Methods for Assessing the Innovative Capacity of Agri-food Enterprises

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Summary
The article proposes a methodical approach to assessing the innovative capacity of agri-food enterprises. This approach is based on the calculation of personnel, investment, technical and technological, information components of the ability of agri-food enterprises to innovate. The algorithm of search of production, intellectual, financial, information resources reserves, which are necessary for functioning of the enterprises of agro-food sphere, is defined. The approach developed by the authors, in contrast to the existing ones in the scientific world, allows the tools of mathematical modeling to identify shortcomings in the development of agri-food enterprises, to forecast the development of these enterprises and on this basis to form different models of market stakeholders. The method proposed by the authors to assess the innovative capacity of agri-food enterprises allows market participants to assess the current state of agri-food enterprises and form the necessary management levers to influence its activities to eliminate market failures and pitfalls.

Key words: *innovative potential, agri-food enterprises, personnel policy, financial reserves, modeling*

1. Introduction

The methodology for assessing the innovative capacity of agri-food enterprises should include the calculation of a comprehensive indicator. This indicator should systematize, group and summarize management, material, logistical, technological and human resources, which reflect the degree of ability of the object to carry out the transformation of its activities based on innovations with the active use of existing cash flows. Such activities are aimed at transforming the results of production activities into goods, know-how or services that can meet certain segments of the consumer market or cover their constantly emerging needs. The analysis of the existing results of research in the scientific world to solve the current problem of assessing the innovative capacity of enterprises shows the need to improve and update existing approaches or adjust the set of metrics for its integrated analysis. While solving this issue, modern scientists mainly rely on a fairly common system of methods for estimating statistical indicators, which are not always reflected in the financial statements of enterprises. This requires a revision of methods for assessing the innovative capacity of agri-food enterprises.

2. Literature Review

Domestic and foreign scientists offer a significant array of different indicators that assess the innovative capacity of agri-food enterprises (Klerkx and Leeuwis, 2008; Hermans et al., 2013; Schut et al., 2015; Micheels and Nolan, 2016; Ronnie et al., 2017; Turner et al., 2017). Note that the methodological basis of these works of scientists is to identify individual components of the innovative capacity of enterprises using the resource approach. Under such conditions, it is possible to segment the evaluation of innovative components, followed by the development of strategies and mechanisms for managing the enterprise. The calculation of innovation capacity by such methods will show the resource potential of the studied object to the implementation of innovation activities.

Assessing the innovative capacity of agri-food enterprises using a comprehensive indicator has been reflected in the numerous works of scientists (Klerkx and Leeuwis, 2009; Spielman et al., 2009; Chhetri et al., 2012; Vanclay et al., 2013; Kilelu et al., 2013; Kuksa et al., 2019; Hnatenko et al., 2019; Zos-Kior et al., 2021; Mazur et al., 2021; Mykhailichenko et al., 2021). At the same time, they all need to be reviewed in accordance with the current state of transformation of the national economy, the available information sources of analytical information, taking into account the institutional links between all market stakeholders. A wide range of modern scientists thoroughly investigate the role of human and investment potential in the system of accumulation of innovative capacity. In the scientific works of Rossel and Bouma (2016), Ren et al. (2016), Sarkar et al. (2018), Fielke et al. (2020), Hnatenko et al. (2020), Semenov et al. (2021), Gryshchenko et al. (2021), Lozhachevska et al. (2021) Brockova et al. (2021), Zherdetska et al. (2021) the author's methods of assessing innovation capacity are quite contradictory, fragmentary, outdated. Among other shortcomings proposed by the

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authors of the method, it should be noted that the set of selected indicators does not fully take into account all available resources of the agri-food enterprise, which can not be ignored in the process of analytical work. Paying tribute to the research of these scientists, it should be noted that they do not reflect a comprehensive approach to the study of the problem. This gap in the theory and practice of modern science should be filled with updated methods of assessing the capacity of agri-food enterprises, which will allow to make rational management decisions and manage the enterprise effectively.

3. Methodology

The following components are offered to be calculated when assessing the innovative capacity of agri-food enterprises: personnel component of the company's ability to innovate; investment component of the company's ability to innovate; technical and technological component of the company's ability to innovate; information component of the ability to innovate. In order to systematize the indicators for each component and the convenience of their evaluation, the following formulas have been proposed.

