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Assessment of the agricultural innovations institute efficiency: methodical approach

Scientific problem. Approaches to the definition of efficiency significantly differ from each other and not all of them are equally acceptable for institutions efficiency research. It is necessary to consider value of innovations and changes in provision of resources while assessing economic efficiency under modern conditions. Conceptions of optimization the use of given resources quantity (i.e. conception of allocative efficiency) seem to be unjustifiable narrowing of the efficiency problem. The conceptions of efficiency that pay substantial attention to economic changes, institutional dynamics and adaptation of institutions are becoming the most actual.

Analysis of recent researches and publications. Problems of institutions efficiency in scientific surveys is debatable and is considered from various viewpoints, which context is determined mainly by the scientific research methodology. In this aspect, D. Nort introduced the conception of adjustive efficiency according to which the resources allocation effectiveness differs with admitting an opportunity to reach the standard neoclassic Pareto criterion [6, p. 106]. According to I.M. Shyriaiev, adjustive efficiency is institutions' concordance with certain principles according to which political order is preserved facing economic changes [10, p. 100]. In his research, V.F. Islamutdinov links the institutions efficiency to their ability to minimize transactional expenses and justifies methodological approach to transaction efficiency determination [4]. Sociobiological approach considers efficiency of institutes as an ability to maintain their own existence and extend even against the interests of economic entities, whose way of thinking and activity form these institutes [13, p. 103].

Such domestic and foreign scientists as A. Holubev [1], O. Datsii [2], V. Dementiev [3], N. Vasylieva [14], M. Malik [5], P. Sabluk [7], S. Tyvonchuk [8], L. Fedulova [9], O. Shpykuliak [11], O. Shubravska [12] dedicated their scientific research to the problems of institutional provision of innovative development, development of mechanisms for realization of innovative process in agricultural industry and methodological approaches to its estimation. Despite certain development of the raised problem, there is no unanimity as for the estimation of the institute's innovations among the researchers, neither unified approaches to determination of innovative process effectiveness at meso and macro levels, nor united methodological approaches to the integral index of agricultural innovations efficiency. The necessity to determine the innovative process activation tools in agrarian sphere and solving institutional problems that hinder innovative development of agricultural production outlines the further development of methodological tools and support for research and evaluation of innovation dynamics in the institutional aspect.

The objective of the article the analysis of existing methodological approaches to the estimation of institutional efficiency of agricultural innovations and justifying the author's approach to the integral estimation of efficiency of institute's agricultural innovations.

Statement of the main results of the study. Forming the effective institute of agricultural innovations outlines identification and consideration of institutional dynamics factors. Translational or evolutional institute changes provide inheritance, variability and selection that act as endopathic causes of institutional dynamics, implement the institute's functional purpose and are directed to stabilization, adaptation and regulation of innovative development. Exopathic impact on the development of an institute is performed by means of import, design and creation of new institutes. This impact causes structural changes in the institute or its transformation, modernization or modification.

Understanding that the institute of agricultural innovations has to provide implementation of three functions: stabilizing, adaptive and regulative, we suggest establishing an integrated index of the institute of agricultural innovation actions efficiency based on their functional efficiency estimation.

We believe that further effective development of the institute of agricultural innovations is impossible without determination of indexes and limitations that determine such state. In this context, we suggest preliminary evaluating the initial state of the institute based on the unified integrated index that would have clear identification criteria (numerical and linguistic). To form an integrated index of institutional efficiency of agricultural innovations we combine the tools of fuzzy sets theories with econometric tools for assignment of tasks and formation of a multiplex econometric model.

The condition of extension of functional impact of the institute of agricultural innovations on agricultural producers is as follows: introduction of product, process, organizational or marketing innovations; reception of funds in terms of the state support program by manufacturers; impact of stimuli to innovative activity on agricultural producers.

We believe that stabilizing capacity growth, adaptive and regulative capacity of the institute of agricultural innovations provide the institute of agricultural innovations efficiency that is reflected on the growth of innovative activity of agricultural producers, extending of new kinds of innovations, increasing share of the innovative products. Due to this, to form a mathematical expression of the integrated assessment of the institute's efficiency as the resultant index (Y), we take the results of the aspectual estimation of agricultural innovations conducted by expertize.

