
НАУКОВІ ГОРИЗОНТИ



Засновник, редакція, видавець
ПОЛІСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ

**Свідоцтво про державну реєстрацію
Серія KB № 24997-14937 ПР від 11.10.2021 р.**

Науковий журнал включено до категорії Б Переліку наукових фахових видань України, в яких можуть публікуватися результати дисертаційних робіт на здобуття наукових ступенів доктора і кандидата ветеринарних, економічних, сільськогосподарських та технічних наук зі спеціальностей – 071, 072, 073, 075, 076, 101, 133, 201, 202, 203, 204, 205, 206, 208, 211 (наказ МОН України № 1643 від 28.12.2019 р., наказ МОН України № 409 від 17.03.2020 р.).

Журнал включено до міжнародних наукометричних баз і каталогів наукових видань: Index Copernicus; Directory of Open Access Journals (DOAJ); Open Academic Journals Index (OAJI); Google Scholar; Crossref; Національна бібліотека України імені В.І. Вернадського, AGRICOLA, CAB Abstracts and Global Health (CABI), Open Academic Journals Index, Scopus.

Друкується за рішенням Вченої ради Поліського національного університету, протокол № х від хх.хх.2022 р.

ISSN: 2663-2144
e-ISSN: 2709-8877

Підписано до друку хх.хх.2022 р.
Формат 210×297. Ум. друк. арк. 16
Наклад 300 примірників
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SCIENTIFIC HORIZONS



Founder, Editorial and Publisher
POLISSIA NATIONAL UNIVERSITY

Certificate of state registration
KV No. 24997-14937 PR of October 11, 2021.

The scientific journal is included in category B of the List of scientific professional periodicals of Ukraine. It enables publishing the thesis results for Doctor and Candidate degrees in economic agricultural, technical and veterinary sciences (Order of the Ministry of Education and Science of Ukraine No 1643 of December 28, 2019; Order of the Ministry of Education and Science of Ukraine No 409 of March 18, 2020). It comprises the following specialties – 071, 072, 073, 075, 076, 101, 133, 201, 202, 203, 204, 205, 206, 208, 211.

The journal is included in the international scientific databases and catalogs of scientific publications: Index Copernicus; Directory of Open Access Journals (DOAJ); Open Academic Journals Index (OAJI); Google Scholar; Crossref; National Library of Ukraine named after V. I. Vernadskiy, AGRICOLA, CAB Abstracts and Global Health (CABI), Open Academic Journals Index, Scopus.

Recommended for publication by the decision of the Academic Council Polissia National University Minutes No. x of xx/xx/2022.

ISSN: 2663-2144
e-ISSN: 2709-8877

Signed for publication xx/xx/2022
Format 210×297. Conventional Printed Sheet 16
Circulation 300 copies
© Polissia National University, 2022

НАУКОВІ ГОРИЗОНТИ

Том 25, № 7
2022

НАУКОВИЙ ЖУРНАЛ

Засновано 12 березня 1998 р.

Періодичність випуску: дванадцять разів на рік

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SCIENTIFIC HORIZONS

Vol. 25, No. 7
2022

SCIENTIFIC JOURNAL

Year of establishment: Since March 1998.
Publication frequency: Twelve times a year

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Editorial Speech

Agricultural production is a vital economic sector, the role of the successful functioning of which cannot be underestimated. Well-established activity at all stages of agribusiness automatically means that there is no resource shortage and, as a result, consistently high quality of life for the population. Without the regular improvement of theoretical and practical approaches to the management of agricultural enterprises, the development of production potential is impossible since there is a direct link between the level of agriculture and technological progress. It is also important to consider the specific features of each individual country to ensure the effectiveness of innovations that are regularly developed by leading experts in the agricultural field. The urgent need for new technologies in manufacturing enterprises of various areas has formulated the relevance of the publication of this issue.

Tracing the dependence of the quality of population's life on the level of development of the agro-industrial sector in the state is not an extremely challenging task. The degree of management efficiency in various agricultural sectors affects the presence or absence of poverty, large-scale pandemics, average life expectancy, and satisfaction with it by the population. Through the competent introduction of technologies into the spheres of food, industrial, power, and political management of agro-industrial enterprises, it is possible to restore the balance of material, natural, and labour resources, thereby preventing a crisis period in the history of humankind. Countries in the process of economic development can adopt the practices of conducting agro-industrial activities from more developed countries. Suppliers of energy resources can gradually move to more environmentally friendly options while adapting the ways of regulating conventional ones. Political, economic, and communication systems can be subjected to a number of innovative changes designed to improve existing methods of planning and management of agribusiness. This issue consists of studies that contain algorithms for overcoming modern problems in the agricultural sector.

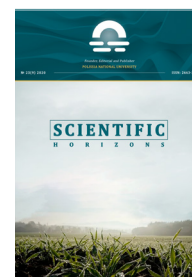
The amplitude of the subjects raised in the framework of the presented studies ranges from the modernisation of the production management system to the engineering features of the machinery design. The problems that have been scientifically resolved include both global and local cases. Thus, the studies included in the issue are related to the synthesis of multi-connected digital systems, financial accounting and analysis of the results of agricultural enterprises, production planning models, specific features of farming, prospects for the development of the cotton industry, marketing of corporate social responsibility of agri-food enterprises. The included papers are also related to the fields of oil supply development and machine-building industry, including regional development of agricultural and farming enterprises. Studies, concerning different states, namely the Republic of Kazakhstan, Tajikistan, Azerbaijan, Ukraine, and Canada were selected to ensure the geographical scope.

The presented papers are distinguished by a prominent level of scientific value in relation to the practical application of their results. In the course of the conducted investigations, a number of discoveries were made: the development of a method for the synthesis of multi-connected digital systems, which ensures an increase in the accuracy of management; the definition of the main characteristics of production planning models of various types; the identification of the dependence of the development of the cotton industry on the political situation; the definition of a three-level vector for the implementation of marketing programmes of corporate social responsibility of agricultural enterprises. The researchers also managed to analyse and evaluate the existing areas of accounting and analysis of the financial aspect of agricultural enterprises; compare priority approaches to agribusiness in Canada and Ukraine; come to the conclusion about the increase in oil demand in the medium term in Azerbaijan; identify the main prospects for the development of mechanical engineering in the Republic of Kazakhstan; trace the main prerequisites for the development of agribusiness in Ukraine. The range of areas of agricultural production, subject to detailed research, is quite wide. However, the economic sector of the agricultural sector itself is a complementary phenomenon, which entails the need to analyse all its components.

Each of the subjects under study carries substantiated importance for the current state of the agricultural industry in the represented states. Analysis of the financial transactions of agricultural enterprises will ensure their profitability, meaning it will have a positive impact on the economy in general. The synthesis of planning models is required to minimise losses during the production process and increase the overall efficiency of the enterprise. Tracking policy trends that have had an impact on the agro-industrial sector is important for building a new, more innovative business strategy and identifying relevant technical implementations. The improvement of marketing strategies is useful to develop a financial interest in the manufactured product from consumers and investors. Investigating the situation of oil exporting countries allows using the resource more intelligently while adapting the business to the transition to other types of energy. Ultimately, the identification of ways to abandon outdated production techniques at machine-building enterprises will provoke the development of more technologically advanced types of equipment, and the results of the analysis of the state of agricultural enterprises from the historical perspective will allow tracing the progress in the industry and formulating recommendations for its further development.

The tandem of scientific and practical approaches in the agricultural sector of the economy is extremely important at the current stage of world development. The rapid pace of change in political, socio-economic, and environmental circumstances requires the elimination of imperfections in the system of agricultural production activities to guarantee universal security and ensure a decent standard of living for people regardless of their country of residence.

Oleh Skydan
Editor-in-Chief



UDC 334.722.3:38.432

DOI: 10.48077/scihor.25(7).2022.10-19

Financial Mechanisms of Regulatory Development of Entrepreneurial Activity of Agricultural Business Entities

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Article's History:

Received: 11.08.2022

Revised: 10.09.2022

Accepted: 11.10.2022

Suggested Citation:

Prokopchuk, O., Bechko, P., Vlasyuk, S., Nepochatenko, O., & Ptashnyk, S. (2022). Financial mechanisms of regulatory development of entrepreneurial activity of agricultural business entities. *Scientific Horizons*, 25(7), 10-19.

Abstract. Market relations in the agrarian sector of the economy of Ukraine influenced the growth of the independence and commercial responsibility of agricultural business entities regarding the formation and rational use of financial resources. The development of market mechanisms for the regulation of agriculture, the liberalisation of the economy with the simultaneous reduction of the regulatory role of state management structures, without the appropriate preliminary elaboration of the legal, economic, and financial foundations of the transition to market relations led to an increase in the financial risks of many economic entities in the agricultural sector, which are successfully levelled at the expense of financial mechanisms of regulatory development of their entrepreneurial activity. An effective financial mechanism and an effective agrarian policy, its implementation, have been relevant in the context of scientific research for an extended period. Considering this, the purpose of this study was to substantiate a complete system of financial mechanisms for the regulatory development of entrepreneurial activity of economic entities in the agricultural sector of Ukraine. The study used economic and mathematical methods of analysis using statistical data of the EU and OECD countries for 1986-2020, using regression modelling of the interdependencies between the volumes of agricultural production and general state support to farmers, its volumes in terms of types, the influence of individual vectors of support for the total cost of products. The obtained studies indicate the need to develop measures related to the transformation of the system of financial mechanisms for the regulatory development of entrepreneurial activity of agrarian business entities of Ukraine, related to the prioritisation of mechanisms aimed at increasing the volume of investments in the agrarian sector of the economy, comprehensive development of the knowledge system, changes in the infrastructure of services, restrictions on control over the activities of business entities, the volumes of which in Ukraine substantially exceed similar indicators of the countries of the European Union with developed market relations and countries that are part of the OECD

Keywords: subjects of agrarian business, financial mechanisms of regulatory development of entrepreneurial activity, national support, agrarian policy



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INTRODUCTION

The financial mechanisms of the regulatory development of business activities of the agrarian business entities of Ukraine affect the food security of the country, providing the rural population with the income necessary for its existence. The effectiveness of entrepreneurial activities of Ukrainian farmers depends on both macroeconomic and microeconomic factors. Their list includes economic growth, inflation, the exchange rate of the national currency, which is used to set prices for material, labour resources, fixed and non-current assets.

The agricultural sector of Ukraine is the riskiest compared to all spheres of the national economy. Considering this, the agrarian industry is most in need of national financial support since the primary purpose of agrarian policy is both national interests and the creation of the most favourable conditions for the development of entrepreneurial loyalty of business entities of all organisational and legal forms of business. In the arsenal of world practice, to solve this problem, agrarian business entities apply price liberalisation on the one hand, and on the other hand – limit access to markets, provide various types of subsidies, while simultaneously applying measures related to trade protection.

The war between Ukraine and Russia, the global budgetary crisis caused by COVID-19 brought substantial adjustments to the regulatory development of entrepreneurial activity of Ukrainian farmers. The problems of the agricultural sector have become even more acute due to the following factors – the increase in migration of the Ukrainian population, mostly able-bodied, the occupation of up to 20% of Ukrainian territories, namely the Donetsk, Luhansk, Kherson, Zaporizhzhia, Kharkiv oblasts, the blocking of last year's grain harvest in seaports for its further implementation until countries of the Third World, specifically to Africa. The above actualises the need to increase national support through the application of proper programs aimed at the smooth functioning of business entities of the industry.

The purpose of this study was to substantiate the system of financial mechanisms for regulatory development and national support for entrepreneurial activity of agrarian business entities of Ukraine using EU and OECD data.

LITERATURE REVIEW

Financial mechanisms of regulatory development of entrepreneurial activity of economic entities in the agricultural sector of Ukraine for a long time have been a priority and are in the centre of attention of both theoreticians and practitioners investigating this issue. Thus, Joe Dewbre and Cameron Short (2002) investigated the impact of political measures on the competitiveness of agribusiness entities and on trade indicators. They put special emphasis on government incentives in the form of agricultural subsidies, which are paid to agribusinesses to supplement their income, manage the supply of agricultural products,

and influence the price and supply of such goods. This enables them to compete on the domestic and global markets. Evaluating the impact of political measures on competitiveness, scientists substantiated that the causes of competitiveness are its factors – phenomena and processes of production and economic activity of agrarian business entities that cause a change in their competitiveness.