We propose to calculate the *personnel component* of the assessment of the innovative capacity of agri-food enterprises using the following system of indicators:

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1. Coefficient of conformity of intellectual level and qualifications of personnel to the needs of the innovation process:

$$K_1 = \sum_{i=1}^{n} q_i t_i \cdot \left(\sum_{j=1}^{m} q_j t_j\right)^{-1} \quad (1)$$

where q_i is the level of qualification of the *i*-th employee;

t_i - planned working time of the *i*-th employee;

n - number of staff;

q_j - the average level of qualification required for the implementation of the *j*-th innovation project;

t_j - time required for the implementation of the *j*-th innovation project;

m - number of innovative projects.

2. Coefficient of readiness of organizational and managerial staff for innovations:

$$K_2 = \sum_{i=1}^{n} (\varepsilon_i \cdot g_i \cdot \lambda_i)^{\frac{1}{2}} \quad (2)$$

where ε_i - the level of motivational readiness of the *i*-th employee to implement an innovative project;

g_i - the level of cognitive readiness of the *i*-th employee to implement an innovative project;

λ_i - the level of emotional readiness of the *i*-th employee to implement an innovative project;

n - the number of organizational and managerial staff.

3. Coefficient of innovative capabilities of staff in the field of research:

$$K_3 = \sum_{i=1}^{n} \varpi_i \delta_i \quad (3)$$

where ϖ_i is the innovation potential of the *i*-th employee;

δ_i is a correction factor that reflects the degree of realization of the potential of the *i*-th employee in the field of research;

n is the total number of staff.

4. The share of employees engaged in innovation:

$$K_4 = \frac{\sum_{j=1}^{m} a_j}{A} \quad (4)$$

where a_j - staff involved in the implementation of the *j*-th innovation project;

m - number of innovative projects;

A - the total number of staff.

We propose to calculate the *investment component* of the assessment of the innovative capacity of agri-food enterprises using the following system of indicators:

1. Efficiency coefficient of financial support of innovative projects realization:

$$K_5 = \sum_{j=1}^{m} \frac{\Delta Pr_j}{Inv_j} \quad (5)$$

where ΔPr_j - profit increase due to investments in the implementation of the *j*-th innovation project;

Inv_j - the total amount of financial investments in the implementation of the *j*-th innovation project;

m - number of innovative projects

2. The share of research costs:

$$K_6 = \sum_{j=1}^{m} \gamma_j \cdot C^{-1} \quad (6)$$

where γ_j - the cost of the *j*-th research;

C - the total cost of activities;

m - the total number of scientific studies.

3. The share of costs for innovative diversification of production and marketing research:

$$K_7 = C^{-1} \sum_{j=1}^{m} (d_j + mr_j) \quad (7)$$

where d_j - the cost of diversification of production within the *j*-th innovation project;

mr_j - costs of marketing research within the *j*-th innovation project;

C - the total cost of activities;

m - the total number of innovative projects.

4. The cost ratio of the enterprise for the formation of human capital capable of innovative activities:

$$K_8 = C^{-1}(\eta + \mu + \sum_{i=1}^{n} (\xi_i + \rho_i + \upsilon_i)) \quad (8)$$

where ξ_i - the cost of training and retraining of the *i*-th employee;

ρ_i - costs for advanced training of the *i*-th employee;

υ_i - transaction costs for finding and formalizing the relationship with the *i*-th employee;

η - the cost of staffing;

μ - costs for the development of organizational culture;

n - total number of staff;

C - the total cost of activities.

We propose to calculate the *technical and technological component* of assessing the innovative capacity of agri-food enterprises using the following system of indicators.

1. The level of technologization of innovation processes:

$$K_9 = \sqrt[\kappa]{\prod_{j=1}^{\kappa} X_j} \quad (9)$$

where X_j - individual level of technologization of the j-th process of innovation;

κ - the total number of processes in innovation.

2. Coefficient of efficiency of use of production capacities in innovative activity:

$$K_{10} = \frac{T_f}{T_{max}} \quad (10)$$

where T_f - actually spent production capacity time in the process of implementing innovative activities;

T_{max} - the maximum working time of production facilities involved in the implementation of innovative activities.

3. Coefficient of cost savings as a result of the introduction of scientific and technical measures:

$$K_{11} = \left(1 - \frac{1+\Delta\Upsilon}{1+\Delta\mathrm{P}}\right) \cdot \mathrm{N} \quad (11)$$

where $\Delta\Upsilon$ - increase in costs for the implementation of scientific and technical measures;

ΔP - increase in productivity due to the introduction of scientific and technical measures;

N - the share of costs for the implementation of scientific and technical measures in the cost of production.

