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Modeling of the optimum level of financial provision of Ukrainian enterprises' innovative activities

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ABSTRACT

The purpose of the article is the establishment of the tightness of the connection between the various sources of financing and introduction of innovations at enterprises. In the process of research such scientific methods have been used: modeling – to determine the influence of the source of funding for innovation activities, on the number of new technological processes introduced and the introduction of new types of products; economic-statistical – to evaluate the dynamics of the amount of realized innovative products and the index of the efficiency of innovation costs; correlation-regression analysis – to determine the relationship density and the relationship between factors of influence and performance indicators; abstract-logical – for the implementation of theoretical and methodological generalizations. The results of the research – analyzed the connection of the indexes of dynamics of sources of financing of innovation activity and the amount of implemented new technological processes and development of new types of products for 2011-2017. The influence of the most significant sources of financing on the amount of innovations is described. Further development of methodological and practical aspects of the dependence of the amount of implemented innovative products and the index of the efficiency of innovation costs, using multiple regression models, has been found for the establishment of the influence of system-based economic indexes. The practical significance of the obtained results is to determine the optimal level of financial support for innovation activity of enterprises, which will allow to predict the growth of innovative processes in the country in the short and medium term.

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INTRODUCTION

In modern economic conditions, the decisive factor in the economic growth of the country's economy and increasing the competitiveness of each individual enterprise is the introduction of innovation activities. According to foreign and domestic experience, one of the important problems of enterprise development is the effective management of innovation processes and the development of innovative enterprises through their own and attracted financial resources. Experts estimate that the decline in investment activity in recent years and the limited availability of own resources are the biggest problem hampering the innovation activity of enterprises. Questions of financial support of innovative activity of enterprises are considered in different cases of foreign and domestic economists such as; (Dutta, *et al.,* 2014; Freeman, 2008; Lundvall, 2015; Pidgorodetskaya, *et al.,* 2012; Petrovskaya, 2013; Pustovalov, 2013; Stecchenko, 2012). It is worth noting that the research is devoted to the issues of assessing the investment attractiveness of enterprises. However, the issue of the optimal level of financing for innovation activities has not been given enough attention. The problems of modeling and developing the model of management of innovation processes are relevant. This topic is devoted to many publications of the theoretical and practical plan of domestic and international scholars, in particular by (Danylkiv, 2015; Babenko, *et al.,* 2017; Vasilieva, 2010; Kolodiziev, 2011; Robinson, *et al.,* 2013; Shorikov, 2014; Chorna M., 2018) and many others. Reducing the financial capacity to support the innovation sector from both the state and private enterprises, reducing innovation demand, underdevelopment of innovation infrastructure, and raising the financial support of innovative enterprises. Issues of the amount of resources that provide the innovation process at all its stages, as well as the efficiency of institutions that direct the flow of resources and coordinate various aspects of innovation activity, are critical important for the Ukrainian economy. This substantiates the importance and relevance of the study of financial support for innovation activities of enterprises. This study has been carried out in Ukraine in 2018.