Management of the competitiveness of agricultural business entities allow ensuring the best ratio of the constituent elements (factors) of competitiveness in production and economic activities. Jared Greenville *et al.* (2019), Gibran J. Puntak (2020) comprehensively assessed the driving forces that create value in the agricultural sector and developed a strategy due to the supply of agricultural products to foreign markets with high added value by forming the main vectors of export potential at the national support of agrarian business entities. Miranda Meuwissen, Tsion Tai Assefa, Marcel van Asseldonk (2013), Alan Matthews (2018) concluded that overcoming the instability of agricultural incomes is and should remain a priority vector for agricultural policy. Guillaume Gruere and Jonathan Brooks (2021) examined the impact of the COVID-19 pandemic on the economies of countries with developed market relations, which mostly applied effective measures aimed at financial support for farmers, and those developing countries that took the state of trade policy as a basis, providing information about their food security. Scientists prove that the COVID-19 pandemic will disrupt the labour market but will not fundamentally change the strategic trends and challenges to supporting food security. The uninterrupted functioning of the agrarian sector of the economy is based on such key points as productivity and the state of ecology, which is the main prerequisite for national support for farmers. This issue is explored in the studies of Gwen DeBoe (2020), Cohen Deconinck (2020), Ben Henderson (2020), and Yussi Lankoski (2019; 2020), who substantiated the environmental consequences of greenhouse gas emissions, water quality, biodiversity, and market price support. Scientists state that reducing emissions and increasing the volume of waste processing will contribute to the production of ecologically clean organic products and encourage business and private investors to advance funds for progressive environmental technologies and infrastructure. Considering this, the authors propose to create a more effective waste management system capable of stimulating and handling the reduction of their volumes, while simultaneously increasing their reuse and recycling.

Attracting foreign direct investment in the agricultural sector of the economy, according to the research of J. Punthakey (2020), is one of the main vectors of the industry development. The same thesis is followed by P. Heisey and K. Fuglie (2018), who substantiate that state investments in development of the agricultural sector and scientific research have recently slowed down,

because of which the quality of agricultural products and the productivity of the functioning of agricultural companies are decreasing. Z. Kristkova, M. van Dijk, and H. van Meijl (2016) investigated the influence of the amount of public investment on scientific research and development in agrarian business, which positively affects the productivity of agriculture. Therewith, according to the results of their studies, the investments provided cannot stimulate agricultural production to a level capable of satisfying the production of agrarian business entities.

Research by Alessandro Olper (2014) proved that national support has different forms, and therefore, affects the amount of labour involved in the agricultural sector. O'Toole & Hennessy (2015) emphasise the effectiveness of investments in active farms. K. Anderson & E. Valenzuela (2021) comprehensively assessed the agricultural export indicators under the conditions of expanding sales markets, increasing the net profit of agricultural entities, which can positively influence the national economic well-being with a simultaneous increase in investment volumes. Integration into the global trade space allows supplying agrarian business entities with an institutional environment capable of adapting production to the standards and requirements of international markets. Under such conditions, technological and innovative decision-making will be simplified, thereby increasing the productivity of labour and capital, stimulating the renewal of existing industries and expanding the offer for the foreign market.

According to the studies of Kassum Ayoub, Jean-Philippe Boussemart, Stefan Vigeant (2017), the provision of state subsidies is important for stimulating the inflow of investments, the introduction of innovations and progressive effective technologies for farmers, because of which their recipients can effectively use their resources. The same opinion is held by Laura Latruffe and Ian Desjeux (2016), who note the positive impact of the provided subsidies on the productivity growth of the agricultural sector. The results obtained by Jean-Joseph Minviel, Laura Latruffe (2017) confirm the positive effect of government subsidies on the capital intensity of their recipients and argue that such government support is sensitive to the modelling method.

Considering the conducted research, under present-day conditions, scientific discussions regarding the financial mechanisms of the regulatory development of the entrepreneurial activity of the agrarian business entities are still ongoing, which confirms the need for further studies, the structural volumes of national support, and their impact on the final results of the agrarian activity.

MATERIALS AND METHODS

For the empirical analysis, panel data based on the unified data of the OECD database (2021a, 2021b) for 1986-2020 were used.

During the study on this issue, the following tasks were set:

1. To investigate the dependence between the total volume of agricultural products in terms of value and national support to farmers.
2. To provide a comprehensive analysis of the impact of the structural volumes of general national support, its types, on the total value of agricultural products.
3. To specify which types of national financial support of agrarian business entities of Ukraine are the most effective, capable of contributing to the increase in the volume of agricultural products.
4. To carry out a comparative analysis of the financial support of agrarian business entities of the EU, OECD, and Ukraine for 1986-2020.

As for the dependence between the total volumes of agricultural products in terms of value and national support to farmers, the results were obtained upon applying a regression analysis between the independent variable TSE (total support directed towards agricultural entities) (OECD, 2021b) and an indicator that is effective TVP – the total value of production (OECD, 2021a), using formula (1):

$$TVP = b_0 + b_1 * TSE \quad (1)$$

where b_0 , b_1 are the independent variables used in the regression equation.

The assessment of the dependence between the total cost of production and the general support provided to the agrarian sector is based on the construction of a regression equation between the independent variable given to it and the effective indicator. The studies conducted show that the parameters of the regression analysis are measured using the indicators of multiple determination R^2 , p-criterion, and F-criterion.

Analysis of the influence of the structural volumes of general national support and its types on the total value of agricultural products is calculated using the following indicators:

- general national support (TSE), the part of which is transfers by producers (PSE producer support (OECD, 2021b)).
- consumer support from budgets of all levels (Consumer support, CSE (OECD, 2021b)).
- public expenditures directed to general services for the agricultural sector (GSSE general service support (OECD, 2021b)).
- b_2 , b_3 are independent variables used in the regression equation.

The results of the study of the influence of the structural volumes of general national support, its types on the total value of agricultural products were constructed using the following regression equation (2):

$$TVP = b_0 + b_1 * PSE + b_2 * CSE + b_3 * GSSE \quad (2)$$

The regression equation estimation parameters are measured by the multiple determination index R^2 , the p-criterion and the F-criterion.

To find the most effective areas of support for the agricultural sector, the values of the parameters of the regression equation b_1 and the pairwise correlation coefficients of the resulting TVP indicator and the PSE, CSE, GSSE factors were estimated as follows (3):

$$r_{xy} = \frac{\overline{x \cdot y} - \bar{x} \cdot \bar{y}}{s(x) \cdot s(y)} \tag{3}$$

To find more effective areas of national support for farmers and to detail the system of financial mechanisms for the regulatory development of agricultural business entities, a regression equation was constructed (4):

$$TVP=b_0+\sum b_i \cdot x \tag{4}$$

where x is the volumes, types of the most effective vectors of national support for agrarians; i is the total number of types of national support in the most effective areas.

The regression equation estimation parameters are measured by the multiple determination index R^2 , the p-criterion, and the F-criterion. To find more effective vectors of national support for farmers, the assessment of the values of the parameters of the regression equation b_1 and the pairwise correlation coefficients of the resulting TVP indicator and the chi factors are used.

Indicators of support, their volumes, types that are the most effective in the EU, OECD, and Ukraine countries were calculated by applying a comparative analysis using graphic interpretation, the total amount of support and vectors of support in the agricultural sector of the EU and OECD that are the most effective using the relevant statistical data of Ukraine. This allowed substantiating the transformation vectors of the system of financial mechanisms for the regulatory development of business activity for agricultural producers of Ukraine.

RESULTS AND DISCUSSION

Study of the dependence between the total volume of agricultural products in terms of value and national support to farmers. Using EU and OECD panel data for 1986-2020, a regression equation was constructed (5):

$$TVP=27955.3+3.303424 \cdot TSE \tag{5}$$

The simulation results show that the total cost of agricultural products in the absence of national financial support in EU and OECD countries will amount to USD 27,955.3. Therewith, the coefficient b_1 shows that when increasing the amount of national financial support by USD 1 million, the total value of agricultural products will increase by USD 3.303424 million dollars. The regression statistics of equation (5) are presented in Table 1.

Table 1. Regression statistics of the equation of dependence between the total financial support provided to the agricultural sector and the total cost of agricultural sector products

Regression statistics	
Multiple R	0.816343585
Several R^2	0.66641685
Adjusted R^2	0.661511215
F(1.68)	135.847226
P	0.0000
Standard error of estimate	198947.59

The criteria of statistical significance of the equation in the research process are reliable and verified (Table 1). The results of the study show that 66.64% of the total variability of the value of agricultural sector products is due to changes in the factors of general support of the agricultural sector.

Analysis of the impact of the structural volumes of general state support, its types, on the total value of agricultural products. The results of the analysis per the constructed regression equation based on EU and OECD panel data for 1986-2020 show a substantial impact of structural volumes, types of general support on the total value of agricultural sector products (6):

$$TVP=-75277.4143+4.6268 \cdot PSE+4.5431 \cdot CSE+10.0329 \cdot GSSE \tag{6}$$

The results of the simulation (6) show that the total value of agricultural products of the agrarian sector upon increasing the total amount of national financial support for agricultural producers by USD 1 million leads to its growth by USD 4.6268 million. Under the condition of increasing financial support of consumers, the volume of agricultural products increases by USD 4.5431 million, and with the increase in support for services to the agrarian sector – by USD 10.0329 million. Considering the results of the analysis, the most influential is the

support of services to the agrarian sector, which contributes to the corresponding increase in the total value of the products of the agrarian sector. The significance of the equation constructed according to the criteria of

statistical data (2) is reliable and verified (Table 2). In this situation, 96.79% of the total variability of the value of agricultural products is directly dependent on the provided financial support, its types and structural volumes.

Table 2. Regression statistics of the equation of influence of structural amounts of general national support, its types, on the total value of agricultural products

Regression statistics	
Multiple R	0.92843889
Several R ²	0.967948797
Adjusted R ²	0.845491924
F (1.68)	664.401693
P	0
Standard error of estimate	62595.2366

The conducted studies give reasons to claim that the assessment of paired coefficients of determination is more closely related to the total cost of agricultural sector products under the conditions of national financial support of the agricultural sector ($r=0.928$). This indicator is less close, but in comparison with the support of producers, the relationship is more significant – ($r=0.845$), and the support of consumers of agricultural products has the least significant influence ($r=-0.38$). Considering the study results, the most influential type of national support for the development of the agricultural sector is national support for infrastructure and services.

Analysis of national agrarian financial support of agrarian business entities. In the structure of national financial support, which is effective and contributes to increasing the volume of agricultural products and services, the following are highlighted:

- Agricultural knowledge and innovation system – AKIS.
- Inspection and Control – IC.
- Development and maintenance of infrastructure – DI.

- Marketing and promotion – MP.
- Cost of public stockholding – PS.

Based on OECD data (2021a), an analysis was conducted for the EU and OECD countries for 1986-2020, based on the results of which the following regression equation was constructed:

$$TV=26495.3561+58.821*AKIS+68.1605*IC+9.6531*DI-21.6207*MP+15.3409*PS \quad (7)$$

The analysis of the conducted research shows that the most substantial impact on the total cost of agricultural products of the agrarian sector, and the effective vector of service support are innovations in the agrarian sphere, support for inspection and control, and knowledge systems. The statistical significance of equation (7) was verified (Table 3). The conducted studies show that 98.21% of the total variability of the value of agricultural products in the agrarian sector depends on changes in the factors of general support services.

Table 2. Regression statistics of the equation of influence of structural amounts of general national support, its types, on the total value of agricultural products

Regression statistics	
Multiple R	0.991009055
Several R ²	0.982098947
Adjusted R ²	0.980700428
F(1.68)	702.241747
P	0
Standard error of estimate	47505.1162

The results of the research show that national financial support to the agricultural sector has a close relationship with the cost of products, namely due to the support of the system of knowledge and innovations in the agricultural sector ($r=0.958$), support for inspection and control ($r=0.966$); less close connection – with

infrastructure development and support ($r=0.877$) and marketing and promotion support ($r=0.806$); and public shareholding ($r=-0.147$).

Comparative analysis of national support, their volumes, types, which are the most effective in the EU, OECD countries, and Ukraine. The agricultural sector of

Ukraine proves on average higher volumes of agricultural production in the structure of GDP compared to EU countries and OECD countries (Fig. 1), which indicates that Ukraine uses specific regulatory policy mechanisms.

The results of the conducted research show a reduction in the share of support for innovations and knowledge systems in the agrarian industry in Ukraine since 2015. Since 2020, this indicator is the lowest compared to EU and OECD countries (Fig. 2).