4. Coefficient of staffing with modern equipment:

$$K_{12} = \left(\alpha_{hw} + \alpha_{ot} + \alpha_{per} + \alpha_{sw}\right) \cdot A^{-1} \quad (12)$$

where α_{hw} is the cost of computer equipment used by employees;

α_{ot} - the cost of high-tech production equipment used by employees;

α_{per} - cost of peripheral and network equipment used by employees;

α_{sw} - the cost of software used by employees;

A - the total number of staff.

We propose to calculate the *information component* of the innovative capacity assessment of agri-food enterprises using the following system of indicators.

1. Intensity of information use in the process of implementation of the innovation process:

$$K_{13} = \sqrt{\beta_i \beta_r} \quad (13)$$

where β_i is the coefficient of integration of information technologies in the process of innovation implementation;

β_r - information reuse rate.

2. Staff access to information ratio:

$$K_{14} = n^{-1} \sum_{i=1}^{n} Ac_i \quad (14)$$

where n is the total number of staff;

Ac_i - individual level of access to information of the i-th employee.

3. Coefficient of software security of information:

$$K_{15} = \omega \cdot k^{-1} \quad (15)$$

where ω is the cost of software protection of information;

k is the total cost of software.

4. Coefficient of completeness of information support:

$$K_{16} = \frac{f_i}{f_{max}} \quad (16)$$

where f_i is the actual level of information support;

f_{max} - the maximum possible level of information security.

Thus, in order to determine the assessment of the innovative capacity of agri-food enterprises, we propose to use recombinations of indicators for the assessment of personnel, investment, technical and technological, information components. This will make it possible to calculate an integrated matrix for assessing the innovative capacity of agri-food enterprises, as well as to identify the main trends that will shape the future development of enterprises.

4. Results and Discussion

In order to test our proposed method of assessing the innovative capacity of agri-food enterprises, we will perform calculations in accordance with formulas 1-16. We propose to test the method on the basis of: SE Experimental Farm "Elite" of the V. Yuryev Institute of Plant Breeding of the National Academy of Agrarian Sciences of Ukraine, “Zorya-Agro” Agricultural Company LLC, “Chista Krynytsia” Elevator LLC, “Globino Agro” LLC.

We offer the following segmentation of levels of enterprises ability to innovative development: 0-20% - high level of deformation of all components of innovation capacity, lack of prospects for innovation development; 21-40% - above average level of deformation of the components of innovation capacity, which differ in the depth of impact on innovation; 41-60% - the average level of deformation of the components of innovation capacity, which allows the company to develop innovatively; 61-80% - below average level of deformation of the components of innovation capacity, where almost all indicators have a positive trend, which contributes to the development of innovation; 81-100% - low level of deformation of the components of innovation capacity and high compensatory capacity for innovation. According to the carried-out calculations by formulas 1-16 we obtain matrices that characterize the personnel components of the assessment of enterprises innovation capacity in 2020 (Fig. 1).