MATERIALS AND METHODS

In the context of ensuring sustainable economic growth in Ukraine, the development of effective practical measures for the structural adjustment of the existing mechanism of financial support for the introduction of an innovative development model within existing investments, structural and institutional constraints are of particular importance. The development of innovative activities of enterprises requires the attraction of financial resources, but it must be understood that the investment does not always bring the desired economic effect. The main elements of the state financial policy to promote the development of the innovation environment are: creation of financial mechanisms of state support of innovation activity in the direction of financing through the system of state scientific and technical programs of different levels and through specially created funds; organizational and legal methods of state influence on the formation of infrastructure of innovation sphere; creation of an information base on the market of innovative products; institutional and organizational and legal support for the functioning of an effective mechanism for the implementation of the state's financial policy (Rassozhdaj *et al.,* 2008). According to Chemodurov (2013), with an increase in budget commitments and a constant budget deficit, it can be clearly argued that public funding for the near future cannot become the main source of financing for innovation development. The lack of public funding and lack of real investment is one of the reasons for delaying the innovation development of enterprises and the lack of market security in innovative products and technologies. The majority of scientists in analyzing financing of innovation activity in Ukraine distinguish the following main problems: limited possibilities of attracting public resources; lack of own resources of economic entities; underdevelopment of institutional investors (banks, insurance companies, investment funds and companies, stock market, etc.); underdevelopment of innovation infrastructure; lack of effective legal framework for attracting funds from foreign investors, including venture financing. In Ukraine, no investment bank for long-term lending has yet been set up, no decision is taken on the establishment of a state bank for reconstruction and development (Fominiev *et al.,* 2017). Studies of literary sources indicate that the researchers point to the dependence of financial levers of innovation support (Dekhtyar *et al.,* 2014; Omelyanenko, 2017). It is believed that the actuality of the problems associated with the formation and

improvement of the financial system of innovation activity is determined by the exceptional importance of innovative processes in the economic and social development of the country, as well as the need to create effective forms of financial relations that mediate each stage of innovation activity.

The linearity with respect to the parameters of the equation will look like Eq. 1.

$$Y = a_0 + a_1X_1 + a_2X_2 + \ + a_kX_k + \varepsilon \quad (1)$$

Where, a0 is a free member of the equation;

bi – coefficient of regression; shows how the Y changes with Xi;

ε – the non-observed quantity has a probable nature and reflects the influence of those factors that it cannot be determined.

Parameters of the regression equation are determined by the method of least squares (MNCs), the main condition of which is minimization of the sum of squares of deviations of empirical values u and from theoretical Yi, using Eq. 2.

$$\sum(y_i - Y)_i^2 = min \ , \quad (2)$$

Where, i – is the serial number of the object in the sample (Kozmenko, 2014).

To assess the significance of the regression equation, Fisher's criterion is used, or the F– criterion, which is calculated by Eq. 3.

$$F = \frac{MS_r}{S^2}, \quad (3)$$

Where, MSr – is the average amount of squares due to regression; S2 is the middle square due to the residual variation. The value F is subordinate to Fischer's F-distribution with N-n and n-2 degrees of freedom. This fact is used as a criterion for the estimation of the null hypothesis (the coefficients of the regression equation are zero). It is only necessary to compare the value F obtained by calculating the regression equation from the 100 (1-α)% Fischer tabular point, in order to conclude whether it is possible to calculate the F-value, to accept or reject the null hypothesis, that is, is there statistically between variables reliable communication. The value of α is usually chosen to be 0.05 and if F obtained by calculating the coefficients of the regression equation exceeds the table value, then the null hypothesis is rejected. The standard mistake of the coefficient of the regression equation is determined by Eq. 4.

$$V(a_i) = \sqrt{\sigma_{ii} S_{ii}} \ , \ i=1,2,\ldots,n, \quad (4)$$

Where, σii is the diagonal element of the matrix inverse to the matrix of the system of linear equations, on the basis of which the coefficients of the regression equation were determined, and the S_{ii} – variance of i-th independent factor. The value V (ai) is compared with the value of ai. If ai> V (ai), then the i-th coefficient of the regression equation is considered statistically significant and for it it is possible to construct probable boundaries that are determined from equality using Eq. 5.

$$\overline{a_i} = a_i \pm t_\alpha * V(a_i), \quad (5)$$

Where, t_α is the tabular distribution point of the Student with n-2 degrees of freedom with the probability level α = 0.95 using Eq. 6.

$$R^2 = 1 - \frac{S^2_{зал}}{S^2_y}, \quad (6)$$

The value R^2 is called the square of the multiplication correlation coefficient, or the determination factor. It reflects the portion of the variation of the dependent variable, which is explained by the independent variables included in the regression equation. The determination coefficients for individual factors of influence are calculated according to Eq. 7.