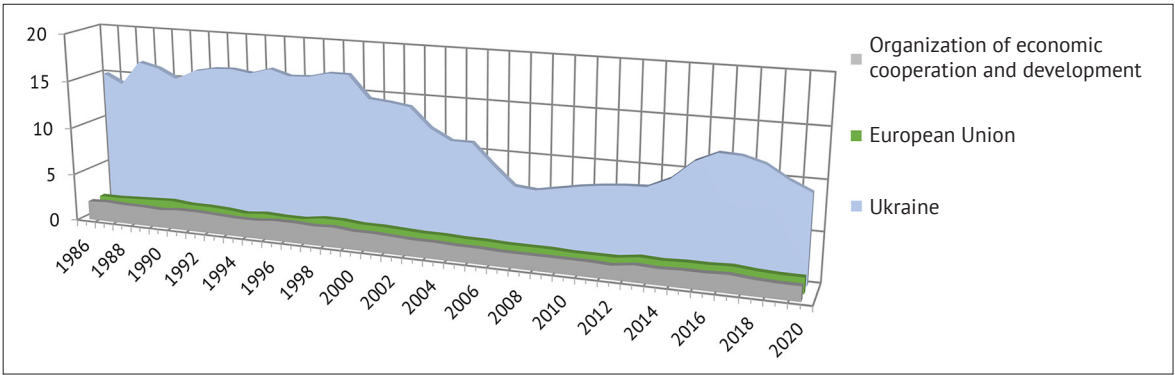


Figure 1. The share of agriculture in GDP, % (based on OECD data (2021)

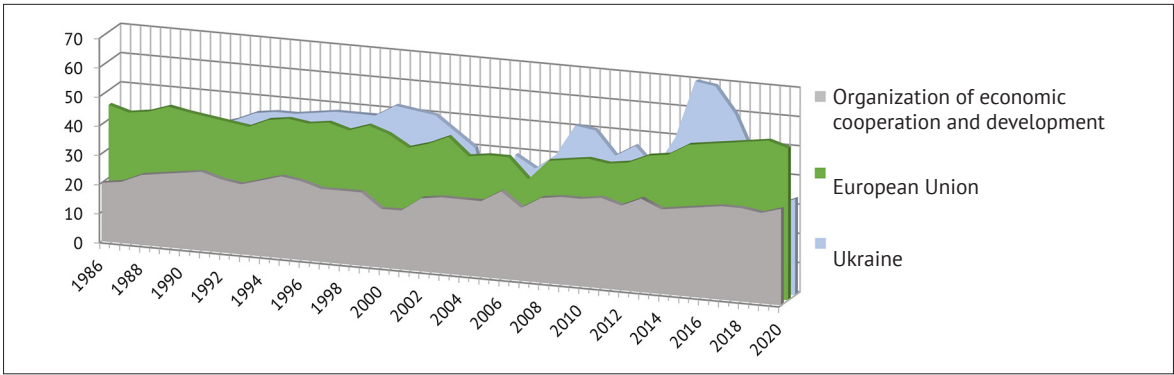


Figure 2. Agricultural knowledge and innovation system, % GSSE (constructed according to OECD (2021a) data)
Source: constructed according to OECD data (2021a)

At the same time, during this period, an increase in the share of inspection and control in the agricultural sector is observed, and as of 2020, it is equal to 63.0% of the total support of services in the agricultural sector of Ukraine (Fig. 3). During 2006-2020, there is a tendency to decrease national support for the infrastructure of the

agricultural sector of Ukraine (Fig. 4). The obtained analysis of the development and maintenance of the infrastructure of Ukraine, the EU, and the Organisation for Economic Cooperation and Development shows a substantial decrease in the indicator under study, in comparison with 2020 to 2000, in the OECD – by 6%, the EU – by 11%, and Ukraine – by 22%.

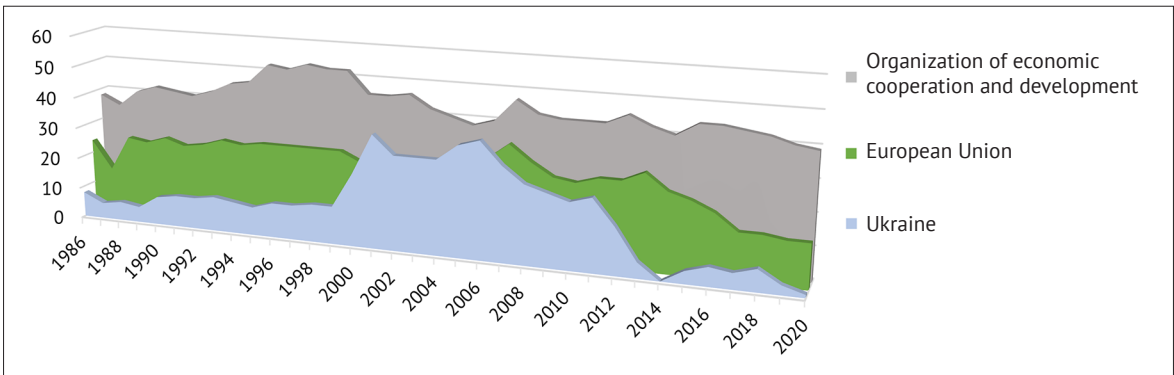


Figure 3. Infrastructure development and maintenance, % GSSE Source: constructed according to OECD data (2021a)
Source: constructed according to OECD data (2021a)

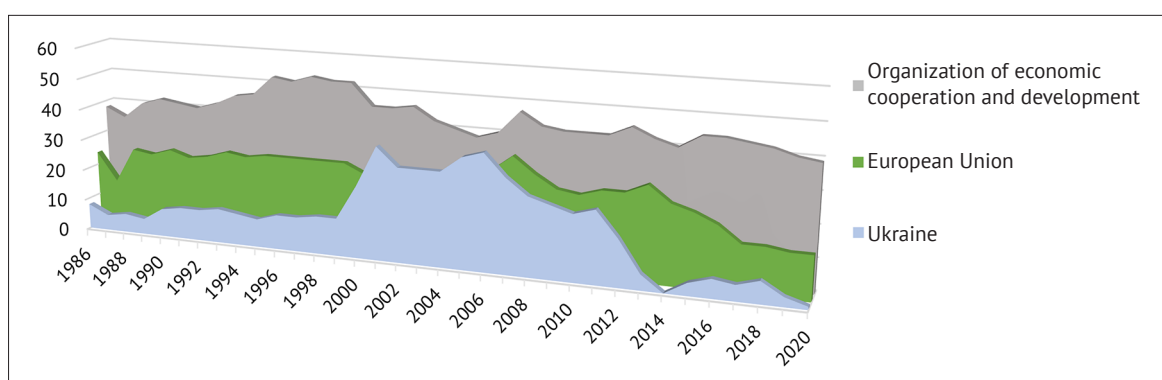


Figure 4. Infrastructure development and maintenance, % GSSE

Source: constructed according to OECD data (2021a)

At a stably low comparative level for 1986-2020 in Ukraine, marketing support for the agricultural industry is and stays at an insufficient comparative level (Fig. 5). Considering this, the financial mechanism for the regulatory

development of the entrepreneurial activity of domestic economic entities in the agrarian sector needs improvement towards transformation of mechanisms aimed at national financial support of services in the agrarian sector.

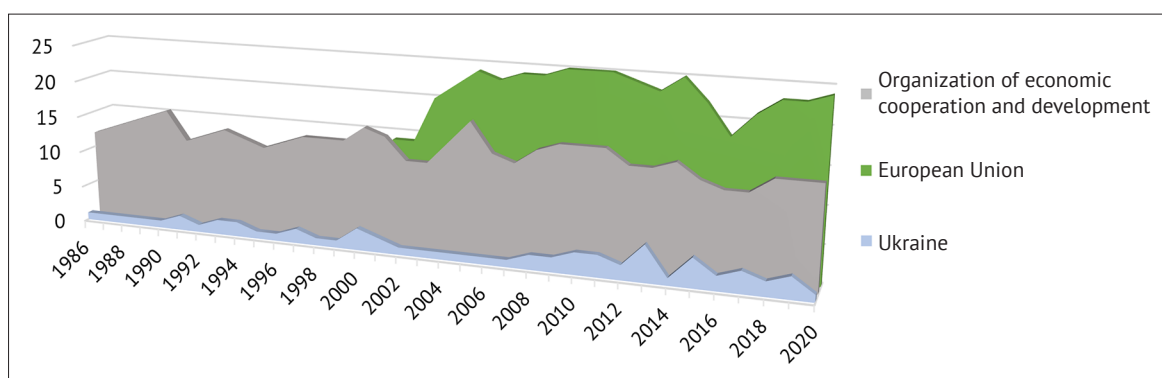


Figure 5. Marketing and promotion, % GSSE

Source: constructed according to OECD data (2021a)

It should be emphasised that a more substantial effectiveness in predicting the dependence of the development of the agrarian sector depends on national financial support, considering its types and structure. This is convincingly evidenced by the lower level of the coefficient of multiple determination in modelling the dependence of the value of agricultural sector products on the total amount of national support (Table 1) compared to the similar dependence on the structural amount of the same support by its types (Table 2).

Producers of agricultural products receive transfers, specifically to support the market price, payment of budget payments of all levels, and the cost of lost income. Considering this, transfers substantially affect the productivity of the agricultural sector, calculated in value terms, as they reduce the price of finished products.

From the perspective of national financial support, the most effective is the provision of services and infrastructure of agricultural activity. In this regard, it is important to finance innovations and the system of knowledge in the agrarian sphere, subject to continuous control and inspection of the activities of economic

entities in the agrarian sector, and financing for the development of infrastructure and marketing of business activities in the agrarian sphere. According to the simulation results of equation (6), the financing of innovations has a close correlation and influences the cost of products of economic entities in the agrarian industry, which is confirmed by the results of studies by Kassum Ayoub (2017), Laura Latruffe, Yana Desjeux (2016), Zuzana Kristkova, Van Dijk, Van Meijl (2017).

At the same time, GSSE transfers do not contribute to an increase in income and do not reduce the costs of commodity producers of agricultural products, while creating favourable conditions for the agricultural industry through the development of public services or private institutions and OECD infrastructure (2021c).

The data show that Ukraine has considerable agricultural potential. Therewith, it does not make sufficient use of financial mechanisms for supporting services in the agricultural sector. Much of such support, up to 60%, is directed to ensuring inspection and control, and such a critical area as innovation, infrastructure, and marketing still is out of the focus of agricultural policy.

The results of the analysis and proof of effectiveness indicate the need to transform the regulatory financial mechanism for the development of entrepreneurial activity in the agrarian sector and to ensure those mechanisms aimed at innovative activity, the development of the knowledge system, the infrastructure of services by optimising inspection and control (simplification of procedures for registration, certification, regulation of inspection activities).

Reforming the national agrarian policy should ensure the solution of these problems, while simultaneously creating favourable conditions for effective entrepreneurial activity, communication, and coordination of agricultural market participants, namely the international one, which will contribute to increasing the export of agricultural products, the development of coordination and transport systems.

CONCLUSIONS

The results of this study, which aimed to solve the problem of figuring out effective financial mechanisms for the regulatory development of entrepreneurial activity of agricultural entities in Ukraine, the effectiveness of which has been proven by world practice, can be adapted to Ukrainian agrarian policy.

The obtained results of the study allowed showing that the change in the volume of the value of the agricultural products of Ukraine by 94.72% depends on the national support for the agricultural sector of the economy. According to the analysis, the most productive vector of support for the development of business activities of agricultural producers of Ukraine is national support, specifically innovations in the agricultural sphere ($r=0.971$), control ($r=0.91$), support and development of infrastructure ($r=0.802$), marketing support ($r=0.810$).

The results of the study allowed proving that the increase in the total value of the products of the ag-

ricultural industry is determined not only by the amount of general national financial support provided to the agricultural industry, but also by its structure and types. The results of the conducted research using the EU and OECD statistical data for 1986-2020 confirm that the most effective vector of financial support for the development of entrepreneurial activity is national support for services in the agricultural sector: inspection and control, development and support of infrastructure, and support for marketing and promotion of the knowledge system and innovations in the agricultural sector.

The obtained results proved the expediency of the transformation vectors of the system of financial mechanisms for the regulatory development of entrepreneurial activity in the agricultural sector of Ukraine by providing components aimed at innovative activity, the development of the knowledge system, the infrastructure of services by optimising the support of control and inspection, namely the simplification of procedures for registration, certification, regulation of inspection activities, the volumes of which are overestimated in the regulation of the agricultural sector of Ukraine, comparing with the indicators of the EU and OECD countries.

The obtained provisions are of fundamental importance and can be used in the agricultural sector of Ukraine, which allows reducing direct financial support directly to producers by creating favourable conditions for effective entrepreneurial activity, strengthening coordination and communication of agricultural market participants, including the international one.

The perspective of further research on this problem and scientific discussions should be to figure out the predicted effectiveness of the proposed financial mechanisms for the regulatory development of entrepreneurial activity of agrarian business entities of Ukraine, which will contribute to their effective development.