Aspectual characteristic of innovations introduced (or not introduced) by enterprises points to the direct correlation between the size of an enterprise, output volume, specialization, innovative demand of agricultural producers and kinds of innovations they introduced. Aspectual characteristic of innovations was performed according to the results of questioning the 32 largest agricultural producers of Dnipropetrovsk region. The results are shown in Tables 1-2. Previous surveys showed that there is a tight correlation between productive efficiency and kinds of innovations introduced by producers. Enterprises with the highest profitability and profit volume introduced almost all kinds of innovations and had their own innovative concepts.

Table 1

Value of the weight of components of aspectual characteristics of innovations*

Characteristics	Grade number conferred by experts	Estimated value of the characteristic
Innovative product	1	0.33
Innovative process	2	0.27
Own innovative concepts	3	0.20
Marketing innovations	4	0.13
Organizational innovations	5	0.07

*Determined according to the results of expert estimation.

Source: Author's calculations.

It is significant that enterprises with low financial indexes introduced only a certain kind of innovations (predominantly product innovations) depending on their own specialization and financial ability. We consider the fact that stabilizing function of the institute of agricul-

tural innovations aims to ensure the innovation process implementation and maintenance of available routines and use it for its financial, technological indexes of agricultural producers' activity and productivity indexes estimation that indirectly reflect the innovation activity state.

Table 2

Estimation of experts' opinion consistency according to the aspectual characteristics of innovations

Indexes	Sum of grades	Deviation from average	Deviation square
Characteristics of institutional changes adaptation			
Innovative product	44	-52	2,704
Innovative process	73	-23	529
Own innovative concepts	91	-5	25
Marketing innovations	120	24	576
Organizational innovations	152	56	3136
Evaluation characteristics			
Average grade	96	x	x
Sum of deviation squares	x	x	6970
Maximum sum of deviation squares	x	x	10240
Concordance coefficient	x	x	0.68

Source: Authors' calculations.

Variables of our model are as follows:

X_1 – profitability of main activity, %; X_2 – labor productivity, thousand UAH/man; X_3 – capital productivity index; X_4 – material consumption of agricultural production; X_5 – power consumption of agricultural production, kW/thousand UAH; X_7 – wear coefficient of main production inventories; X_8 – coefficient of renewal of main production inventories.

When presented variables taken to the model we will consider that they have competing direction concerning characteristic of the innovative activity of studied enterprises. Profitability growth, labor productivity, coefficient of renewal of main funds must be a testimony of the innovative activity. At the same time enterprises' coefficient decline indirectly might point out the decline of energy consumption, wear coefficient of main production means and material consumption.

We will characterize the adaptive function of the institute with expert evaluation of state support programs, tax stimulation efficiency, availability of credit resources, availability of stimuli to innovative activity, levels of informative and infrastructure software. After grading and determining the weight of every factor we will submit this index as a single variable:

X_9 - Institute of agricultural innovations adaptability.

The growth of this index must testify institutional effectiveness of agricultural innovations. Regulative function of the institute of agricultural innovations is directed to provide tax tools for stimulating innovations, realization of projects in designing and development of innovative infrastructure, realization of programs of monetary and credit stimulation of agricultural industry, realization of programs of innovative development of agricultural industry. We will assume the total expression of the impact of government on activation of innovative process as a single variable:

X_6 - the amount of state support for 100 hectares, UAH th.

Studies conducted on the basis of 32 enterprises of Dnipropetrovsk region that are overcome with the impact of the institute of agricultural innovations and is potentially capable to realize innovations. Considering that most factors are dimensionless coefficients and some of them are represented in monetary form (labor productivity indexes and state support volume), variables normalization needs to be conducted. We will normalize statistics data by the formula:

$$X_{ij}^{0} = \frac{X_{ij} - \overline{X_i}}{\sqrt{n} * \delta_{x_i}}, \left(j = \overline{1,n}\right), \left(i = \overline{1,m}\right), \qquad (1)$$

where n – number of enterprises studied =32; m – number of factors =9; $\overline{x_i}$ – factor's

average value x_i; δ_{x_i} - average quadratic deviation of x_i factor

Statistic characteristics are calculated according to such conditions:

$$\delta_{x_i} = \frac{\sum_{j=1}^{n}\left(X_{ij} - \overline{X_j}\right)^2}{n-2}, \quad \overline{X_i} = \frac{\sum_{j=1}^{n} X_{ij}}{n}. \qquad (2)$$

Calculation results are contained in the table 3.