$$d_i = a_i \times ryx_i \times Sx_i / Sy \ , \quad (7)$$

Where, i – factor number; ai – coefficients of regression of the i-th factor; ryxi - coefficient of correlation of the sign of y with the i-th factor; Sxi – standard deviation of the i-th factor; Sy is the standard deviation of the y sign. The coefficient of elasticity shows how many percentages will change the average resultant sign (Y) when the factor sign (X) changes by 1% using Eq. 8.

$$E = f'(x) \times \frac{\bar{x}}{\bar{y}}, \quad (8)$$

In this case, the linear equation model is written as Eq. 9.

$$E = a_1 \times \frac{\bar{x}}{\bar{y}} \ , \quad (9)$$

Improvement of the new methods of management of innovative activities and approaches to the solution of this issue, including the financial provision of innovation activities, is primarily due to the relevance of the study.

RESULTS AND DISCUSSION

The success of innovation activity is largely determined by the forms of its organization and the ways of financial support. Depending on how new scientific developments and technologies become the fundamental components of national security, developed countries have diverse opportunities to support and develop innovation. In this case, a variety of methods for financing innovative activities and a range of measures to indirectly support innovation.

The research revealed that during 2011-2017 the financing of innovation activity in Ukraine was rather uneven. Thus, during 2011-2014 there was a tendency to reduce the amount of financing of innovation activity from UAH 14333.9 million in 2011 to UAH 7695.9 million. in 2014. It is natural that the share of expenditures on innovation activity in GDP declined substantially and in 2014 it was only 0.48%. It is worth noting the positive dynamics, in 2016 there is a rapid growth of expenditures on innovation, in comparison with 2014 they increased more than 3 times and amounted to 23229.5 million UAH. The largest amount of financing during the analyzed period. In 2017, expenditures declined 2.5 times in comparison with the previous year, and the share of expenditures on innovation activity in GDP was the lowest and amounted to only 0.31% (Fig. 1).

Despite the fact that the amount of financing during the years 2011-2014 tended to decrease, the indicator of the efficiency of the costs of innovation during the period was relatively stable. Beginning in 2015, the situation has changed dramatically and cost efficiency has started to decline. So, if in 2011 for 1 UAH of innovation costs accounted for 2.95 UAH of realized innovation products, then in 2017 only 1.94 UAH. This trend shows a decrease in the growth rate of sales of innovative products compared with the growth rate of innovation costs (Fig. 2). Developed countries draw financial resources for innovation from both public and private sources: for most countries in Western Europe and the United States, there is an even distribution of financial resources between public and private capital. After analyzing the structure of sources of funding for innovation activities in Ukraine during 2011-2017, it was established that the main sources are the company's own funds, that is, the net profit of the enterprise. It is worth noting that the share of own funds in the structure from year to year increased and in 2017 amounted to 84.5% (Table 1).

On the one hand, the use of own funds to finance innovation is characterized by the stability, simplicity and speed of their involvement, the possibility