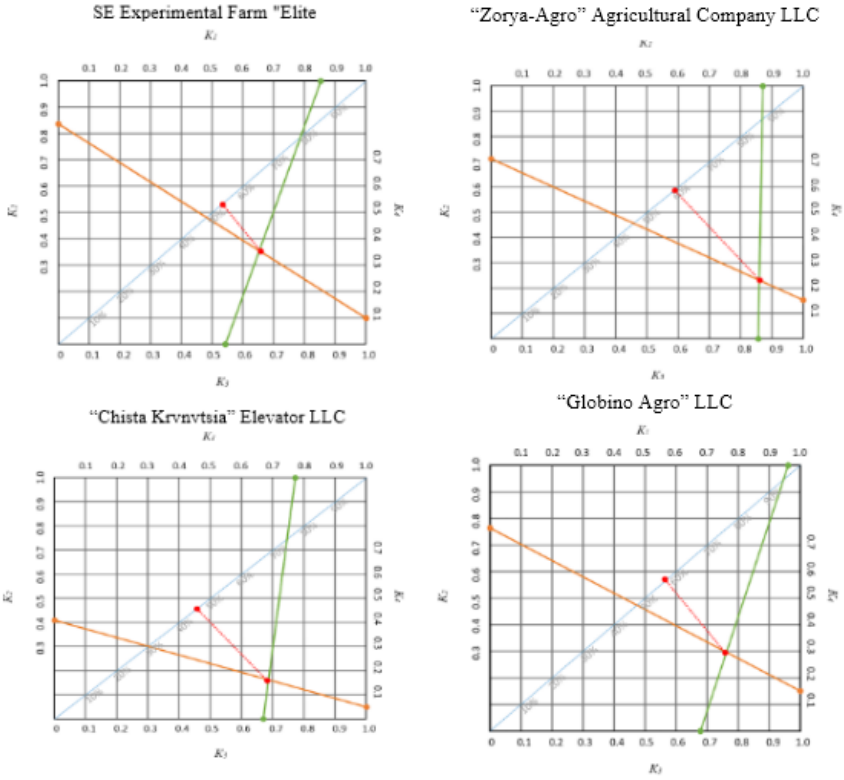

Fig. 1 The results of the matrix for assessing the innovative capacity of enterprises by human resources in 2020
Source: proposed and calculated by the authors

The personnel component of assessing the innovative capacity of agri-food enterprises involves determining the intellectual level of specialists to implement the innovation process, the degree of readiness of organizational and managerial staff to innovate, staff capabilities in research and the level of innovation. The best in this component are "Globino Agro" LLC (58%), "Zorya-Agro" Agricultural Company LLC (59%). It should be determined that according to the component under analysis, all enterprises are those that have an average level of deformation of the innovation capacity components. Adoption of innovative decisions that will contribute to the accumulation of innovative capacity is one of the main in the process of achieving competitive advantage of business entities, both in domestic and foreign markets.

Lack of financial potential is not the only reason for low innovation activity of enterprises in the national economy. Other reasons include the lack of a strong managerial core among government officials and entrepreneurs. Such a core should be formed taking into account: a combination of creativity, innovation, leadership qualities and full responsibility for management decisions; taking into account, monitoring and forecasting risks and possible failures in public administration or management of an innovative enterprise; search for additional sources of human, technological, technical and information potential for the development of innovation; willingness to experiment, to test, to implement utopian ideas which seems to be the ones at first glance; to choose strategies, mechanisms for the development of innovation potential in a qualified and professional way; to manage teams of creative and enterprising people, as well as to attract innovators, inventors, including from abroad; to have skills in managing innovative projects. The obtained matrices for assessing the innovative capacity of agri-food enterprises, respectively, the investment component will be considered (Fig. 2).

