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MODELLING OF INVESTMENT AND INNOVATIVE PROCESSES IN AGRICULTURE DEVELOPMENT

У статті проаналізований рівень інвестицій в аграрне виробництво. Розглянута необхідність використання методів економіко-математичного моделювання та обгрунтований вибір багатофакторних моделей для моделювання інноваційно-інвестиційних процесів розвитку сільського господарства. Показана можливість прогнозування основних результативних показників господарської діяльності підприємств агропродуктового комплексу, очікуване фінансування інновацій та інвестицій у сільське господарство.

Ключові слова: сільське господарство, моделювання інвестицій та очікуваний обсяг інвестицій, методи, процеси, інвестиції, інновації, агропродовольчий комплекс.

Statement of the problem. Overcoming the crisis and choosing the right targets predicted in the trends of economic development of agricultural enterprises shows that the most appropriate of the possible directions of development in the field of agricultural production is innovative investment . Only in this way one can quickly and efficiently transform agricultural production, stimulate small and medium enterprises and at the same time provide access to the World markets, which is extremely important for our country, with its vast agricultural potential [4]. Therefore the problem of innovation and investment to ensure the development of agriculture is a large-scale one and it requires considerable efforts from agricultural enterprises, academic institutions, government and economic management.

Publications research. The essence, content and features of innovative activities of the agricultural enterprises are investigated by V.G. Andreychuk , M.V. Zubez, I.A. Pavlenko, P.T. Sabluk *et al.*

The theoretical basis of investment and innovation activities are developed in scientific papers : M. Tugan- Baranovsky, N. Kondratiev , F. Makhlupa , H. Freeman , L. Soti, S. Glazyev , J. Yakovets.

The questions of economic-mathematical modeling of innovation and investment in agriculture development are discussed in the papers of O. Ermakov, Yu.B.Lyzhnyk , Nail S. and other problems of modeling processes in agriculture is widely discussed in the papers of leading Ukrainian and foreign scholars: Vitlinskiy V. Kravchenko V., V. Vovk , Kadiyevskiy VA Klyebanovoyi TS , Lysenko, Y., Claus AM, Petrov AA, Pospelov IG, Ulianchenko OV Usykina VM Baltensperhera E. Bellman , R., Rose , P., broken rice D., Forrester, D. *et al.* However, in these researches multifactorial modeling innovation and investment in agriculture development have not been investigated.

Target. The aim of this article is researching and economic modeling of investment and innovation processes in agriculture.

The main material. According to the State Agency of Investment and National Projects of Ukraine in the first quarter 2013 the index of investment attractiveness of Ukraine amounted to 2.18 points according to the five-point scale, compared with this index 2,6 in May 2009 - and 2.2 in May 2008, indicating a reduction of investment attractiveness of Ukraine for investors. Investments in agriculture of Ukraine was 6.9 % o direct foreign investment into the economy . [5]

Unlike other industries, agricultural production is characterized by a large period of circulation of capital . This is due to long-term production, which is in crop and most of livestock industries is more than a year . Increased risks of agriculture as an object of investing difficult financial state of agricultural enterprises *ad hoc*, the negative impact of inflation due to the delay in payment, a small proportion of liquid assets as part of the of advance capital, poor development market for agricultural products, the unresolved problems of land ownership and property causes difficulty in attracting private investment in this sector [2]. In 2012, foreign investments into the economy of Ukraine came to 5986.0 millions. U.S. direct investment: from EU countries invested $ 4605.8 millions (76.9 % of total) , other CIS countries - $ 849.2 millions (14.2 %) from other countries - $ 531.0 millions (8.9 %). At the same time, the capital of non-residents decreased to the 809.7 millions. Investment was made mainly in the form of monetary contributions amounted to $ 5684.8 millions (95.0 % of invested amount). The growth of foreign capital in the country economy in 2012 came to $ 4655.0 millions, which is $ 104.9 % of the previous year. For comparison, the growth of direct investment in Ukraine in 2011 was $ 4436.6 million. (73%), and in 2010 $ 6073.7 million. (76.5 %).

Figure 1 shows trends the distribution investments according to the major economic activity in 2011-2012.

