972132; a_1 = 12;$

$a_0 = 3405 - 3768 + 1222 = 859;$

The regression equation looks as follows: $y^p = 859 + 12x_1 - 94x_2$

This regression equation suggests that production costs increase with the increased number of employees and decrease with the increased costs of energy resources; this fact proves the presence of efficient technologies.

If the number of employees increases by 1%, the total production costs will be increased by:

$$E_{x_1}\left(y^p\right) = \frac{\partial y^{(p)}}{\partial x_1} \cdot \frac{x_1}{y^p} = 12 \cdot \frac{x_1}{859 + 12x_1 - 94x_2}(\%)$$

If the cost of energy resources increases by 1% due to the introduction of more efficient technologies, production costs will be reduced at enterprises by:

$$E_{x_2}\left(y^p\right) = \frac{\partial y^{(p)}}{\partial x_2} \cdot \frac{x_2}{y^p} = \frac{-94x_2}{859 + 12x_1 - 94x_2}(\%)$$

Therefore, the regression equations allow us to make forecasts regarding the future production costs; to choose the optimal strategy for the production development; to conduct a qualitative analysis of the economic indicators; to restore the missing economic indicators (by means of interpolation); to create a database needed for management decisions.

One can also save some resources by means of a better organization of production, the use of information technologies, optimization methods, i.e. by means of virtual factors – KTV (*Quality of Virtual Technologies*). Similarly, we can express KTV as follows:

1. $QTV = by_1^{\beta_1}$ (4)
2. $QTV = by_1^{\beta_1} y_2^{\beta_2}$ (5)
3. $QTV = by_1^{\beta_1} y_2^{\beta_2} y_3^{\beta_3}$ (6)

Where $y_i^{\beta_i} \longrightarrow i = 1,2,\dots,m$ – saving materials, energy, labour and other production resources by means of virtual methods. Taking into consideration the interaction degree of material and virtual technology factors, the quality of technology is described as follows:

$$QT = QTM + QTV \tag{7}$$

Every type of technology may be described by its differential (evolutionary, dynamic) equation. There seems to be a problem with describing the links between different types of technology, which are interdependent in a way. For example, according to S. Sukharev, based on the assumption that the technology "n" can be expressed in terms of the technology "k", we can develop a production function (Sukharev, S. 2014):

$$QT_n = b \cdot QT_k^{\tau} \tag{8}$$

where b is the proportionality factor,

τ is the index (*elasticity* $E_{KT_k}(KT_n) = \tau$).

One should assume that the evolution of the technologies n and k in time can be described by the following differential equations:

$$\frac{\partial QT_n}{\partial_t} = \alpha(QT_{n-1} - QT_n) \tag{9}$$

$$\frac{\partial QT_k}{\partial_t} = \beta(QT_{k-1} - QT_k) \tag{10}$$

$\frac{\partial QT_n}{\partial_t} = \alpha\left(QT_{n-1} - b\left(QT_{k-1} - \frac{1}{\beta} \cdot \frac{\partial QT_k}{\partial_t}\right)^{\tau}\right)$ – the change of the technology QT_n depending on the evolution of the technology QT_k.

The quality of the technologies consists of QTM and QTV – the material and virtual technologies:

$$QT = QTM + QTV = \alpha\left(QTM_{n-1} - QTM_n\right) + \theta\left(QTV_{k-1} - QTV_k\right) \tag{11}$$

If $QTM = ax_1^{\alpha_1} x_2^{\alpha_2}$ (12)

and $QTV = by_1^{\beta_1} y_2^{\beta_2}$ (13)

$$than \frac{\partial QT}{\partial t} = \left(ax_1^{\alpha_1} x_2^{\alpha_2}\right)_t + \left(by_1^{\beta_1} y_2^{\beta_2}\right)_t = ax_1^{\alpha_1} x_2^{\alpha_2}\left(\frac{\alpha_1}{x_1}\frac{\partial x_1}{\partial t} + \frac{\alpha_2}{x_2}\frac{\partial x_2}{\partial t}\right) + by_1^{\beta_1} y_2^{\beta_2}\left(\frac{\beta_1}{y_1}\frac{\partial y_1}{\partial t} + \frac{\beta_2}{y_2}\frac{\partial y_2}{\partial t}\right)$$

The overall efficiency of the used technology is defined by its novelty. It is known that all economic agents seek to maximize the difference between total revenues and total costs. The increase of every additional unit of the final product increases the amount of marginal costs; it also increases total profits by the value of marginal revenues. If the production growth increases the firm's profit by at least 1 cent, then such a growth is justified.