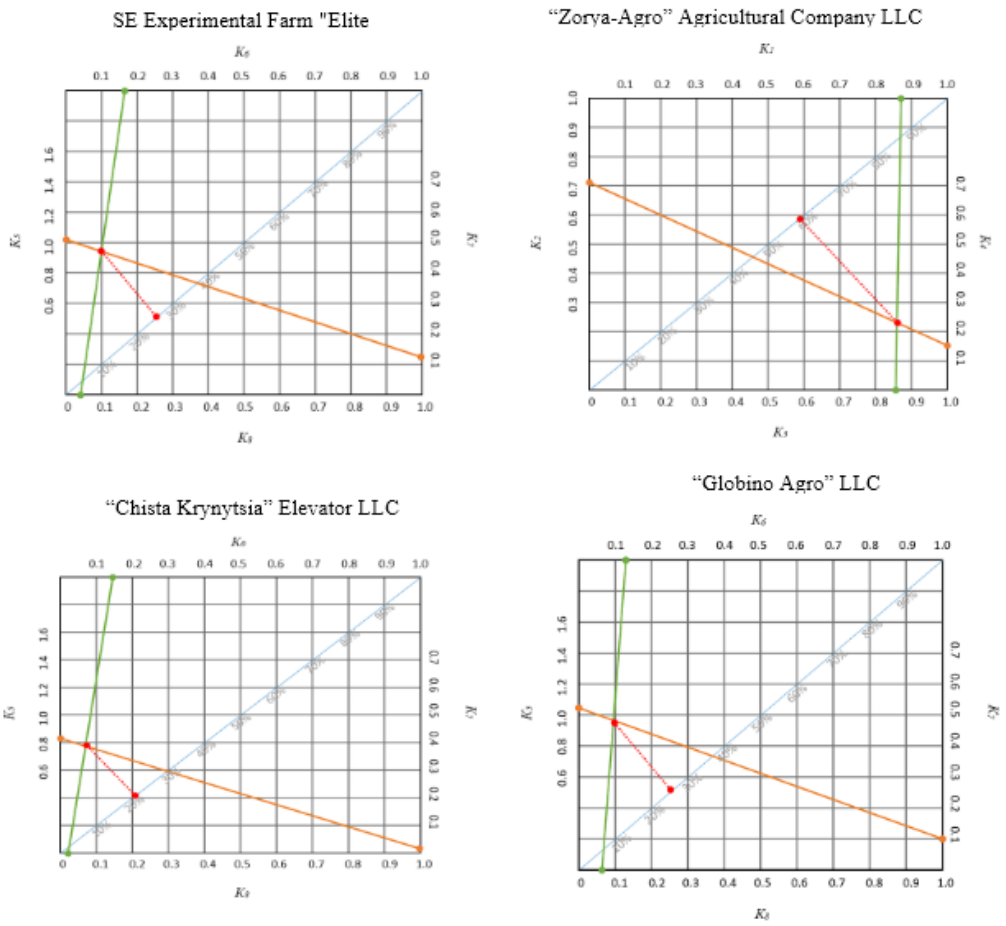

Fig. 2 The results of the matrix for assessing the innovative capacity of enterprises by investment component in 2020
Source: proposed and calculated by the authors

The calculations of the investment component were carried out according to the parameters of the effectiveness of financial support for innovative projects, research costs, innovative diversification of production, marketing research, as well as the formation of human capital capable of implementing innovative activities showed the following results. The highest level of deformation by investment component was observed at "Chista Krynytsia" Elevator LLC (21%). The best level was recorded at "Zorya-Agro" Agricultural Company LLC (59%). According to the obtained results, all the enterprises analyzed, except for "Zorya-Agro" Agricultural Company LLC (average level of deformation), are referred to those ones that have above-average level of deformation of the innovative capacity components. One of the most important problems of accumulation and creation of financial reserves of innovative capacity is undoubtedly the provision of financial support for innovation processes at all stages of production. The costs of these activities, as the analysis showed during the transformation of the national economy is at an almost consistently low level. Moreover, a relatively large proportion of research work conducted in the country is covered from the sources of the already weak private sector of the economy. As a result, this means low opportunities for the national economy to conduct basic research, the level of funding of which in the world's leading innovative countries is quite high, as well as creativity, knowledge, activity, professionalism, competence and so on. Innovative entrepreneurship lacks sufficient investment security from the state, which causes a small scale of development of knowledge and technology.

The result of diagnostics of technical and technological component of innovative capacity of enterprises, based on calculating the level of technological processes, efficiency of production capacity, cost savings as

a result of the introduction of scientific and technical measures, staffing with modern equipment is shown in Fig. 3.