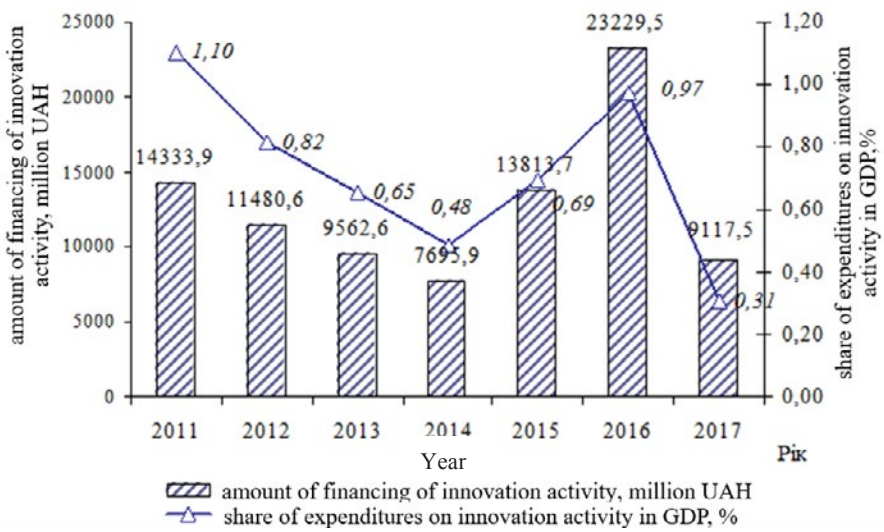

Fig. 1: Dynamics of financing of innovation activity in 2011-2017

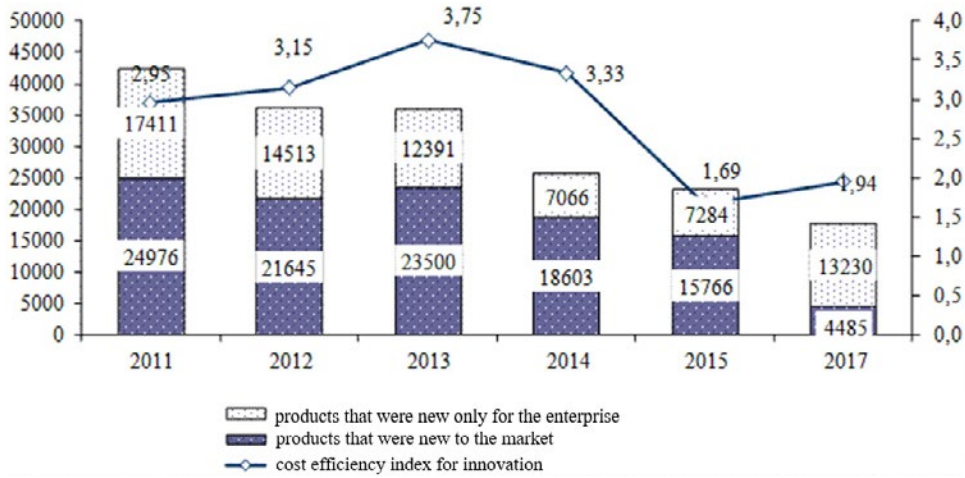

Fig. 2: Dynamics of the volume of realized innovative products in 2011-2017 (There is no data for 2016)

Table 1: Structure of sources of financing of innovative activity in Ukraine in 2011-2017

Sources of funding		Year						
		2011	2012	2013	2014	2015	2016	2017
Total, UAH million		14 334	11 481	9 563	7 696	13 814	23 229	9 118
	own	*52,92*	*63,9*	*72,92*	*84,98*	*97,2*	*94,86*	84,5
	involved	*47,08*	*36,1*	*27,08*	*15,02*	*2,8*	*5,14*	15,5
	state budget	1,04	1,95	0,26	4,47	0,4	0,77	2,5
of them at the expense	local budgets	0,09	0,15	1,65	0,07	0,28	0,43	1,0
(in% to the total amount of financing)	domestic investors	0,32	1,35	1,29	0,11	0,54	0,58	3,0
	foreign investors	0,4	8,66	13,11	1,8	0,42	0,1	1,2
	loans	38,3	20,97	6,59	7,29	0,82	2,69	6,5
	others	6,94	3,01	4,16	0,84	0,33	0,57	1,3