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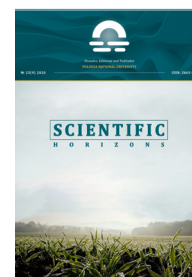
Фінансові механізми регуляторного розвитку підприємницької діяльності суб'єктів господарювання аграрної галузі

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Анотація. Ринкові відносини в аграрному секторі економіки України суттєво вплинули на зростання рівня самостійності та комерційної відповідальності суб'єктів господарювання аграрної галузі щодо формування та раціонального використання фінансових ресурсів. Розвиток ринкових механізмів регулювання сільського господарства, лібералізація економіки з одночасним зниженням регулюючої ролі державних структур управління, без відповідного попереднього опрацювання правових, економічних та фінансових основ переходу на ринкові відносини призвели до зростання фінансових ризиків багатьох суб'єктів господарювання аграрної галузі, які успішно нівелюються за рахунок фінансових механізмів регуляторного розвитку їх підприємницької діяльності. Дієвий фінансовий механізм і результативна аграрна політика, її реалізація є актуальними в контексті наукових досліджень за тривалий період. З огляду на це, мета дослідження полягає в обґрунтуванні цілісної системи фінансових механізмів регуляторного розвитку підприємницької діяльності суб'єктів господарювання аграрної галузі України. Дослідження здійснювалися із застосуванням економіко-математичних методів аналізу з використанням статистичних даних країн ЄС та ОЕСР за період 1986-2020 рр., з використанням регресійного моделювання взаємозалежностей між обсягами аграрної продукції та загальною державною підтримкою аграріям, її обсягів у розрізі видів, тісноти впливу окремих напрямів підтримки на загальну вартість продукції. Отримані дослідження свідчать про необхідність напрацювання заходів, пов'язаних із трансформацією системи фінансових механізмів регуляторного розвитку підприємницької діяльності суб'єктів аграрного бізнесу України, пов'язаних з наданням пріоритетності механізмам, які спрямовані на нарощування обсягів інвестицій до аграрного сектора економіки, всебічний розвиток системи знань, зміни інфраструктури послуг, обмеження контролю за діяльністю господарюючих суб'єктів, обсяги яких в Україні суттєво перевищують аналогічні показники країн Європейського союзу з розвинутими ринковими відносинами та країн, що входять до ОЕСР

Ключові слова: суб'єкти аграрного бізнесу, фінансові механізми регуляторного розвитку підприємницької діяльності, державна підтримка, аграрна політика



UDC 658.628.011.1: 339.13

DOI: 10.48077/scihor.25(7).2022.xx-xx

Boston Consulting Group Matrix: Opportunities for Use in Economic Analysis

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Article's History:

Received: 16.08.2022

Revised: 14.09.2022

Accepted: 15.10.2022

Suggested Citation:

Gorb O., Dorohan-Pysarenko, L., Yehorova, O., Yasnolob, I., & Doroshenko, A. (2022). Boston consulting group matrix: Opportunities for use in economic analysis. *Scientific Horizons*, 25(7), 20-30.

Abstract. Boston Consulting Group Matrix is the most popular methodological tool for analysing corporate portfolios. However, the method of using the Matrix has been frequently criticised, and the peak of popularity of this tool has passed. The purpose of this study is to find new areas of application for the Boston Consulting Group Matrix in the economic analysis of entrepreneurial activity. The following research methods were used: monographic, dialectical, abstract-logical, graphic, and tabular. It is shown that the use of the conventional BCG Matrix method is limited due to the ambiguity of conceptual foundations, methodological problems, and lack of complete information about the activities of competitors. The study proved that inaccuracies in the analysis of the market growth rate and the relative share of individual entities in it allow accurately assessing business prospects in this area. Methodological and applied issues arising when a company evaluates its market share of certain products are considered. A modification of the BCG Matrix is proposed, which distributes the assortment units of the analysed business entity according to certain profit growth reserves. Depending on the objects of a particular analysis, grouping in the modified matrix can be carried out according to individual types of products (goods, works, services) or by groups of buyers (consumers). The main problems with application of the BCG Matrix were clarified and systematised. Solutions for certain shortcomings of the conventional BCG Matrix were found, namely regarding the method for calculating the indicators it holds. A modification of the BCG Matrix is proposed, which classifies types of products (goods, works, services) by prospective profit reserves and changes in their share in the company's profit structure. A similar matrix is designed to classify buyers of goods or consumers of a company's services. The study figured out the place of the proposed BCG Matrix modification in economic analysis. The proposed variations of BCG Matrix have an advantage over the classical version, since they are based on internal analysis of only one subject of activity, and not on evaluating the potential of competitors. The developed modification of the analysis method can be integrated into the system of comprehensive economic analysis of any company. The results of the analysis using modified BCG Matrix can be used in financial strategic planning and marketing strategy development, specifically when planning advertising campaigns

Keywords: BCG Matrix, matrix approach, strategic analysis, revenue analysis, portfolio analysis, product range analysis



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INTRODUCTION

Boston Consulting Group Matrix is currently the most well-known methodological tool for analysing corporate portfolios using the matrix approach. The Matrix method was developed in 1968 by the founder of the well-known American firm Boston Consulting Group (BCG) Bruce Henderson and its employee Alan Zakon. The authors consider companies as a portfolio of products or businesses, each of which contributes to the growth of profitability, and which require strategic management. The essence of the method is to classify the assortment units of companies according to the growth values of the received cash flows and relative market share, followed by the recommendation of a development strategy for each group of units.

The method gained popularity with the publication of the works "The Product Portfolio" (1970) and "Perspectives on experience" (1970). For over 50 years, BCG Matrix has gained worldwide distribution and gained a reputation as the "gold standard" for analysing the company's product line. However, as the BCG itself admits, the peak popularity of this portfolio analysis tool has already passed.

Admittedly, many scientific and educational materials are devoted to the BCG portfolio analysis matrix. Of the recent publications analysing the methodological aspects of application and examples of using this method, scientific articles by researchers from the East attract attention. Thus, the study of the Vietnamese scientist Tien (2022) used the BCG Matrix to figure out the state of Dat Xanh in the real estate market and form its investment policy. Chinese scientists Zhang *et al.* (2021) used the Matrix to compare energy-saving technologies involved in the cement industry of China. Son & Park (2022) developed strategic recommendations based on the BCG Matrix to ensure Amazon's sustainable competitiveness. A group of scientists from Indonesia (Nurfitriya *et al.*, 2020) used this method to estimate the export market of certain West Java products (rubber, coffee, spices, etc.) and develop proposals for strategic planning of the region's economic development. Furthermore, the method was applied in the analysis of the aviation industry (Chang, *et al.*, 2019, Heiets *et al.*, 2021), ports (Mo, *et al.*, 2020), and Port Container Terminals (Chandrasekhar Iyer & Nihar, 2021), family firms (Belling, 2022), etc. The BCG Matrix method is currently used in various branches of social production, both at the micro- and macroeconomic levels. Kader & Hossain (2020) note that the BCG method is a valuable tool for evaluating which strategic units should be invested and which should be disposed of, which allows companies to effectively distribute available resources and manage their business.

At the same time, many scientists pay attention to the methodological shortcomings of analysing the portfolio of products based on the BCG Matrix. As Madson (2017) notes, the BCG Matrix has been criticised on many occasions and, according to the researcher, is even

discredited in academic circles. However, the scientist admits that many practitioners consider this method important in planning a corporate product portfolio.

BCG employees (Reeves *et al.*, 2014) tried to take a fresh look at Matrix. They admitted that the classical 1970 approach had lost its relevance due to two circumstances:

- 1) the modern business environment is changing rapidly, which requires fast response by accelerating the redistribution of resources between products;
- 2) market share is no longer a direct predictor of sustainable financial results.

The presence of these and other methodological and applied issues arising upon evaluating the assortment of a particular market subject dictates the relevance of further research of the BCG Matrix method.

The purpose of this study is to substantiate the recommendations for using the BCG Matrix method, provided that there is no complete information about the company's competitors in a particular market. The goals of this study are to further develop the critical analysis of the method, adapt the classical Matrix to the uncertainty of competitors' activities in the market, and modify this method depending on the objects of research.

MATERIALS AND METHODS

The idea to modify the classic BCG Matrix came from a practical need – while performing research on the order of a client who wished to remain anonymous, there was a problem with information about his competitors. One of the tasks set by the customer was to form recommendations regarding the company's assortment, the implementation of which was expected using a matrix approach. However, the use of the conventional BCG Matrix method proved impossible because the company had not one, but two main competitors and the lack of accurate data on the sales volumes of certain products by these competitors.

The study of the possibilities of using the BCG Matrix method without complete information about competitors was conducted in five stages. The first, theoretical stage, involved an in-depth study using the BCG Matrix monographic method developed by its authors, and suggestions for improving this method proposed by its proponents and critics. The source material for the study included scientific and popular science articles by scientists and practitioners from all over the world. Based on the dialectical approach and using the abstract-logical method, the features of the Matrix method were generalised, which narrow its practical use.

At the second stage, by brainstorming for each identified defect, a way to eliminate it was proposed. As a result of the examination, a modified version of BCG Matrix was proposed, which can be used if there is no one main competitor of the company in a particular market, and which is based on the search for internal reserves for increasing sales. The methodological framework for constructing a matrix is analytical grouping,

modelling, and the matrix approach. The third stage included finding, justifying, and calculating reserves for sales growth of particular types of products of the company that is the object of research. The work was performed using comparative analysis, analysis of relative dynamics indicators, expert method, and benchmarking. The next step was to test the proposed method based on the data of the customer company.

The following sources of information were used: statistical reporting of the company, data from its accounting and management accounting, results of marketing research, expert evaluation, etc. The conclusions of the study are formulated using methods of analysis and synthesis, induction, and deduction. According to the terms and conditions of the agreement, researchers have the right to publish the results obtained only with the consent of the customer company. The latter allowed the partial publication of the results obtained and without specifying its name. Thus, the data and calculations of using the BCG Matrix presented in this paper will be considered a conditional illustrative example constructed using the idealisation technique. At the final stage of this study, the results were clearly illustrated using graphical and tabular methods.

RESULTS AND DISCUSSION

The main theoretical and methodological foundations of the BCG Matrix are described on the official website of the Boston Consulting Group (2022). The BCG Matrix is also called "The growth share matrix" – this name reveals the essence of the method – the division of the company's assortment units into categories according to market growth criteria and market share to decide on investment priorities in each of the categories. As assortment units (other name variants – businesses, business units, strategic units, products), individual products (goods, securities, services, areas of activity), brands or firms that together form the portfolio of a given company can be investigated. As noted by members of the Management Study Guide content (2022) team and A. Upadhyay (2022), the total market volume is more often measured in cash receipts, but it can also be measured in natural units. The relative market share of a business is found by dividing current-year sales by current-year sales of the main competitor. The market growth rate is defined as the percentage of current-year sales to last-year sales.

Graphically, categories are represented as a matrix divided into four sectors. Each cell of the matrix clearly stands for different types of business and is indicated by a certain symbol.

According to the official website of Boston Consulting Group (2022), the BCG Matrix names the following business categories:

1. "Cash cow" – characterised by a prominent market share and low market growth rates. These are the main generators of cash receipts, which are the main source of the company's current prosperity. Their management is aimed at maximising current profits with small investments. The main strategy for such products is to support the existing market share without expanding operations.

2. "Star" – future sales leaders characterised by high sales growth rates and a high market share. They have sales potential with investment, and considerable resources are distributed for their development. "Stars" are the future of the company, but only for a certain time.

3. "Question mark" (or "difficult child") – a high market share, but low sales growth rate. They require more investment than they generate cash. They should be controlled as much as possible and developed only if investment opportunities are available.

4. "Pet" (for the most part, this category is represented by the "dog" symbol) – small market share and small growth prospects. They are useless, and traditionally liquidation or sale strategies are recommended for such products.

The BCG Matrix distributes products according to the product life cycle model, according to which any product goes through four stages of development: market entry ("Question mark"), growth ("Star"), maturity ("Cash cow"), and decline ("Pet").

Gunasekarage *et al.* (2020), Chiu & Lin (2020) describe some practical aspects of matrix construction. In the matrix, the horizontal axis shows the market share that each product occupies, and the vertical axis shows the growth rate of this product. For each product, a circle is constructed on the matrix field, the size of which corresponds to the volume of cash flows from this product. The upper part of the matrix shows business units whose growth rates are higher than the average growth rate of the corresponding market, while the lower part shows those with lower growth rates, respectively. In the original model, the average growth rate, which is the limit of high and low rates, is 10% market growth per year. The left part of the matrix shows products with a "high" market share of the business – more than 1.0, i.e., the company's share exceeds the equal share of the main competitor.

Here is an example of the BCG Matrix. As noted above, the name of the company whose factual material is used as an illustration of the method is not disclosed under the terms and conditions of the agreement for consulting. The company sells oil on the local market, namely: cold-refined sunflower oil (shown in Figure 1 as A), extra-pressed sunflower oil (B), unrefined sunflower oil (C) and olive oil Extra virgin olive oil (D) Virgin olive oil (E), Olive oil (F).