Table 3

Statistic characteristics of indexes

Indexes	Independent variables									Dependent variables
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y
Average values	22.2	335.4	0.74	0.72	0.03	45.2	0.49	0.11	1.86	2.72
Average quadratic values	16.1	185.9	0.39	0.10	0.02	33.3	0.21	0.14	0.36	1.09

Source: Authors' calculations.

On designing economic model one of the problems is the issue of defining the materiality of impact of individual factors on the Y index. Materiality of the factors' impact on the Y index can be determined by the correlation matrix or using F - statistics. The r matrix consists of paired correlation coefficients that indicate the tightness of the correlation between the factorial features.

Correlation coefficients are calculated by the formula:

$$r_{x_i x_j} = \frac{\sum_{k=1}^{n} X_{ik} * X_{jk} - n * \overline{X_i} * \overline{X_j}}{n * \delta_{x_i} * \delta_{x_j}}. \qquad (3)$$

Matrix of paired coefficients has a view:

$$r = \begin{bmatrix} r_{x_1 x_1} & r_{x_1 x_2} & \dots & r_{x_1 x_9} \\ r_{x_{2x_1}} & r_{x_2 x_2} & \dots & r_{x_2 x_9} \\ \dots & \dots & \dots & \dots \\ r_{x_{9_{[1}} & r_{x_9 x_2} & \dots & r_{x_9 x_9} \end{bmatrix}. \qquad (4)$$

Y index should be included in this correlation matrix since factors that correlate with the resultant index and do not correlate with each other must be included to the model. Correlation matrix with the use of available data has been obtained (table 4). According to table, X7 index has the lowest impact on the Y index. But, on the other hand, the linearly independent between each other factors– not multicollinear – must be included into this model.

Table 4

Matrix of paired coefficients of correlation

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y
X_1	1.00	0.68	0.67	-0.59	-0.63	0.45	-0.47	0.63	0.45	0.79
X_2	0.68	1.00	0.53	-0.40	-0.61	0.48	-0.61	0.68	0.25	0.65
X_3	0.67	0.53	1.00	-0.39	-0.52	0.69	-0.50	0.51	0.59	0.65
X_4	-0.59	-0.40	-0.39	1.00	0.37	-0.24	0.44	-0.32	-0.04	-0.46
X_5	-0.63	-0.61	-0.52	0.37	1.00	-0.61	0.44	-0.56	-0.26	-0.60
X_6	0.45	0.48	0.69	-0.24	-0.61	1.00	-0.52	0.46	0.55	0.52
X_7	-0.47	-0.61	-0.50	0.44	0.44	-0.52	1.00	-0.69	-0.24	-0.36
X_8	0.63	0.68	0.51	-0.32	-0.56	0.46	-0.69	1.00	0.26	0.59
X_9	0.45	0.25	0.59	-0.04	-0.26	0.55	-0.24	0.26	1.00	0.51
Y	0.79	0.65	0.65	-0.46	-0.60	0.52	-0.36	0.59	0.51	1.00

Source: Authors' calculations.

To explore the availability of multicollinearity we will apply the Farrar-Glauber Method. First, general multicollinearity is tested. To research the general multicollinearity χ^2-criterion has been used. Estimated criteria value has been determined by the formula:

$$X^2_{fact} = -\left[n - 1 - \frac{1}{6}(2m+5)\right] Ln|r|, \qquad (5)$$

where $|r|$ - determinant module of correlation matrix of factors

We will obtain

$$X^2_{fact} = -\left(32 - 1 - \frac{1}{6} * (2*9+5)\right) * Ln0.08 = 68.62 \qquad (6)$$

The critical value of the criterion is determined according to the X^2 allocation table at the given error level $\alpha = 0{,}05$ and freeness number $k = 0{,}5m*(m-1) = 0{,}5*9*8 = 36$. We will obtain the following:

$$X^2_{crit} = X^2(\alpha;k) = 50.99, \text{ and } X^2_{fact} > X^2_{crit}. \quad (7)$$