of flexible and prompt investment decisions, minimizing the cost of the project by the amount of interest on loans, which ensures high mobility of cash flow and preventing the risk of insolvency and bankruptcy under time of their use. But on the other hand the constant lack of own funds and the high level of risk inherent in innovation activity does not always guarantee high rates of development by self-financing innovative measures. Studies show that one of the main forms of financing innovative activity in Ukraine is lending. In comparison with own funds, the share of credit resources is insignificant, however, it is the largest in the structure of attracted funds. Thus, during 2011-2017, the share of credit funds decreased significantly by almost 32% and in 2017 it was only 6.5%. In a financial crisis, such a rapid decline is associated with economic instability and distrust of the banking system. It is worth noting and positive changes, so in 2017, the share of credit resources in the structure of sources of funding began to increase and reached the level of 2013, indicating the activation of financial institutions and innovation processes of the domestic economy. It should be noted that starting from 2014 there is a significant reduction of domestic and foreign investment in financing innovative activities. The main reasons preventing foreign investors, apart from the high level of innovation risk, are political and economic instability in the country and imperfect legislation. For a more detailed analysis, a correlation-regression analysis of the influence of sources of financing of innovation activity, in particular on own (x1), local budget funds (x2), funds of the State budget (x3), funds of foreign investors (x4), loans (x5) and other sources x6) financing, previously adjusted for the level of inflation, on the number of new technological processes implemented (Y1) and the introduction of new types of products (Y2) for 2011-2017. It is

necessary to distinguish such sources of financing as own funds and among those involved – local budget funds and state budget funding with the most significant correlation coefficients (Table 2).

The dependency analysis revealed a strong link between the number of newly introduced technological processes (Y1) and the financing of innovation activities at their own expense (X1), a significant link between the number of newly introduced technological processes (Y1) and the financing of innovation activities at the expense of the State budget (X3) and between the number of new products introduced (Y2) and the financing of innovation activities at their own expense (X1); the existence of a moderate link between the implemented new technological processes (Y1) and the local budget (X2) and between the number of new products introduced (Y2) and the state budget funds (X3), the influence of the remaining factors is insignificant.

On the basis of established relationships, multifactorial regressive dependencies of the influential sources of financing of innovative processes and the number of new technological processes introduced (Y1) and introduced new types of products (Y2) were constructed. Multi-factor regression analysis is used to find a functional relationship between a dependent variable – a function and independent variables – factors. By Fisher's criterion, the equations are statistically significant: the calculated values of the Fisher coefficient exceed the table values of the coefficients with a probability of 0.95. The regression coefficients tend to fluctuate in small sample sizes, so they should be checked for significance. at a linear connection Limit value of the Student coefficient with probability P = 0.95 Tgr = 1.96. The value of t-characteristics exceeds the critical value of the Student's t-criterion. It means that the coefficients of the equation in the variables are statistically significant, and also with the probability of 0.95 confirms the significance of the influence of these factors. The coefficient of multiple correlation for the first model is 0.8654, which indicates a strong connection between the number of new technological processes introduced by the influential sources of innovation financing. For the second model - 0.6851, which indicates a significant relationship between the investigated factors (Table 3). The unit of measurement of simultaneous influence, caused by the variation of three factors, is the coefficient of multiple determination. In this case, the R^2 for the first model is 0.7489. That is, the variation in the number of implemented technologies by 74.9% depends on changes in the factors under investigation, including 46.07% of financing at their own expense (X1), 3.2% - at the expense of local budgets (X2) and 25 , 59% - of the state budget funds (X3). Despite the fact that all three factors have a significant impact, the main sources of finance remain the enterprises' own funds. For more effective implementation of innovative technologies it is expedient to attract external sources of financing, such as loans, investments, etc. All factors have a direct impact on the resultant sign, with the increase of these factors (X) the value of the resultant sign Y increases. The value of the coefficient of the regression equation (a_1 = 0,093, a_2 = 0,732, a_3 = 0,3,257) determines the coefficient of increase of the variable Y with an increase of Xi per unit relative to the average. Consequently, it can be concluded that with the increase of funding from own funds, funds from local budgets and the State budget the number of implemented technological processes increases. According to the coefficients of elasticity: an increase in the amount of financing from own funds, funds from local budgets and the State budget by 1%, the number of introduced technological