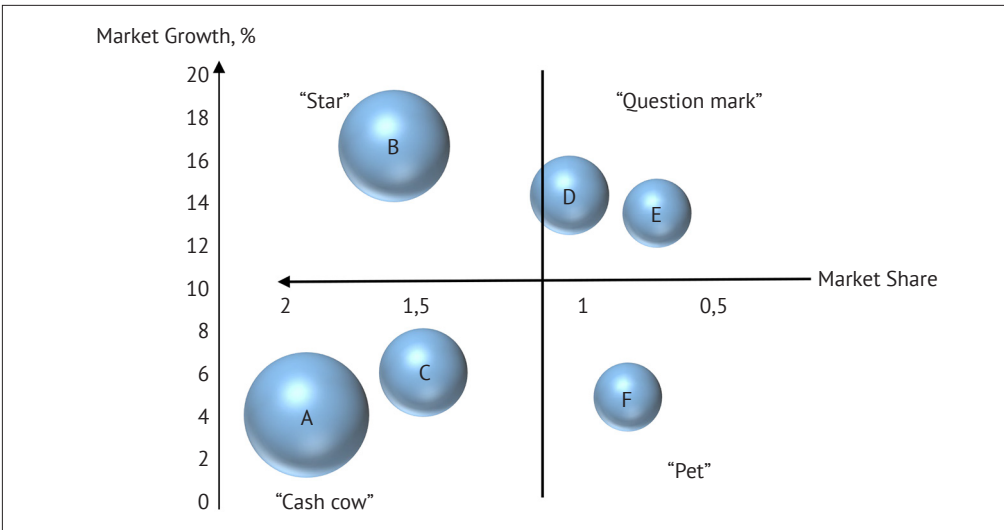


Figure 1. The BCG Matrix of the company

Source: compiled by the authors

In practice, there may be situations when a certain product category does not include any product range, e.g., if the company has already optimised its portfolio and does not have “Pet” products. This situation occurred in the practical activities of the authors, as well as its possibility is noted by researchers from the teams “Prachi Juneja”

and Management Study Guide Content (2022). Building a BCG Matrix is not the usual grouping of assortment units by the degree and direction of change in profitability compared to the earlier period and with competitors. The classification is based on conceptual propositions, which are summarised and critically characterised in Table 1.

Table 1. Conceptual foundations of the BCG Matrix and their critical evaluation

Theoretical position	Critical assessment of the situation
Cash flow is an indicator of business success	A business can generate a lot of revenue, but it can be low-profit or unprofitable due to considerable costs. The financial success of a business is figured out by net cash flow and profit. Furthermore, a low-income (or low profit) business unit can increase the profits of a related business due to the synergy effect (e.g., if buyers prefer a seller who has a full range of product group lines, or if the product is made from waste or a lack of main production)
Cash flow depends on the company's market share. The relative market share characterises the company's competitiveness	The regulation is generally valid, the market leader has price advantages and experience, with an increase in the scale of production, variable costs per unit of production are minimised, which contributes to profit growth. But in practice, there are limitations, which include as follows: 1. A business may be outside the standard competitive field, e.g., run in the “blue ocean” or be a monopolist, but not receive super-profits due to inefficient management or state regulation of the market. 2. Cash flow depends on the volume of the market, even the position of a leader in a limited market does not guarantee an increase in sales. If a firm sells products on the local market and does not have the potential to reach wider markets, then sales volumes are limited by effective demand for these products. Furthermore, some specific products (e.g., components to produce spacecraft or medicines for a rare disease) have a limited number of buyers or consumers, whose limited needs depend on sales volumes. 3. One of the ways to increase market share is to reduce the price, so in the short term, the growth of market share may not be accompanied by an increase in cash flows. 4. When calculating the share of a business in a particular market, the value that is compared (the numerator of the fraction) is the indicator of income (cash flow). That is, in the model of the relationship between market share and cash flow, the latter is considered both as a factor of influence and as a result of the influence of this factor
Cash flow depends on the growth of this market. The growth of the market dictates its attractiveness for the company	Undoubtedly, the first-order factor affecting future earnings is the prospects for market growth or contraction. However, a long-term assessment of market development, like forecasting any other process, is probabilistic in nature, and therefore cannot be precise. Furthermore, stable markets that show neither growth nor contraction are also attractive
Use of two parameters in the analysis (market share and market growth rate)	Reducing the criteria for evaluating the effectiveness of an assortment portfolio to two parameters simplifies its use. However, the model does not consider other key factors that affect performance, such as the impact of prices, production costs, the ability to adapt to rapidly changing circumstances, macroeconomic indicators, the efforts of competitors in the market, etc.

Table 1, Continued

Theoretical position	Critical assessment of the situation
Only retrospective information is used in calculating the evaluation parameters	Of the two matrix parameters, one (market share) is static, i.e., it is figured out only for the last year, and the other (market growth rate) evaluates the dynamics only in the studied year compared to the previous one. The annual analysis period is, on the one hand, too short, since data for one year is almost always biased, on the other hand, it is too long, since it does not allow quickly responding to changes in the situation. The method does not make provision for added research on the prospects for changing the parameters of the model, the strategic potential of the company, and therefore cannot be considered predictive. In particular, the method does not provide an estimate of the duration of the product life cycle stage – for instance, the Matrix does not answer the question of how long “cash cows” will generate income, or when a “star” will become a “cash cow”

Source: developed by the authors based on (BCG Matrix, 2020; Nurfitriya et al., 2021; Özemre & Kabadurmus, 2020)

The main issues arising upon constructing the BCG Matrix are related to the ambiguity of the following methodological and practical aspects of the method:

1. Lack of clear criteria for assigning a company's business to a particular market.

Local, regional, national, and global markets are distinguished beyond geographical boundaries. However, the BCG method does not provide recommendations on how to analyse a business if, for instance, a product is sold in the domestic national market and the markets of several countries located on different continents, while the market share and their potential differ. Or, given that there are different markets for objects, what is the best way to explore soy tofu cheese – as a component of the vegan cheese market, or to factor in that it is not consumed by vegetarians exclusively?

2. Availability of alternative methods for calculating the product's market share, each of which is not methodically perfect.

There are two methods that are methodically correct in figuring out the share that a company's product occupies in the total product market:

– divide the total revenue from the sale of a given company's product by the total revenue from the sale of that product to all sellers. Problems that arise when using this method – income can be measured in different currencies, and their conversion into a single currency causes inaccuracies due to exchange rate differences; income depends on price fluctuations that can be caused by random, objective circumstances or subjective reasons; lack of complete information about total income due to shortcomings in official statistics, the presence of the shadow economy, “pirate markets”, state and trade secrets, etc.;

– the amount of product sold by this company is divided by the total amount of product sold on the market. Disadvantages of the method – measurement in natural units does not objectively estimate the income (e.g., the income from the sale of one painting by a recognised artist may exceed the income from the sale of hundreds of paintings by an unknown artist) and the above disadvantages of sales statistics.

In practice, when figuring out the market share of a business, the approach described above is most often used – the company's income from the sale of a product

divides the income from the sale of this product to the main competitor. According to the authors, the indicator calculated in this way cannot fully reveal the company's competitiveness because it does not factor in the number of competitors. Often, the competition in the market is strong, and it is difficult to find the main one among 2-3 strong competitors. It is also difficult for a leading company to find the main competitor among market outsiders with insignificant sales, the volumes of which do not differ substantially. Another issue is the need to obtain objective information about competitors' sales since data can be hidden and distorted in open sources.

3. There is no unambiguous quantitative criterion for classifying a product as a “high” or “low” market share.

In the classical matrix, the methodology of which is described on the BCG website, the standard is a co-efficient of 1.0, i.e., the company's share is equal to the competitor's share, but if it exceeds 1, then the business share is considered “high”. However, considering the shortcomings of the calculation of the “market share” indicator, this approach is not dogmatic, it can be revised. In an oligopoly, the first three companies to cover 80% of sales are usually considered market leaders. In this situation, the share of each of these companies can be considered high. Furthermore, there may not be a leader in the market, or vice versa, the leader of an innovative product may temporarily be a monopolist.

4. It is insufficient to compare indicators for only two years to estimate market growth.

A common way to calculate the growth rate is the ratio of a company's revenue from current-year product sales to last-year revenue, expressed as a percentage. However, it is necessary to agree on this formula to further use this indicator – based on the dynamics in the past, determine the phase of the product life cycle and predict revenues for the future. To achieve this, one needs to evaluate the trend, and not just compare data for two years. Therefore, the “market growth rate” indicator should be calculated at least three years in advance, and the predicted extrapolated value of the indicator should be factored into the BCG Matrix.

Since not all markets are growing, it is more correct to use the term “rate of market change” instead of the term “market growth rate” for products that are at the stage of decline.

5. There is no unambiguous quantitative criterion for classifying a product as a business with a “high” or “low” growth rate.

In the original BCG Matrix classification, B. Henderson (1970) set the boundary between “high” and “low” product growth rates at 10% market growth per year. However, the limit level is not immutable and can be reviewed by the analyst. According to the recommendations of T. Kaufmann (2021), this level should not be set below 5% or the level of growth of the economy (industry). Some analysts (Heiets *et al.*, 2021) take the growth rate as a benchmark, calculated based on statistical data from open sources on total revenues from the sale of a given product on the market. Some scientists (Mo *et al.*, 2020) calculate the growth rate based on the revenues of leading companies. In the latter case, there is again an already defined problem with information about competitors’ revenues and total sales in the market.

It is considered that in cases where it is impossible to obtain objective information about the market of a particular product, or if a new product is being analysed, the market of which has not yet formed, or a new company that does not yet have a basis for comparing its revenues, the classical BCG Matrix approach can be used in a modified form.

The authors of this suggest using the BCG Matrix classification to summarise the results of the analysis for finding profit growth reserves for the main assessments of the company’s potential and the market. It is generally recognised that an important task of economic analysis is the search for reserves to increase the efficiency of activities, to mobilise opportunities to enhance the effect of positive and neutralise negative factors to improve financial results. Each business entity periodically determines the areas of increasing revenues, optimising production costs, and calculates the impact of implementing these reserves on financial results. Admittedly, different reserves bring different economic effects – some do not require considerable investment, but are less effective, while others require considerable investment, but give a greater effect. Furthermore, the amount of added profit that can be obtained from assorted products also varies – some have a considerable real potential for substantial profit growth, while some, on the contrary, have almost completely exhausted their capabilities. A detailed description of the method for finding reserves to increase profitability is not part of the tasks of this study. The authors consider only how the results of such an analysis can be generalised using the BCG Matrix approaches.

The authors offer to divide the assortment units of products (goods, works, services) into the following categories:

1) “Cash cow” – products that currently bring considerable profit, but do not have the potential for its growth. In other words, these are currently strategically important products, the main profit generators, but there are no

real prospects for its substantial increase yet. Since such a business is already set up, the cash flow is well-balanced, and it does not require considerable investments. Managing such a business is aimed at maximising current profits with small investments. The main strategy of action in the market is “harvesting” – supporting an existing position without trying to expand its activities.

2) “Rising star” – promising products, future sales leaders that have considerable potential not only for sales growth, but also for substantial profit growth. These are usually new products that can considerably increase returns with a large investment. It is expedient to direct the profit received from the “cash cows” to the development of a “rising star”, it is also possible to use the funds raised, namely bank loans.

3) “Dark horse” (“question mark”) – products that currently bring little profit but have the potential to increase it. They are distinguished from “Rising stars” by the following features: the development of such a business needs investments that have a long payback period, there is intense competition in the market, there is a considerable investment risk or there are factors that increase uncertainty in increasing profits or at least the return on investments. Since these are assortment units with a high degree of uncertainty about future profitability, one should invest in their development with caution and only if funds are available.

4) “Lame duck” – products with low or zero profit or loss. These are unpromising types of products for which no real reserves for improving financial results were found. However, it is not always necessary to get rid of these products, they can give added competitive advantages, be necessary components of the company’s assortment policy, etc. It is merely necessary to minimise their presence, try to eliminate the impact of negative factors on the results of activities.

To set a quantitative limit for assigning a product to a particular category, the authors of this study offer the following options:

- to decide a significant or insignificant contribution of product profit to the total profit of the company, set either a 10% barrier or use the principle of ABC analysis, wherein products with a significant contribution are considered to be those assortment units that are leaders in profitability and collectively give 80% of profit.

- to find a significant or insignificant rate of profit growth prospects, set either a 10% barrier or an average value of the potential profit growth rates of all the company’s products.

The proposed version of the Matrix differs not only by the considered methodological features of assigning assortment units to squares of matrices, but also by the location of categories on the scale – in a two-dimensional coordinate system with the direction of movement from a smaller (low) to a larger (high) value.