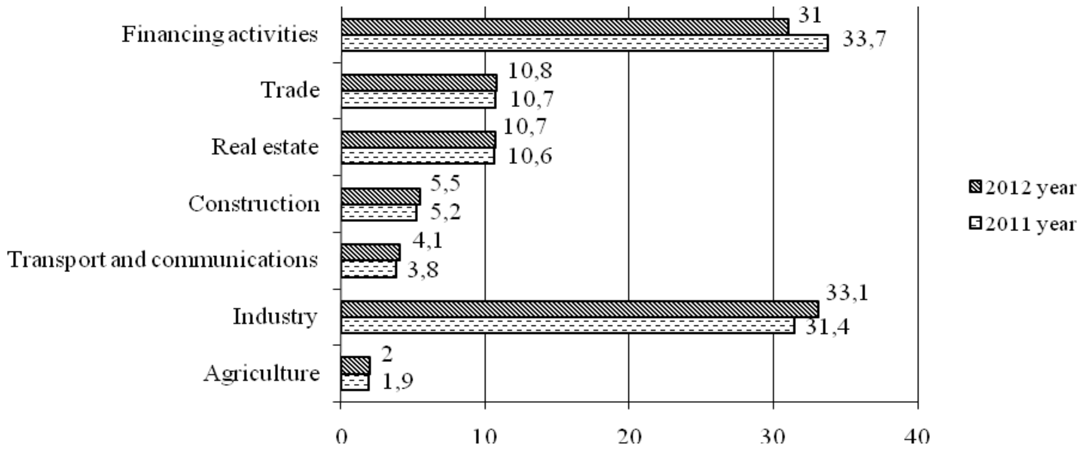

Figure 1 – **Trends of distribution of investments according to the major economic activity in 2011-2012.**

Analysis of the distribution of investment shows that agriculture is now one of the branches of Ukraine, which receives very small part of the total investment coming into the country, at the same time a slight trend of increasing investment into the agricultural production (compared to the 2011 year).

The process of increasing investment into agricultural economy is prevented by a number of factors, including: inconsistent governmental policy in the agrarian sphere of production , low liquidity of investments , mortgage problems , significant deterioration and lack of conditions for extended and even simple reproduction of fixed assets , the lack of conditions for small businesses develpment in rural areas; imperfect mechanism of economic relations between branches, undeveloped innovation infrastructure . In addition, the low level of return on capital in agricultural enterprises, low paying capacity , limited credit constrains their innovation and investment activity. High transaction costs and monopoly on agricultural production markets and investment resources do not allow to form the sources for the extended reproduction of inputs .

Thus the results of the economic activities of modern enterprises of agri-food industry of Ukraine are affects by a large number of factors of internal and external environment , that's why for quantitative prediction of their investments support, the most effective is using of multi regression models . For such models or processes using the method of multiple correlation and regression analysis , which provide the opportunity to study and measure the internal and external relationships between factors which forming model will be appropriate. It will allow operating patterns and trends of the researched features.

The major terms of building a multi-factorial communication model is a sufficient amount of units together (at least 8 times more than the number of factors) and the absence of multicollinearity of factors (close to the functional relation between them). In case when two factor values are multicollinear, one of them must be excluded from the model.

In practice, two types of multiple regression equations are used. They are:

- Linear (additive):

$$Y_x = a_0 + a_1X_1 + a_2X_2 + ... + a_mX_m \quad (1)$$

- Non-linear (multiplicative):

$$Y_x = a_0 \cdot X_1^{a_1} \cdot X_2^{a_2} \cdot ... \cdot X_m^{a_m} \quad (2)$$

Where $a_0, a_1, a_2, ..., a_m$ are multiple regression equation parameters;

$X_1, X_2, ..., X_m$ are factor variables [6].

Estimation of parameters of multiple regression equation is done by the method of the least squares. Parameters a1, a2,. . . , Am are called regression coefficients, indicating how many units varies with increasing x per unit, provided that the other factors are constant.

Summary multifactor linear regression model can be presented as:

$$y = a_0 + a_1x_1 + a_2x_2 + ... + a_px_p + \varepsilon \quad (3)$$

where y – the dependent variable,

$x_1, x_2, ... x_p$ – independent variables (factors)

$a_0, ... a_p$ – model parameters to be estimated,

e – is not observable random variable [2].

Summary regression model is a model which is valid for the entiregeneral aggregate. The unknown parameters of the summary model are constant and a random variable are not observed , and one can only assume in accordance with the law of its distribution. In contrast to the summary regression model , selective model is built for a particular selection, unknown parameters of selective model are random variables, the expected value is equal to the parameters of the summary model.