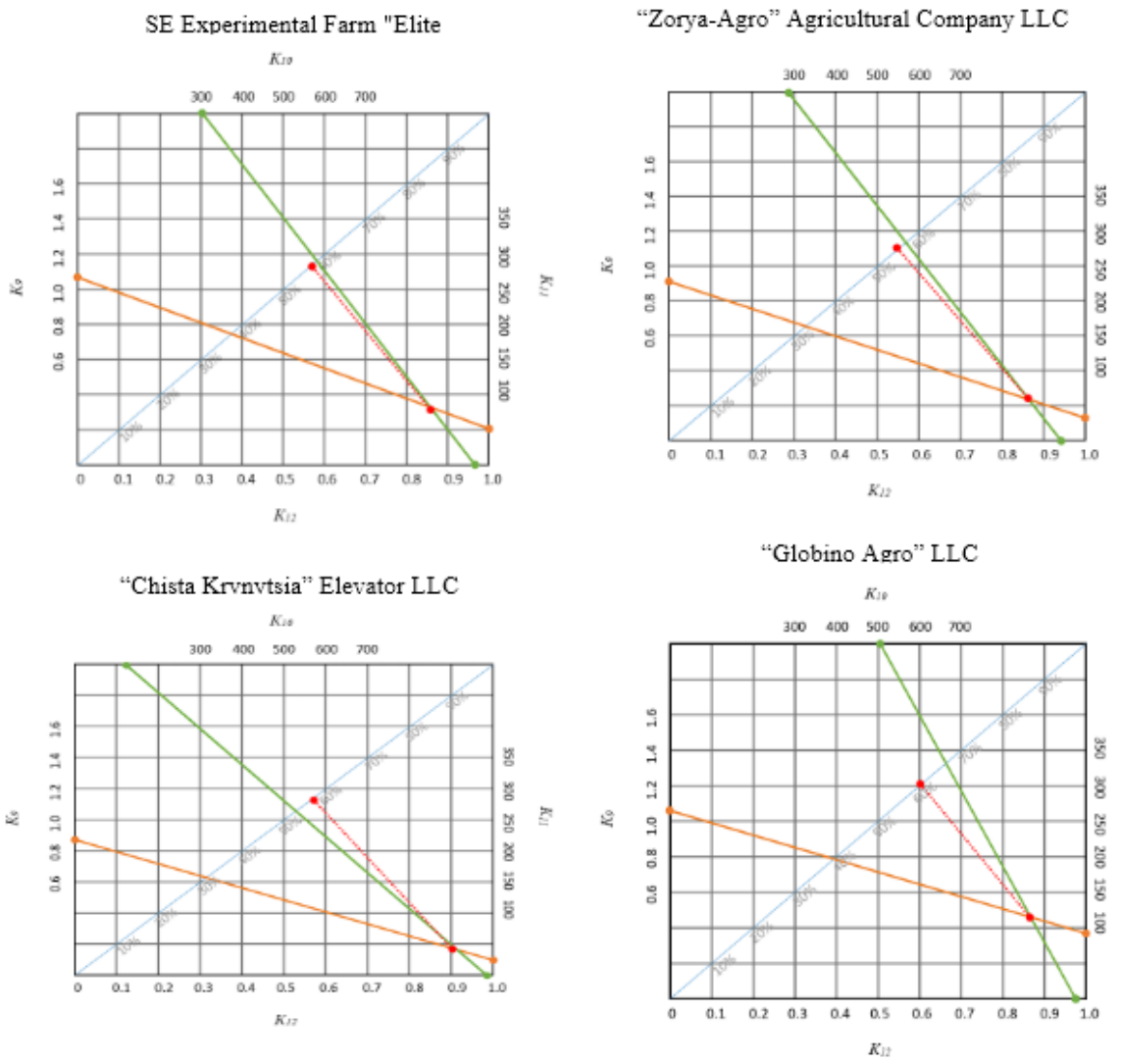

Fig. 3. The results of the matrix for assessing the innovative capacity of enterprises by technical and technological component in 2020

Source: proposed and calculated by the authors

The calculations show that the largest deformations in terms of technical and technological component occurred at "Zorya-Agro" Agricultural Company LLC (55%, respectively). According to the evaluation results, 3 enterprises were classified as having an average level of deformation of the components of innovation capacity, which allows the enterprise to develop innovatively. The calculations are shown in Fig. 3 show that agri-food enterprises face significant difficulties in implementing technological innovations, especially for small and medium-sized enterprises. Receiving funds from the state for technological re-equipment or robotization of production is too complicated organizational procedure for business. Another problem is the lack of an established market for experimental testing of innovations and developments, insufficient cooperation between business and government, a large number of legislative obstacles, their frequent updating (not always in favor of business),

excessive bureaucratization and corruption in public authorities.

Diagnosis of the information component of the assessment of innovative capacity of enterprises was based on the calculation of the intensity of information use, the level of staff access to information, determining the degree of software security of information, the completeness of information support. The results of the calculation of the relevant indicators are shown in Fig. 4.