Next, the study considered the technique of applying the Matrix on the example of the aforementioned

company, which sells sunflower and olive oil on the local market and plans to start selling corn oil. The analysis of profit increase reserves gave the following results (Table 2).

Table 2. Summary of the company's profit growth reserve search results

Types of products (oil)	Last year's profit, thousand dollars	Last year's profit structure, %	Reasonable profit next year, thousand dollars	Reasonable profit structure for the next year, %	Prospects for profit growth, %	Sector in the Matrix
A – cold refined sunflower oil	544	32.0	600	27.3	+10.3	"Cash cow"
B – first-pressed sunflower oil	348	20.5	400	18.2	+14.9	"Cash cow"
C – unrefined sunflower oil	320	18.8	350	15.9	+9.4	"Cash cow"
D – Extra virgin olive oil	212	12.5	400	18.2	+88.7	"Rising star"
E – Virgin olive oil	179	10.5	200	9.1	+11.7	"Lame ducks"
F – Olive oil	97	5.7	100	4.5	+3.1	"Lame ducks"
G – corn oil	–	–	150	6.8	×	"Dark horse"
Total	1700	100.0	2200	100.0	+29.4	×

Note: The colour indicates the types of products classified as "high" according to the established criteria and boundaries.
Source: compiled by the author

As Table 2 shows, the company sees reasonable opportunities to increase its profit by 29.4% (in value terms by 500 thousand dollars). Therewith, a higher-than-average growth rate for the company is expected from the sale of Extra virgin olive oil (an increase of 88.7%). It is impossible to figure out the rate of profit growth for a new product – corn oil, but the authors of this study believe that in such cases the product can be attributed to "Dark horse". Other types of products are also expected to show profit growth, but its pace will be less than the company's average. If one takes the average possible growth as a standard, then all other products of the company should be considered business units with a low growth rate. If one chooses the option

according to which the growth standard is 10%, then there will be as many as three "stars". According to reasonable amounts of profit in the coming year, products with a high share in the profit structure (over 10%) are A, B, C, D – together they will bring 80% of the profit.

Figure 2 shows a modified BCG Matrix summarising the results of the assessment of assortment units according to profitability indicators. As in Table 1, the average possible profit growth for the company is 29.4% (for a more visual representation, this indicator is rounded up to 30%). The size of the circle is proportional to the potential share of the product's profit in the total amount of profit.

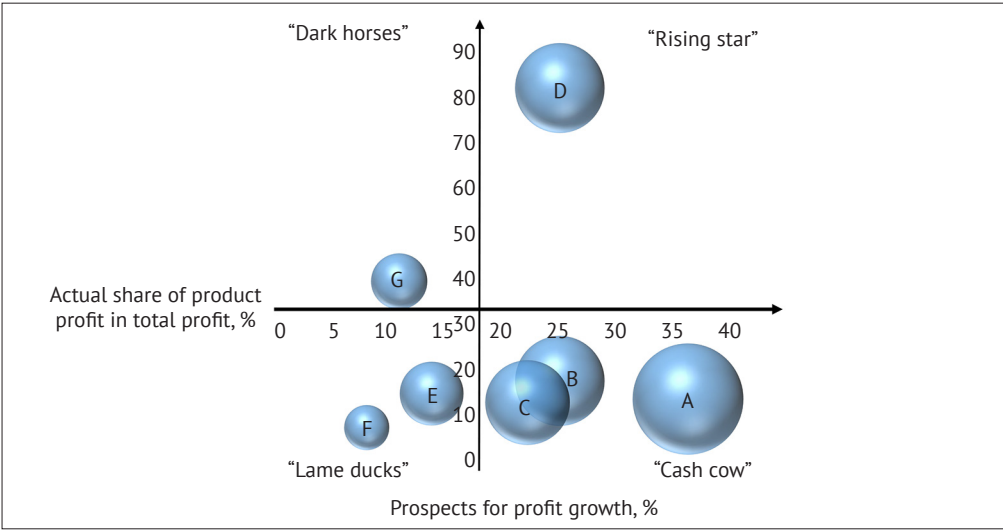


Figure 2. The BCG Matrix of the company for evaluating product range units based on real and prospective profitability indicators

Source: compiled by the authors

It is also suggested to use the BCG Matrix when planning advertising campaigns for the typology of population categories. Currently, such a recommendation is only a conceptual idea that has not passed practical testing. However, subject to detailed elaboration, such an approach can serve as one of the elements of developing the idea of an advertising strategy and directions for its financing.

Based on the results of marketing surveys, one can distinguish separate groups of respondents who have different degrees of interest in this product. Groups should be identified according to the key socio-demographic characteristics (e.g., urban youth, pensioners, residents of a particular region), etc.

According to the BCG Matrix modification, the following groups of individuals can be distinguished in relation to the product under study:

- “regular customers” (“cash cows”). These are long-time supporters of the product, who usually buy it. It is regular customers who bring a stable profit, but their needs are limited, they will not buy a larger amount of product, and therefore will not be able to provide a substantial increase in profit. To support the attention of regular customers to the product, one does not need focused active advertising, just a general reminder ad is enough.

- “perspective categories” (“stars”). Categories of the population that can potentially become regular customers because they are interested in a product may be consumers of a similar product. The main growth in product sales and revenue from its implementation can ensure that these promising categories are favoured. It is these groups of the population that should be targeted with focused advertising adapted to a particular category (e.g., advertising designed for middle-aged or older women living in small localities).

- “dark horses” (“question marks”) – people who have not decided on a choice and do not have a definite opinion about the product. There is a chance that they will be interested in the product, but it is difficult to decide in advance whether they will become regular customers and substantially affect future profits. One can only distribute funds for an advertising campaign aimed at these categories if there is sufficient funding.

- “unpromising categories” that are unlikely to become regular customers under any circumstances.

Comparison of the results of the authors’ study with the results of a study by other scientists on the shortcomings of the BCG Matrix and ways to eliminate them indicates a considerable interest in this issue.

Although the Austrian scientist Kaufmann (2021) calls this method “the mother of portfolio concepts in the business sphere”, he notes that the evaluation criteria in it are reduced to only two aspects. Therefore, the matrix can only be used to compare individual products, and not whole business areas. The researchers of the Prachi Juneja and Management Study Guide Content (2022)

teams agree with the existence of this issue. They find other shortcomings in the method under study, namely they note that the four-element approach is too simplified; the classification has the concepts of “high” and “low” types of business, but there are no “medium” ones; the market for which the comparison is made is not clearly defined; a considerable market share does not always bring large profits, etc.

The authors of this study agree with Chiu & Lin (2020), who note that the conventional BCG matrix does not consider different periods to compare the growth and relative market share of products and suggest extending the period for analysis. Svichkar (2019) notes the following disadvantages of the method: it analyses only achieved results, not future indicators; it is intended for use by companies that are or strive to be leaders; it does not consider the strategic potential of the company, etc.

Nowak *et al.* (2020) proposed the BCG matrix add-on, which was called the Grey Portfolio Analysis method. The authors try to solve the generally recognised problem regarding the static nature of the conventional methodology by using predictive models of the Grey Portfolio Analysis. Researchers believe that when using grey numbers, the issue of information uncertainty is solved at the methodological level.

R. Debasish (2020) considers the Matrix method from unusual angles. He contemplates whether there is a statistically significant correlation between the market growth rate and the relative market share of the leading company and its closest competitor. The availability of a sufficient statistical base allows clearly classifying market participants and deciding the nature of their risk. The proposal to use the generalising BCGI index in the BCG Matrix method for comparative analysis is also worthy of attention.

To overcome the issue of information uncertainty, Özemre & Kabadurmus (2020) used modern Big Data analytics methods for strategic analysis of the international market. It is impossible to disagree with the thesis that modern software can predict the volume of international trade and facilitate the strategic decision-making, providing information about the future of global markets.

Despite the highlighted problems in the BCG Matrix concept, the idea of using a balance between types of businesses that are at various stages of the life cycle for the sustainable development of the company was without exaggeration revolutionary for its time and is still relevant. However, the problems of the BCG Matrix method are not limited to the ambiguity of the conceptual approaches considered. There are some methodological inconsistencies that need to be clarified, as well as practical difficulties. The essence of the latter is that successful application of the Matrix requires comprehensive knowledge of the market and its competitors, but it is not always possible to obtain it.

CONCLUSIONS

One of the tasks facing economic analysis is to evaluate the structure of financial results, find industries, types of products with the most substantial impact on the formation of profits and losses, and figure out the areas for increasing profitability. Analysis of reserves for improving financial results allows finding the types of products (goods, works, services) that have the best prospects, and the use of a modified BCG Matrix allows finding those products that require priority attention and the greatest resources to increase profits.

The proposed variations of the BCG Matrix have an advantage over the classical version, since they assess the prospects not for income, but for profit (which is more important for the business) and are based on internal

economic analysis of only one business entity. Accordingly, there is no need to estimate the potential of competitors in the market of a certain product (service), which is inevitably inaccurate due to incomplete information.

Furthermore, ways to eliminate certain shortcomings of the conventional BCG matrix are proposed, namely regarding the methodology for calculating the indicators included in it. The proposed method of using the BCG Matrix is a tool for prospective analysis and can be integrated into the system of comprehensive economic analysis of any company. The results of the analysis using the modified BCG Matrix can be used in financial strategic planning and marketing strategy development, specifically when planning advertising campaigns.

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Boston Consulting Group matrix: можливості використання в економічному аналізі

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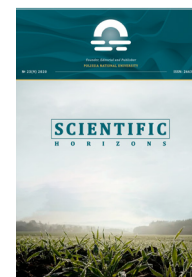
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Анотація. Boston Consulting Group Matrix є найвідомішим та популярним серед практиків методичним інструментом аналізу корпоративного портфеля. Проте, методика використання Matrix зазнала чисельної критики, а пік популярності цього методичного інструменту минув. Метою статті є визначення нових напрямів використання Boston Consulting Group Matrix в економічному аналізі підприємницької діяльності. Використані наступні методи дослідження: монографічний, діалектичний, абстрактно-логічний, графічний і табличний. Обґрунтовано, що використання традиційної методики BCG matrix обмежене внаслідок неоднозначності концептуальних засад, методичних проблем та браку повної інформації щодо діяльності конкурентів. Доведено, що неточності в аналізі швидкості росту ринку та відносної частки на ньому окремих суб'єктів, унеможливають точність оцінки перспектив бізнесу у цій сфері. Розглянуто проблеми методичного та прикладного характеру, які виникають при оцінці компанії її частки на ринку певних продуктів. Запропоновано модифікацію BCG matrix, яка розподіляє асортиментні одиниці аналізованого суб'єкта діяльності за визначеними резервами зростання прибутків.

Залежно від об'єктів конкретного аналізу групування у модифікованій матриці може здійснюватися за окремими видами продукції (товарів, робіт, послуг) або за групами покупців (споживачів). Уточнені та систематизовані основні проблеми, які виникають при застосуванні BCG matrix. Визначені шляхи щодо усунення окремих недоліків традиційної BCG matrix, зокрема, щодо методики розрахунку показників, які входять до неї. Запропонована модифікація BCG matrix, що класифікує види продукції (товарів, робіт, послуг) за перспективними резервами прибутків та за зміною їх частки у структурі прибутку компанії. Аналогічна матриця розроблена для класифікації покупців товарів або споживачів послуг компанії. Визначене місце запропонованої модифікації BCG matrix в економічному аналізі. Запропоновані варіації BCG matrix мають перевагу у порівнянні з класичним варіантом оскільки вони базуються на внутрішньому аналізі лише одного суб'єкта діяльності, а не на оцінюванні потенціалу конкурентів. Розроблена модифікація методики аналізу може вбудуватися у систему комплексного економічного аналізу будь-якої компанії. Результати аналізу з використанням модифікованих BCG matrix можуть бути використані у фінансовому стратегічному плануванні та у розробці маркетингової стратегії, зокрема при плануванні рекламних кампаній

Ключові слова: BCG matrix, матричний підхід, стратегічний аналіз, аналіз доходів, портфельний аналіз, аналіз асортименту



UDC 330.341.1(477)

DOI: 10.48077/scihor.25(7).2022.31-42

Modern Trends of Innovative Activity Ensuring Growth and Sustainable Development of the Economy of Ukraine

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Article's History:

Received: 05.08.2022

Revised: 06.09.2022

Accepted: 05.10.2022

Suggested Citation:

Diachenko, V., Diachenko, N., Suray, I., Novachenko, T., & Vasiurenko, O. (2022). Modern trends of innovative activity ensuring growth and sustainable development of the economy of Ukraine. *Scientific Horizons*, 25(7), 31-42.