The corresponding selective linear multifactor model is:

$$\hat{y} = b_0 + b_1 x_1 + b_2 x_2 + ... + b_p x_p + e, \qquad (4)$$

where ŷ is a dependent variable,

$x_1 \ldots x_p$ is an independent variables,

b_0, $b_1 \ldots b_p$ – estimation of unknown parameters of the summary model, E is a random variable (error).

Let us give the number of observations for the dependent variable $y = \{y_1,...,y_n\}$ and the independent variables or factors. $x_1 = (x_{11}, x_{12},...,x_{1n}),...x_p = (x_{p1}, x_{p2},...,x_{pn})$. Based on these observations, the selective linear multifactorial model is formed and can be presented in the form given (4).

As well as in the case of simple linear regression, the unknown parameters can be foung by using the method of the least squares, minimizing the sum of squared deviations of actual from theoretical data:

$$F(b, b_1,...,b_n) = \min \sum_{i=1}^{n} e_i = \sum_{i=1}^{n} (y_i - b_0 - b_1 x_{1i} - ... - b_p x_{pi})^2 \text{, тобто } \frac{\partial F}{\partial b_i} = 0 (i = \overline{0,8}).$$

The normal system of equations is obtained:

$$\begin{cases} nb_0 + b_1 \sum_{i=1}^{n} x_{1i} + ... + b_p \sum_{i=1}^{n} x_{pi} = \sum_{i=1}^{n} y_i \\ b_0 \sum_{i=1}^{n} x_{1i} + b_1 \sum_{i=1}^{n} x_{1i}^2 + ... + b_p \sum_{i=1}^{n} x_{pi} x_{1i} = \sum_{i=1}^{n} y_i x_{1i} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ b_0 \sum_{i=1}^{n} x_{pi} + b_1 \sum_{i=1}^{n} x_{1i} x_{pi} + ... + b_p \sum_{i=1}^{n} x_{pi}^2 = \sum_{i=1}^{n} y_i x_{pi} \end{cases} \qquad (5)$$

Solving the system of equations (5) with respect to b_0, $b_1 \ldots b_p$ obtained multiple regression equation is obtained.

Linear multivariate models, as well as the main problems of regression analysis, is worth to consider using matrices. For this purpose, we introduce the matrix:

$$(n \times 1) = \begin{pmatrix} y_1 \\ y_2 \\ ... \\ y_n \end{pmatrix}, B((p+1) \times 1) = \begin{pmatrix} b_0 \\ b_1 \\ ... \\ b_p \end{pmatrix}, X(n \times (p+1)) = \begin{pmatrix} 1 & x_{11} & ... & x_{1p} \\ 1 & x_{21} & ... & x_{2p} \\ ... & ... & ... & ... \\ 1 & x_{n1} & ... & x_{np} \end{pmatrix}, E(n \times 1) = \begin{pmatrix} e_1 \\ e_2 \\ ... \\ e_n \end{pmatrix} \qquad (6)$$

Then the system (4) can be written in matrix form:

$$\begin{pmatrix} \hat{y}_1 \\ \hat{y}_2 \\ ... \\ \hat{y}_n \end{pmatrix} = \begin{pmatrix} 1 & x_{11} & ... & x_{1p} \\ 1 & x_{21} & ... & x_{2p} \\ ... & ... & ... & ... \\ 1 & x_{n1} & ... & x_{np} \end{pmatrix} \begin{pmatrix} b_0 \\ b_1 \\ ... \\ b_p \end{pmatrix} + \begin{pmatrix} e_1 \\ e_2 \\ ... \\ e_n \end{pmatrix}, y = \hat{X}B + E, \qquad (7)$$

and the system (5) can be written in the following matrix form:

$$\begin{pmatrix} n\sum_{i=1}^{n} x_{1i} & \sum_{i=1}^{n} x_{2i} & \dots & \sum_{i=1}^{n} x_{pi} \\ \sum_{i=1}^{n} x_{1i} & \sum_{i=1}^{n} x_{1i}^2 & \dots & \sum_{i=1}^{n} x_{1i}x_{pi} \\ \dots & \dots & \dots & \dots \\ \sum_{i=1}^{n} x_{pi} & \sum_{i=1}^{n} x_{pi}x_1 & \dots & \sum_{i=1}^{n} x_{pi}^2 \end{pmatrix} \begin{pmatrix} b_0 \\ b_1 \\ \dots \\ b_p \end{pmatrix} = \begin{pmatrix} 1 & x_{11} & \dots & x_{1p} \\ 1 & x_{21} & \dots & x_{2p} \\ \dots & \dots & \dots & \dots \\ 1 & x_{n1} & \dots & x_{np} \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ \dots \\ y_n \end{pmatrix}, \quad (8)$$