This testifies availability of general multicollinearity. To clarify the issue between what factors multicollinearity exists t-statistics is used. For its determination we will find the matrix enveloped towards the correlation matrix of factors $[Z] = [r]^{-1}$, and then calculate correlation fractional coefficients by the elements of the matrix $[Z]$ by the formula:

$$r'_{ij} = \frac{-Z_{ij}}{Z_{ii} * Z_{jj}}. \quad (8)$$

To determine fractional coefficients we will find t-statistics by the formula:

$$t_{ij} = \frac{r'_{ij} * \sqrt{n-m-1}}{\sqrt{1-(r'_{ij})^2}} \quad (9)$$

Critical meaning of the Student's criterion at given error rate α freeness $K = n-m-1 = 22$ we will determine according to the Student's allocation table $t_{crit} = t(\alpha;K) = t(0.05;22) = 2.074$. Since $|t_{78}| \succ t_{crit}$, $2.719 \succ 2.074$, it is possible to claim that there is a multicollinearity between factors X_7 i X_8. Availability of multicollinearity testifies an impossibility to obtain model's parameters or their insecurity. To eliminate one of the multicollinearity factors we will exclude it from consideration. With an allowance of economic grounds and impact of the X_7 coefficient on Y $(r_{x_7\ y=-0,36})$ we will exclude from further consideration X_7 factor.

We consider that there is a linearly dependence between Y index and X_i *(i=1,2,2,3,4,5,6,8,9)* factors that can be displayed like that:

$$Y = a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_8X_8 + a_9X_9. \quad (10)$$

Parameters of identified dependence we will determine by the least squares method. For all these calculations built-in functions of electronic *Microsoft Excel* spreadsheets are used: LINEAR, MATRIX MULTIPLICATION, MATRIX DETERMINANT, MATRIX TRANSPOSE, INVERTIBLE MATRICES, MEAN/AVERAGE VALUE, ROOT-MEAN-SQUARE DEVIATION, FUNCTIONS Xi2 DISTRIBUTION , STUDENT'S ALLOCATION VALUE Appliance of the LINEAR function at the table of normalized data allows to obtain the linear model of the view:

$$Y = \overline{a}_1X_1^0 + \overline{a}_2X_2^0 + \overline{a}_3X_3^0 + \overline{a}_4X_4^0 + \overline{a}_5X_5^0 + \overline{a}_6X_6^0 + \overline{a}_8X_8^0 + \overline{a}_9X_9^0 \quad (11)$$

or

$$Y = 0.511X_1^0 + 0.167X_2^0 + 0.102X_3^0 - 0.109X_4^0 - 0.098X_5^0 + 0.007X_6^0 + 0.044X_8^0 + 0.145X_9^0.$$

$$a_i = \overline{a}_i * \frac{\delta_y}{\delta_{x_i}}. \quad (12)$$

We will obtain the model of the following view:

$$Y = 0.034X_1 + 0.001X_2 + 0.285X_3 - 1.037X_4 - 5.84X_5 + 0.0001X_6 + 0.349X_8 + 0.439X_9.$$

The obtained model needs to be reviewed for data adequacy. We will determine the determination coefficient by the formula:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \overline{y_i})^2}{\sum_{i=1}^{n}(y_i - \overline{y})^2}. \quad (13)$$

Determination coefficient $R^2 = 0{,}96$ indicates that the change of *Y* index at 96% depends on change of existing factors X, and at 4% depends on other factors not included in this model. Examination of this model at the adequacy to the data by the Fisher's criterion requires comparison of the calculated rate with the critical one. We will obtain calculated rate by the formula:

$$F_{calc} = F_{(m,n-m-1)} = \frac{(n-m-1)*\sum_{i=1}^{n}\left(\hat{y}_i - \overline{y}\right)^2}{m*\sum_{i=1}^{n}\left(\overline{y_i} - \hat{y}_i\right)^2}. \quad (14)$$