Abstract. The urgency of finding ways and opportunities to intensify modern innovative practice determined the purpose of this publication, which is to highlight the results of research into the trends of innovative activity to ensure the growth and sustainable development of the economy of Ukraine, as well as to find factors that inhibit this process. This study is based on the thesis that in modern realities, to obtain a commercial or social effect, it is necessary to intensify innovative activity, as a set of processes aimed at creative search, formation, publication, and implementation of innovations in practice. Such activity involves making investments in objects of innovative activity. Methodological aspects of the study consider the concepts of identifying patterns of influence of the volume of expenditures on scientific, research, and design activities on the number of researchers involved in such activities, on the effectiveness of their research, and therefore on the state of innovative development of the state. The change in the positions of Ukraine in the rating evaluations regarding innovative development was investigated, a comparative analysis of the research and development costs of the leading countries of the world and Ukraine in 2020 was performed, the downward dynamics of changes in the number, organisations, and number of employees carrying out R&D, the costs of performing such works and the share were revealed of these costs in the gross domestic product of Ukraine during 2010-2020. The main factors inhibiting the process of intensification of innovative activity include a decrease in state funding of research and development, and therefore, a decrease in the number of organisations and researchers engaged in the creative activity of scientific research. Positive trends towards the formation of gender parity among the performers of scientific research work (47.6% are women), the growth of activity in the field of innovative activity and the increase in expenses of enterprises for innovative activity in 2020 have been revealed. It is proposed to start the development of an effective national innovation policy with the definition of the conceptual provisions of innovative development. The results of the study can be useful for a wide range of scientists who study issues of innovative development, specialists of management structures who analyse the state of innovative development and take care of issues of developing strategies for recovery and further development of the national economy

Keywords: innovation, innovative development, scientific research, investment, research activity, factors, trends, economy



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INTRODUCTION

The last decades of high competition, globalisation of economic relations, dynamic transformation of technologies, as well as the transitivity of the Ukrainian economy actualised the need to reorient the economy of Ukraine to an innovative model of development through the formation of a coherent national innovation system. Innovative activity, as a basic vector of the further development of the economy, and the foundation of the growth of the economic power of the state, and therefore its competitiveness, is a basic factor of ensuring the sustainable development of the state.

Several institutions and organisations, including the UNESCO Institute for Statistics (UIS), the World Bank, and others, conduct research on indicators that characterise the development of scientific, namely innovative activity.

China's R&D investment was 1.96 trillion yuan (\$298 billion) in 2019 and a record 2.44 trillion yuan in 2020, up more than 10% from 2019 (Jia & Li, 2022).

However, Ukraine is inferior to many countries in terms of the level of relevant expenses, namely R&D expenses in 2020 amounted to UAH 631.4 million, which is more than half as much as in 2013 and is 0.41% of GDP (State Statistics Service of Ukraine). During the period of the 2019 COVID-19 pandemic, R&D spending in 2020 decreased by almost 5.4% compared to 2019.

As D. Toma and E. Gons (2022) emphasise, it is worth considering that each know-how, each patent, contributing to the provision of opportunities for personal professional or economic growth, only with bringing the achievement to the market, introducing it into the practice of production or use, ensures the development of innovative spheres (Toma & Gons, 2022).

According to a group of scientists (Makarenko *et al.*, 2019), in the conditions of the current economic crisis, the relevance of developing an investment strategy of an enterprise is primarily dictated by the need to modernise the endogenous environment and the need to consider exogenous prerequisites, threats, and risks. Therefore, the development strategy must be developed based on adaptive management of the enterprise's innovative activities. E. Afonin *et al.* (2021) emphasise that today, the enterprise's investment strategy should be based on an innovative approach to information and analytical support.

O.E. Grechanyk *et al.* (2022) emphasises that the perspective model of the activity of innovative enterprises should include a combination of such components as the use of additive, adaptive technologies; increasing the role of the creative personnel factor; forecasting prospects for the development of innovative products and services; client-oriented logistics, e-commerce, marketing, creative management, implementation of modern information and communication technologies; cloud services. According to T. Yatsenko (2021), the intensification of the innovative activity of enterprises will ensure the development of their economic stability, which will

contribute to the transition of the Ukrainian economy into the "ascending phase of the sixth economic cycle."

That is why the purpose of this study is to analyse the current state of innovative activity in Ukraine, to find the factors affecting it, and modern trends in innovative activity to ensure the growth and sustainable development of the Ukrainian economy.

MATERIALS AND METHODS

The general methodical approach of this study is dictated by the trend of influence of the results of scientific research, efficiency of transformation of scientific inventions into objects of know-how (goods or services) and innovative activities of enterprises on the state of economic development of the state, confirmed by world economic development.

Methodological aspects of the research consider the concepts of identifying patterns of influence of research and development costs on the number of researchers involved in such activities and on the effectiveness of their research.

The used methods of this intelligence are based on the well-known dialectical approach to the study of economic phenomena, namely general methods (analysis and synthesis with methods of abstraction and generalisation are used in researching the current state of innovative activity and in formulating conclusions; inductive forecasting – during formulating prospects development) and special economic and statistical methods (analysis of dynamic series when identifying existing trends and identifying the dynamics of their changes, indices for comparing the values of relevant indicators, comparison for identifying trends).

The materials used in the study were obtained mainly from information sources that published information about the state of innovative activity, namely the State Statistics Service of Ukraine (hereinafter – the State Statistics Service of Ukraine), the World Intellectual Property Organisation, an American company, a provider of financial information, Bloomberg, statistical organisation of the European Commission (Eurostat). The research used sources that mostly hold information starting from 2010 and limited to 2020 (official data for 2021 has not been made public by the State Statistics Service of Ukraine at this time).

During the analysis of the state of innovative activity in Ukraine, methodological explanations of the State Statistics Service of Ukraine regarding official data published by it were also considered.

RESULTS AND DISCUSSION

An inherent feature of the process of innovative activity is that it directly involves:

- transformation of creative search results into a modernised product or service;
- updating and improving technological processes;

- an updated approach to offering and providing social services, considering the current and urgent needs of society;
- use of intellectual property objects in one’s personal economic activity as an intangible asset.

Notably, in Ukraine, the regulatory foundations of innovative activity have been formed, namely:

- it is determined that innovative activity involves obtaining a social or commercial effect, which determines the need to attract investments in objects of innovative activity (Law of Ukraine “On Investment Activity”, 1991);
- the organisational, legal, and other aspects of the state policy in the sphere of innovative activity of Ukraine are outlined and the instruments of its support are defined (Law of Ukraine “On Innovative Activity”, 2002);
- the basic vectors of the systematic formation of the priorities of innovative activity in Ukraine are outlined (Law of Ukraine “On the Priority Directions...”, 2011);
- provisions are made for full or partial interest-free lending of innovative projects of production-oriented scientific institutions and stipulates the procedure for

their use of budget program funds (Law of Ukraine “On Scientific and Scientific and Technical Activity”, 2015);

- the procedure for carrying out expertise of innovative projects is prescribed (Law of Ukraine “On Scientific and Scientific and Technical Expertise”, 1995);
- the economic and legal principles of the introduction and operation of the special regime of innovative activity of technology parks in Ukraine were determined (Law of Ukraine “On the Special Regime...”, 1991);
- mechanisms for activating communication links of technological platforms are foreseen, where business and the state can become potential customers of innovations, and “scientists, students, inventors will offer innovative solutions that will further scale and become the basis for their innovative business” (“Strategy for the development...”, 2019). However, for the year 2021, according to the international ratings of the European Innovation Scoreboard (European Innovation Scoreboard, 2021), in the field of innovative activity, Ukraine lost the position of the previous year (Table 1).

Table 1. Indicators of Ukraine in rating assessments regarding innovative development

Innovation index	2015	2016	2017	2018	2019	2020	2021
European Innovation Scoreboard 2021	35	35	35	36	36	33	34
Bloomberg Innovation Index 2021	33	41	42	46	53	56	58
Global Innovation Index 2021, WIPO	64	56	50	43	47	45	49

Source: generalised based on (European Innovation Scoreboard, 2021; Bloomberg Innovation Index, 2021; Global Innovation Index, 2021)

In the conditions of martial law, 85% of Ukrainian companies slowed down or suspended their activities, among which 1% do not plan further activities, and 35% are waiting for better times.

Among the basic obstacles are a decrease in orders by 50%, problems with logistics (29%), lack of raw materials (21%), not enough workers (17%) (Tarasovsky, 2022).

The main concerns for business since the beginning of a full-scale invasion are the occupation of territories, the loss of stores or warehouses, disruptions in the work of logistics services, delays in transportation, etc.

That is why the national economy, according to the modern conditions of martial law and considering the priorities of post-war reconstruction, should be based on the development of innovative industries, the implementation of innovative projects, which will contribute to the development of an innovative model of the economy of Ukraine, the dynamic formation of the business environment and create the basis for further sustainable economic development.

Therewith, during the period of martial law, R&D activity requires special attention, since the temporary relocation of scientists and researchers, the limitation of their access to the necessary equipment allowed fully performing the scientific research.

Thus, in Ukraine, as of May 23, 2022, almost 70 scientific institutions were partially damaged, 2 were destroyed, there is no information about the state of institutions located in the occupied territories (Science during the war, 2022).

At the same time, despite the mentioned difficulties, innovative projects are being developed in several higher education institutions, namely the M.E. Zhukovsky National Aerospace University introduced innovative developments in the field of aviation, which will contribute to the formation of prerequisites for victory (Science in wartime, 2022).

Considering the fact that an essential factor in ensuring sustainable economic national development is the innovative activity of enterprises, on February 1, 2022, with the assistance of the Ministry of Education and Science, the project “Science and Business” (An online platform for scientists..., 2022) was launched as an online platform for communication and effective communication of scientists, entrepreneurs, and innovators should give scientists and researchers the opportunity to fulfil their potential, promote the commercialisation of the results of their scientific research, and entrepreneurs – to activate the innovative activities of enterprises.

Currently, the “Science and Business” platform is launching a business support project for internally displaced persons. The key parameters for evaluating the quantitative characteristics of the effectiveness of innovative activity are the costs of carrying out scientific research or development and the profit from their commercialisation (Diachenko & Diachenko, 2021).

The dominant global modern trends are the combination of the processes of transnationalisation of the economy with transformation of innovations into a basic factor of international economic interaction. Considering such trends, countries with developed economies pay considerable attention and funding to support research and development work (Fig. 1).

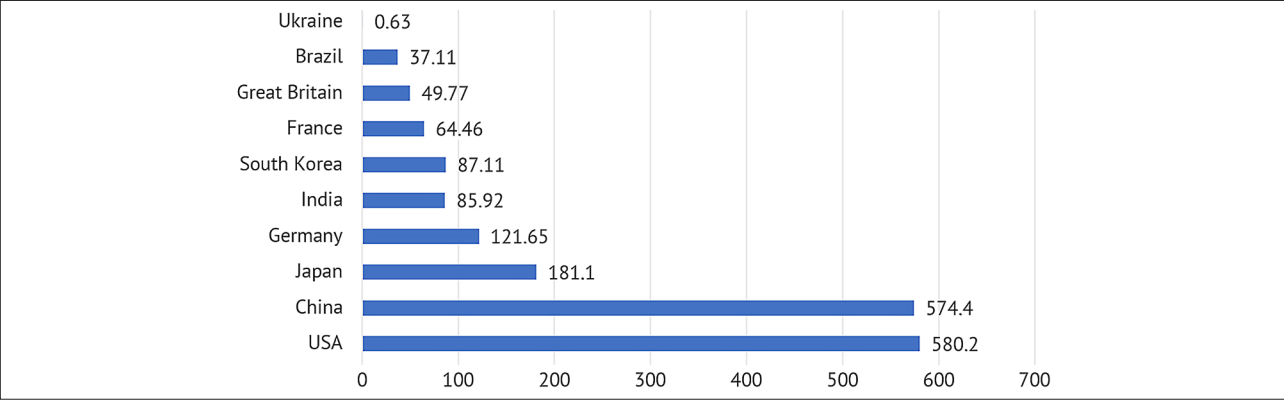


Figure 1. Spending on research and development in 2020, billion dollars

Source: (Global R&D Funding Forecast, 2021)

In 2021, China increased R&D spending by \$47.1 billion and surpassed the USA, where spending increased by 18.5 billion dollars.

level of innovative activity – South Korea, Israel, Japan, Finland, and Switzerland (Fig. 2).

The top 5 leading countries in terms of the share of R&D expenditures in GDP – a basic indicator of the

In Ukraine, R&D expenditures in recent years, as well as their share in GDP (Fig. 3), show a tendency to decrease.