or $X^TXB = X^TY$ If the inverse matrix X^TX exists $(X^TX)^{-1}$then multiplying it last equality, we obtain: $X^TX)^{-1}(X^TX)$ B = $(X^TX)^{-1}$ X^TY, or finally:

$$B = \begin{pmatrix} b_0 \\ b_1 \\ \dots \\ b_p \end{pmatrix} = (X^T X)^T X^T Y \quad (9)$$

Equation (9) is a fundamental result for determining the unknown parameters in matrix form.

If the graph is represented by a curve or regression line, the correlation is called curved (non-linear) equation (2). For example, quadratic functions are used to describe a very wide range of economic processes, due to their universal properties. Indeed, in general quadratic function has the following form:

$$y = ax^2 + bx + c \quad (10)$$

the inverse function can be presented in the followingway:

$$y = \frac{a}{x} + b \quad (11)$$

$$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \varepsilon$$
$$y = \beta_0 + \frac{\beta_1}{x} + \varepsilon \quad , \quad (12)$$

and selective non-linear regression are:

$$\hat{y} = b_0 + b_1 x + b_2 x^2 + e \quad (13)$$

$$\hat{y} = b_0 + \frac{b_1}{x} + e \quad (14)$$

Using the method of the least squares parameters can be found from the system:

$$\begin{cases} b_2\sum_{i=1}^{n} x_i^2 + b_1\sum_{i=1}^{n} x_i + b_0 n = \sum_{i=1}^{n} y_i \\ b_2\sum_{i=1}^{n} x_i^3 + b_1\sum_{i=1}^{n} x_i^2 + b_0\sum_{i=1}^{n} x_i = \sum_{i=1}^{n} x_i y_i \\ b_2\sum_{i=1}^{n} x_i^4 + b_1\sum_{i=1}^{n} x_i^3 + b_0\sum_{i=1}^{n} x_i^2 = \sum_{i=1}^{n} x_i^2 y_i \end{cases} , \quad (15)$$

$$\begin{cases} b_1\sum_{i=1}^{n} \frac{1}{x_i} + b_0 n = \sum_{i=1}^{n} y_i \\ b_1\sum_{i=1}^{n} \frac{1}{x_i^2} + b_0\sum_{i=1}^{n} \frac{1}{x_i} = \sum_{i=1}^{n} \frac{y_i}{x_i} \end{cases} \quad (16)$$

To analyze the relation between y and x, correlation ratio is used:

$$\beta_x = \sqrt{\frac{\sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2}} , \quad (17)$$

where $0 \leq \beta_x \leq 1$ [6].

So, on the basis of the multifactorial models can predict the key performance indicators of agri-food enterprises activity, expected innovation financing, the expected investments financing and the expected investment into agriculture in general.

Conclusions and suggestions. Using economic-mathematical modeling of processes of innovation and investment in agriculture with a help of regression models provides the possibility to predict the dynamics of any indices of the agricultural sector of production concerning increasing production , improving quality, environmental safety and implementation of crop and livestock production , sustainable use of the resource potential for next few years, which allows to adjust the activity and managerial decisions concerning reproduction processes in agriculture on the basis of technical re-equipment of production and implementation of modern energy-saving technologies.

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Моделирование инновационно-инвестиционных процессов развития сельского хозяйства

Л.М. Сатир

В статье проанализирован уровень инвестиций в аграрное производство. Рассмотрена необходимость использования методов экономико-математического моделирования и обоснован выбор многофакторных моделей для моделирования инновационно-инвестиционных процессов развития сельского хозяйства. Показана возможность прогнозирования основных результативных показателей деятельности предприятий агропродуктового комплекса, ожидаемых финансирований инноваций и инвестиций в сельское хозяйство.

Ключевые слова: сельское хозяйство, моделирование инвестиций и ожидаемый объем инвестиций, методы, процессы, инвестиции, инновации, агропродовольственный комплекс.

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