The growth is not appropriate if marginal costs are negative. The countries under conditions of perfect competition have only one parameter to decide: how much to produce for the export market at a given price. Each country will minimize its total costs. The structure of Total Costs, depending on the economic features of the used technologies is different for the same product in different countries. One uses material and virtual technologies for the GDP production. The structure of costs may be presented by the vectors: $X = \left(X_1, X_2, \ldots X_i, \ldots, X_m\right)$ and $Y = \left(Y_1, Y_2, \ldots Y_i, \ldots, Y_m\right)$ respectively, the costs when using material and virtual technologies. Thus, GDP may be presented by the production equations. Therefore:

$$\frac{X_1}{GDP_1} = X_1; \frac{X_2}{GDP_1} = X_2; \frac{X_i}{GDP_1} = X_i; \ldots; \frac{X_m}{GDP_1} = X_m \tag{15}$$

$$\frac{y_1}{GDP_2} = y_1; \frac{y_2}{GDP_2} = y_2; \frac{y_i}{GDP_2} = y_i; \ldots; \frac{y_m}{GDP_2} = y_m; \tag{16}$$

Every component of vectors X and Y (the share of proportion costs and expenses) correlates with both material and virtual technologies.

One establishes the quality functions of material technologies (*QTM*):

$$QTM = ax_1^{\alpha_1} \cdot x_2^{\alpha_2} \cdot \ldots \cdot x_i^{\alpha_i} \cdot \ldots x_m^{\alpha_m} = a\prod_{i=1}^{m} x_i^{\alpha_i}; \tag{17}$$

The quality functions of virtual technologies (*QTV*):

$$QTV = by_1^{\beta_1} \cdot y_2^{\beta_2} \cdot \ldots \cdot y_i^{\beta_i} \cdot \ldots y_m^{\beta_m} = b\prod_{i=1}^{m} y_i^{\beta_i}; \tag{18}$$

Goods and services become competitive if more efficient technologies are developed and implemented to reduce costs by one, some or all the components of quality functions. The dynamics of QTM and QTV change, i.e. the marginal change of each cost component can be estimated using time derivatives:

$$\frac{dQTM}{dt} = a\prod_{i=1}^{m} x_i^{\alpha_i} \cdot \left(\sum_{i=1}^{m} \frac{\alpha_i}{x_i} \cdot \frac{dx_i}{dt}\right); \tag{19}$$

$$\frac{dQTV}{dt} = b\prod_{i=1}^{m} y_i^{\beta_i} \cdot \left(\sum_{i=1}^{m} \frac{\beta_i}{y_i} \cdot \frac{dy_i}{dt}\right); \tag{20}$$

The quality of the technology (QT) equals the sum of qualities of both material and virtual technologies:

$$QT = QTM + QTV = a\prod_{i=1}^{m} x_i^{\alpha_i}\left(\sum_{i=1}^{m} \frac{\alpha_i}{x_i}\frac{dx_i}{dt}\right) + b\prod_{i=1}^{m} y_i^{\beta_i}\left(\sum_{i=1}^{m} \frac{\beta_i}{y_i}\frac{dy_i}{dt}\right); \tag{21}$$

The innovation policy generates new, fundamentally new technologies that would later provide the competitiveness of goods and services, as well as create favorable conditions for both producers and consumers.

The demand dynamics for various goods and services is evolving, which generates different levels of competitiveness. As a rule, for all events, the population tends to keep the usual amount of current consumption of durable consumer goods with the elasticity in the interval (0;1) and, therefore, the demand for these goods is lowly volatile; the volatility of the products with the elasticity in the interval (1; “) is higher. Therefore, the products will be more competitive if they are of high quality, vital and have few analogues and substitutes. One should keep in mind that the level of competitiveness of goods is not defined by the manufacturer, but by the market that sets the price of the relevant goods, as well as by the consumer who demands (or does not demand) this product. The manufacturer “adjusts” to the consumer’s tastes and choice; he also fulfills all consumer’s requirements for each product and additionally invents an exceptional quality of its product in order to attract potential buyers. Nevertheless, high quality and low prices is the true and efficient instrument to attract consumers. The price may be kept low and the quality – high only if manufacturers have innovation technologies of high quality at their disposal.

CONCLUSIONS

1. The interdependence analysis of the innovation process funding and output, as well as the implementation of innovative products has shown that now there is no alternative to government funding of scientific research and innovation development in the Republic of Moldova. The state is the only institution that can ensure the effective implementation of fundamental research aimed at increasing the welfare of the society without any economic purposes.

2. The overall effectiveness of agricultural technology is defined by its novelty. Given the desire of economic agents to increase the difference between revenues and costs, the growth of each additional unit of the final product increases the marginal cost, while increasing the overall return on the marginal revenue. Agricultural products and services are competitive, if more effective technologies are developed and implemented that are aimed at reducing the costs of one, several or all components of quality functions. If increased production contributes to the increase of profits by at least 1 cent, such a growth is justified.

3. Existing tools to support the innovative entrepreneurship in Moldova:

§ Creating partnerships between business and academia in parks and incubators;

§ Discount rates for rent and communal services for the residents of scientific-technological and innovation incubators;

§ Public funding of projects;

§ Provision of services at reduced prices.

4. The necessary tools to facilitate innovative entrepreneurship in Moldova:

· Innovation promotion in the free economic zones;

· Provision of tax and customs incentives for innovative enterprises;

· Creating a public-private partnership for the implementation of innovative technologies;

· Creating synergy between the public and private sector in order to promote innovation in the country;

· Creation and implementation of the Venture Fund.

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