On using the formula we will obtain the calculated value of the criterion $F_{calc.} = 69.14$,

while according to the tables $F_{crit} = F(0,05;k_1;k_2) = 2.37$, where $k_1 = m$; $k_2 = n-m-1$. As $F_{calc.} > F_{crit,}$, with the probability of 95% it is possible to assume that the model created is adequate to the data and can be used for estimation of the institutional effectiveness of agricultural innovations and forecasting. We give the example of the usage of the model for forecasting, known values of factors are given in the table 5. Point estimation of the *Y* index is determined according to the model:

$$Y_{np} = 0.034 * 4.2 + 0.001 * 267 + 0.285 * 0.34 + 1.037 * 0.71 - 5.84 * 0.04 + 0.0001 * 38.94 + 0.349 * 0.18 + 0.439 * 1.43.$$

Table 5

Initial data for forecasting of agricultural innovations' institutional effectiveness

Xfr	X_1	X_2	X_3	X_4	X_5	X_6	X_8	X_9
Numerical expression	4.2	267	0.34	0.71	0.04	38.94	0.18	1.43

Source: authors' calculations.

Calculations allowed to obtain:

$Y_{fr} = 1,72.$

Confidential interval of this point estimate was defined by the formula:

$$\left(Y_{fr} - d\hat{y}_{fr}; Y_{fr} + d\hat{y}_{fr} \right), \quad (15)$$

де

$$d\hat{y}_{fr} = t_{p,k} * S_y * \sqrt{X_{fr} * \left[[X]^T * [X] \right]^{-1} * X_{fr}^T}. \quad (16)$$

We will obtain $d\hat{y}_{fr} = 0.52$. Then $Y_{fr} - d\hat{y}_{fr} = 1.2$, $Y_{fr} + d\hat{y}_{fr} = 2.25$.

Consequently, under the pointed values of these factors the value of the Y index falls in the range of 1.2 to 2.25 with confidential probability of 0.95.

Conclusions. Conducted modeling of integrated efficiency rating of the institute of agricultural innovations revealed a direct linkage between the introduction of innovations by agricultural producers and growth of indexes that characterize efficiency of enterprises' activity and use of the available resources. Results of calculations revealed that profitability growth in 1 (1%) testifies that growth of the integrated efficiency index of the institute of agricultural innovations in 0.034; growth of the labor productivity index in 1 increases the institutional effectiveness of agricultural innovations in 0.001; increase of capital productivity in 1 provides growth of integrated efficiency index of the institute of agricultural innovations in 0.285. Along with this increase of material consumption of the agricultural products reduces the institutional effectiveness of agricultural innovations in 1.037; increase of power consumption of the agricultural products reduces the efficiency integrated index of the institute of agricultural innovations in 5.84. The growth rate of the amount of the state support amount of 100 hectares in 1 increases the institutional effectiveness of agricultural innovations in 0.0001; growth of the coefficient of renewal of the production facilities in 1 increases the institutional effectiveness of agricultural innovations in 0.349; growth of the adaptation index of the institute of agricultural innovations in 1 provides growth of institutional index of agricultural innovations in 0.439.

The results of modeling allowed to obtain the average mean of the integrated index (Y) = 2.72 of the institute of agricultural innovations that corresponds to the "satisfactory" grade according to the author's scale. This index was calculated for different groups of producers. According to the data of enterprises of the first group the value of the integrated index of the institute of agricultural innovations (Y) = 2.16 that according to the scale corresponds to the "satisfactory" grade; institutional effectiveness of agricultural innovations calculated according to the data of enterprises of the second group amounted to (Y) = 3.74 that corresponds to the "good" grade; for the third group of enterprises the index (Y) = 3.8 that also corresponds to the "good" grade.

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Економіко-математичне забезпечення інноваційного управління сільськогосподарськими підприємствами

Постановка проблеми. Відсутність певної системи управління сільськогосподарськими підприємствами стримує процес систематизації економічної інформації про їхню господарську діяльність, розробку на її основі інформаційно-аналітичної моделі інноваційного управління. У зв'язку з цим виникає проблема ефективного інформаційного забезпечення в управлінні сільськогосподарськими підприємствами, яка полягає у знаходженні взаємозв'язку між процесами виробництва та реалізації продукції, зокрема як змінюється її виробництво від умов ринку, який при цьому спостерігається економічний розвиток підприємства, на чому ґрунтується інформація про стан його господарювання. З огляду на це, для її розв'язання необхідно, щоб певна система управління