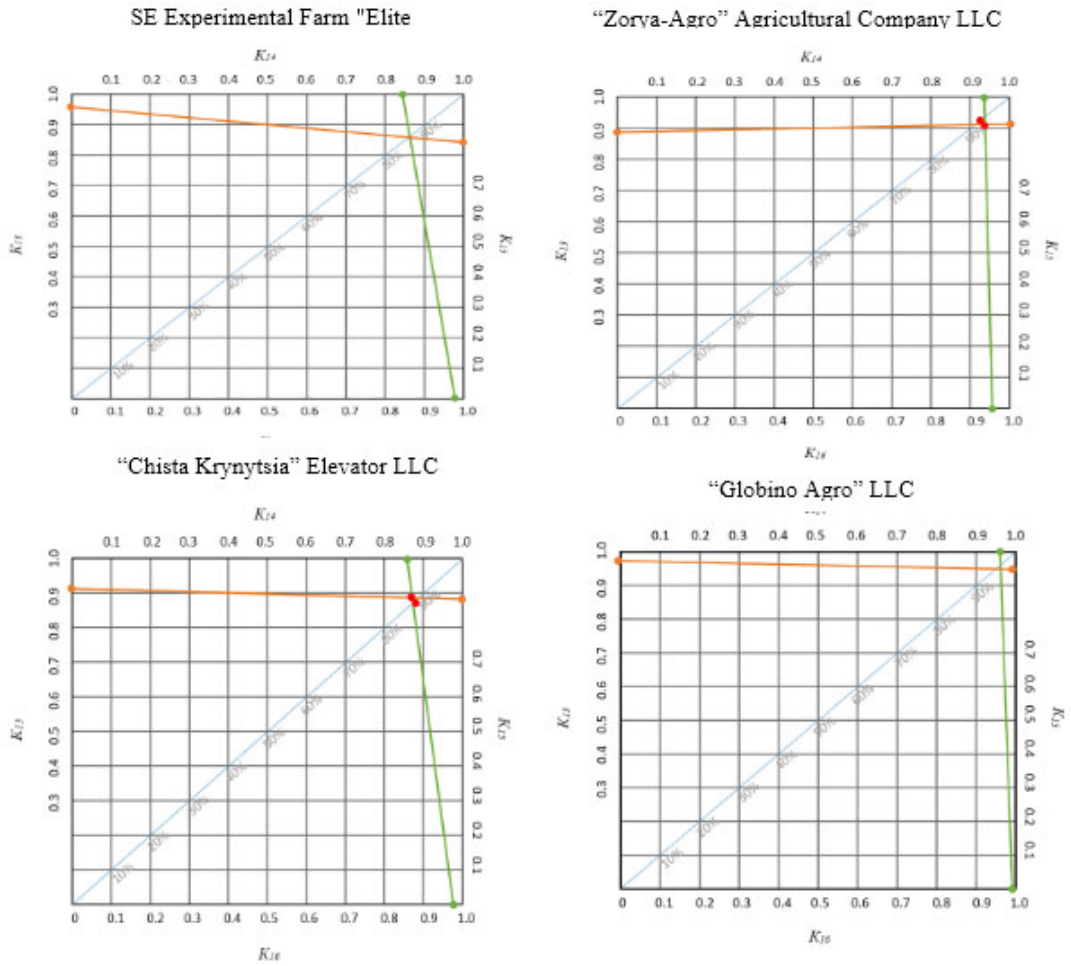

Fig. 4 The results of the matrix for assessing the innovative capacity of enterprises by the information component in 2020.
Source: proposed and calculated by the authors

The results obtained as a result of diagnostics of the information component of the assessment of the innovative capacity of enterprises indicate significant deformations of the information support of SE Experimental Farm "Elite" of the V. Yuryev Institute of Plant Breeding of the National Academy of Agrarian Sciences of Ukraine. The best indicators of the information component of innovation capacity were recorded at "Globino Agro" LLC (96%). The results of the matrix for assessing the innovative capacity of enterprises by the information component show the best indicators relative to the other three components, which indicates a high degree of information support for the activities of the evaluated enterprises. At the same time, not all components have the same impact on further innovation. In order to choose a further strategy of innovation, it is necessary to calculate the aggregate indicator for four components of innovation capacity. The results of the calculation of the aggregate indicator for personnel, investment, information and technical-technological components for 2020 are shown in Fig. 5.