Table 2: Matrix of correlation between indexes of dynamics of volumes of sources of financing of innovation activities and the number of implemented new technological processes and newly developed types of products in 2011-2017

	y1	*Y2*	*x1*	*x2*	*x3*	*x4*	*x5*	*x6*
y1	1							
Y2	0,6197	1						
x1	0,7591	0,6237	1					
x2	0,4378	0,2221	0,6659	1				
x3	0,5776	0,4207	0,2326	-0,0904	1			
x4	-0,1550	-0,0881	-0,3382	0,1197	-0,3780	1		
x5	0,3184	-0,0071	-0,1982	-0,4032	0,0307	0,2714	1	
x6	-0,0187	-0,0217	-0,2053	0,2583	-0,2474	0,9774	0,1944	1

Table 3: Parameters of the regression equation and their estimation

Statistical indicator	a_0	a_1	a_2	a_3
Parameters of the regression equation Y1				
Regression equation: Y= 651,4409 + 0,0934X_1 + 0,7321X_2 + 3,2574X_3				
Fischer coefficient (calculated)	12,982			
Table value of Fischer coefficient	4,35			
Critical limit of the coefficients of the equation		2,4385	2,1789	2,4017
Table value of the t-factor	2,26			
Coefficient of multiple correlation	0,8654			
Determination coefficient	0,7489			
Average values	2079,14	8932,62	69,98	166,42
Standard deviations	747,91	4859,82	75,29	101,73
Determination coefficients for individual factors of influence		0,4607	0,0323	0,2559
Elasticity coefficients		0,401	0,025	0,261
Parameters of the regression equation Y2				
Regression equation: Y= -2494,306+ 0,061525X_1 + 1,540678X_2				
Fischer coefficient (calculated)	11,769			
Table value of Fischer coefficient	4,74			
Critical limit of the coefficients of the equation		1,4846	0,7782	
Table value of the t-factor	2,26			
Coefficient of multiple correlation	0,6851			
Determination coefficient	0,4694			
Average values	3300,29	8932,62	166,42	
Standard deviations	537,80	4859,82	101,73	
Determination coefficients for individual factors of influence		0,3468	0,1226	
Elasticity coefficients		0,167	0,078	

processes increases by 0,401, 0,025 and 0,261%, respectively, relative to the average sample value. A similar dependence is also observed in the analysis of the impact of financing innovative activities at the expense of own funds (X1) and state budget funds (X3) on the introduction of new types of products (Y2). The analysis shows that the introduction of new types of products by 46.9% depends on changes in the investigated factors, in particular 34.7% of their own funds and 12.2% of the state budget funds.

CONCLUSION

The article deals with correlation-regression analysis of the influence of existing sources of financing of innovation activity, in particular, on own resources, local budget funds, state budget funds, foreign investors' funds, loans and other sources of financing, adjusted to the level of inflation, on the number of new technological processes introduced and new ones introduced. types of products for 2011-2017. The authors distinguish the main criteria for the effective functioning of the financial support system for the innovative development of the Ukrainian economy at the present stage: the problems of transformation and the choice of the optimal structure of the financial system; taking into account the specificity of the relationship between its separate structural components, as well as the existing methods of financial provision in the conditions of integration of the national economy into the world economic space; development of financing strategy as the main way of providing innovative development of the economy. The analysis of the current state of innovation development of the Ukrainian economy has allowed to state that there is an imbalance between the objective laws of social development and the conditions for obtaining and introducing innovations. This conclusion is confirmed by a number of factors: directly related to the process of innovations (contradictory, systemic, violation of unity, lack of awareness about the importance of the multiplier effect of innovations, insufficient level of economic conditions, not optimality of the structure of innovations and their financing, inconsistency of individual components of financial provision of innovation development economy; lack of regulatory principles for the implementation of financial support, etc.). The methods proposed by the authors to determine the optimal level of financial support for innovation development will allow to

predict in the short and medium term the dynamics of investment support for implementing the model of economic growth based on innovations in the context of individual sources of financing.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

%	Percent
Eg	Equation
Fig.	Figure
GDP	Gross Domestic Product
R2	Determination coefficient
UAH	Ukrainian hryvnia

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