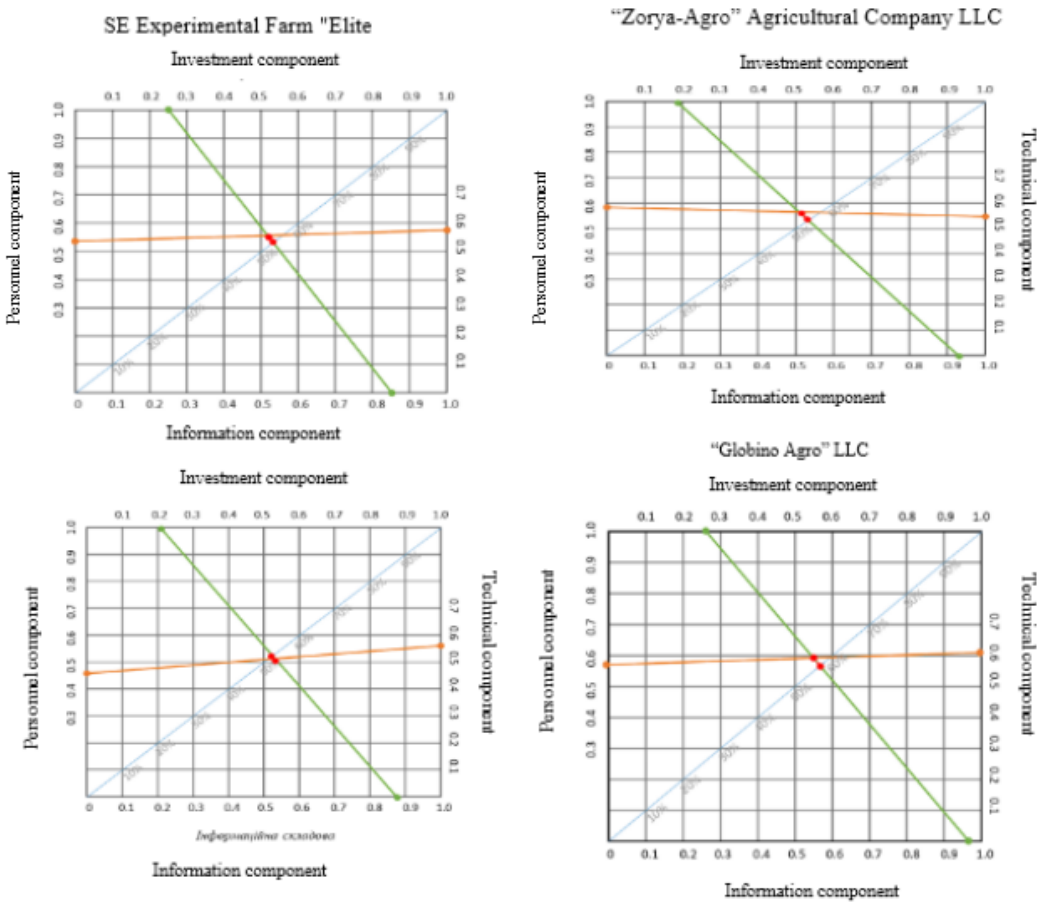

Fig. 5 The results of the final matrix for assessing the innovative capacity of enterprises in 2020
Source: proposed and calculated by the authors

According to the aggregate indicator, "Chista Krynytsia" Elevator LLC has the largest failures or deformations in innovation capacity (51%). "Globino Agro" LLC has slightly better indicators (57%). The main reasons for the negative process of formation, savings and accumulation of innovation capacity can be reduced to the following: lack of long-term ambitious state policy or strategy for revolutionary technological development, imperfection of industrial policy (including industrial reindustrialization caused by the transformation of the national economy); making managerial decisions on strategic directions of innovation development in industry not always taking into account the priorities of socio-economic policy; too low level of state coverage of financial costs for research and development, especially of industrial budget-generating enterprises; imperfect cooperation between domestic research, experimental, design centers and innovative enterprises; the presence of gaps in the legislative support of innovation. The inefficiency of the national innovation policy exacerbates the instability of certain segments of the national innovation system, causes institutional gaps, increases the costs of businesses, due to weak tax policy, intellectual property protection system, antitrust law.

5. Conclusions

The article proposes a method for assessing the innovative capacity of agri-food enterprises. The specified technique contains an estimation of personnel, investment, technical-technological, information components of ability of the enterprise of agro-food sphere to innovative activity. This added an opportunity to calculate an integrated matrix for assessing the ability of enterprises to innovate. In order to increase the innovative capacity of innovative enterprises, attention is focused on the need to stimulate each of its components. This can be done within the formation of scenarios to stimulate innovation potential through government support. The complete reformatting of the leading institutions of the state, which form the institutional matrix of innovative entrepreneurship in the agri-food

sector, should be aimed at developing a new type of business culture that takes into account such values as innovation. In order to increase innovation capacity, there is a need to stimulate each of its components. Thus, there is a need to support the innovative capacity of agri-food enterprises, which is currently one of the main factors of effective socio-economic development. Powerful innovative capacity of agri-food enterprises is a starting point for building a knowledge-based economy. Such an economy meets the requirements of modern civilizational progress.

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