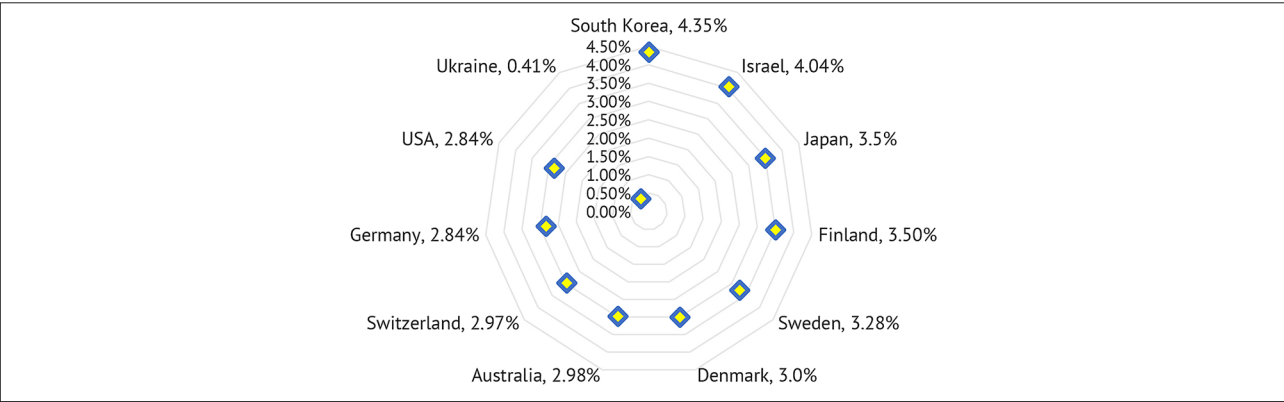


Figure 2. Shares of research and development expenditures in GDP, %

Source: (Global R&D Funding Forecast, 2021)

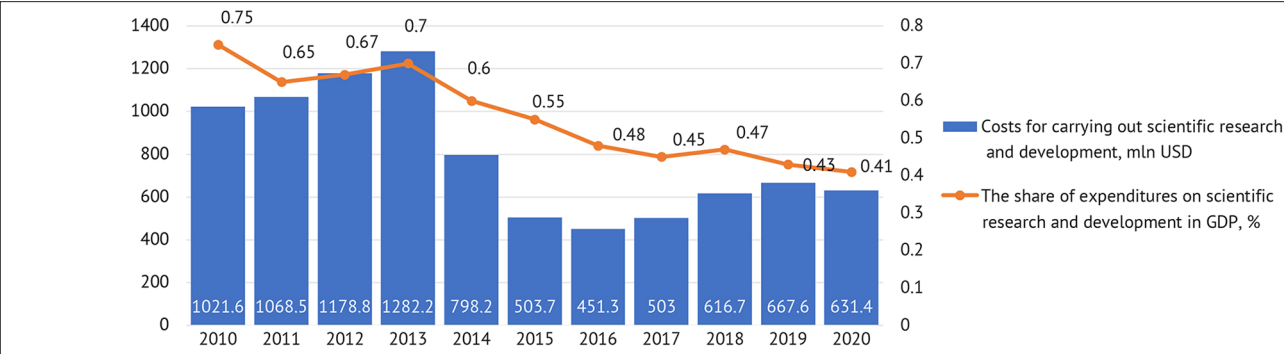


Figure 3. R&D expenses and their share in GDP in Ukraine during 2010-2020

Source: (State Statistics Service, 2022)

In 2020, despite the encouraging growth of spending during 2016–2019, there was a decrease again: compared to 2019 by 5.4% and more than double compared to 2013.

In the current conditions of martial law, Ukraine has limited financial capabilities and institutional capacity. The prerequisite for the effective recovery of Ukraine in the post-war period is the formation of the foundations of an innovative economy. A prerequisite

for ensuring the growth of innovative potential is the support of scientific research, the creation of an effective infrastructure that will form the conditions for the commercialisation of intellectual property objects.

According to the State Statistics Service of Ukraine, during this period the number of scientific institutions and educational institutions that carried out research and development work considerably decreased (Fig. 4).

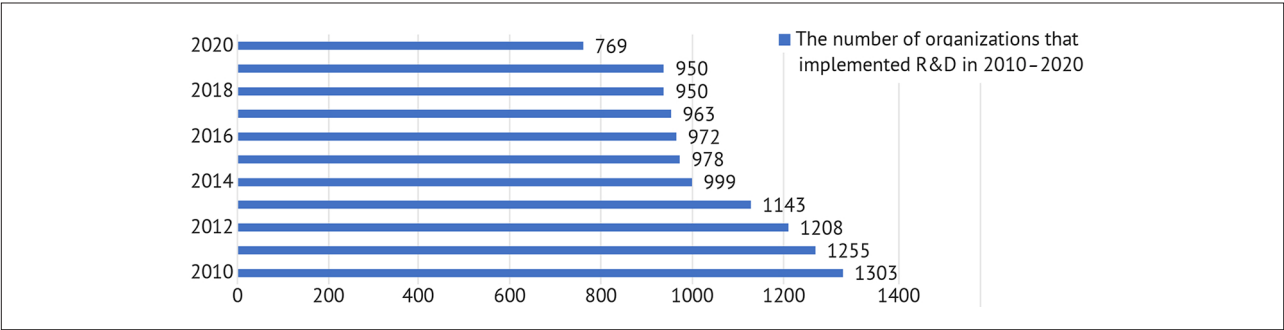


Figure 4. The number of organisations that implemented R&D during 2010–2020, units
Source: (State Statistics Service, 2022)

On July 10, 2019, the Resolution of the Cabinet of Ministers of Ukraine (Resolution of the Cabinet of Ministers of Ukraine, 2019) adopted the Strategy for the Development of the Sphere of Innovative Activity for the Period Until 2030, which makes provision for the tasks of the transition to innovative growth. The strategy provides as follows:

- development of three-year plans and monitoring of their implementation;
- introduction of deductions when transferring technologies abroad.

The implementation of the measures envisaged by the Strategy contributed to the stabilisation of the situation according to the results of 2019: the number of organisations that carried out scientific research activities was preserved, the number of whose executors decreased by 0.5%.

In 2020, there was another decrease in the number of organisations, by 19% compared to 2019, and by almost 41% compared to 2010. Without positive changes, by 2025, according to the trend line, there will be less than 600 research and development organisations (Fig. 5).

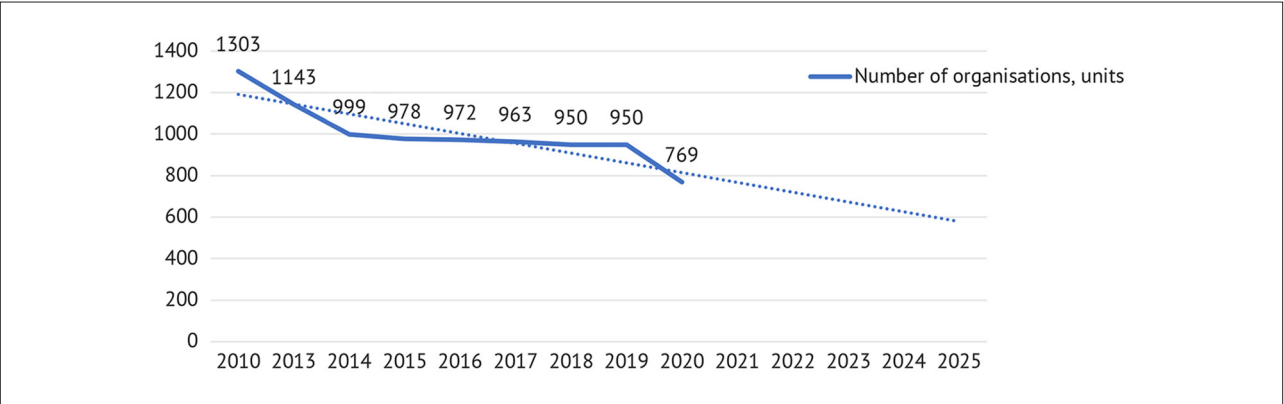


Figure 5. The number of organisations involved in R&D (2010–2020) and the trend
Source: (State Statistics Service, 2022)

The decrease in funding and the number of organisations was also determined by the corresponding trends in the number of employees involved in the

implementation of the R&D (Fig. 6): compared to 2010, in 2020 there was a decrease of almost 57%.

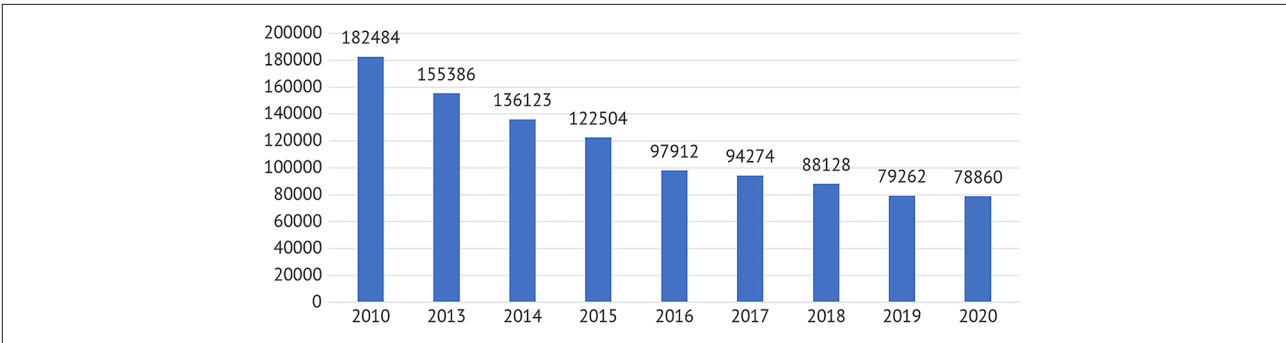


Figure 6. The number of employees (people) involved in the implementation of research and development works
Source: (State Statistics Service, 2022)

With the general state tendency to decrease the number of employees involved in the implementation of scientific and research work, in several regions their number, compared to 2019, has increased. In Sumy Oblast – by 25.7%, in Mykolaiv Oblast – by 19.4%, in Kyiv – by 4.1%. A considerable increase took place in the Ternopil Oblast because, despite the powerful scientific potential, in 2019 there were only 135 people performing

the R&D, and in 2020 there was an increase in their number by 2.4 times (327 people).
The undisputed leader in terms of the number of employees involved in the implementation of research and development work in 2020 (Table 2) is the capital – Kyiv, Kharkiv and Dnipropetrovsk Oblasts. The smallest number of researchers is in Khmelnytskyi Oblast – 44 people.

Table 2. The number of performers of R&D work in 2020, by region (people)

Region	City of Kyiv	Kharkiv Oblast	Dnipropetrovsk Oblast	Zaporizhzhia Oblast	Lviv Oblast	Odesa Oblast	Kyiv Oblast	Kirovohrad Oblast	Volyn Oblast	Khmelnytskyi Oblast
Number	28,768	8,089	4,738	2,645	2,579	1,694	1,248	67	61	44

Source: (State Statistics Service, 2022)

The tendency to decrease the total number of employees involved in the implementation of scientific research work during 2010-2020 (by more than 2 times in 2019 compared to 2010), leads to a gradual degradation of scientific potential. In 2020, despite the

decrease, compared to 2019, of the total number of research workers by 402 people, the number of researchers increased by 306 people, while the number of technicians and support staff decreased by 353 and 355 people, respectively (Fig. 7).

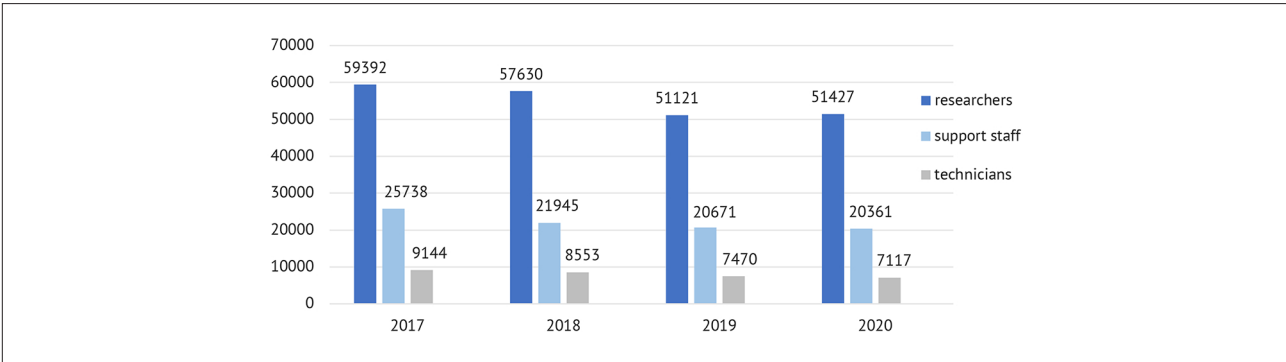


Figure 7. Dynamics of changes in the structure of employees involved in the implementation of R&D work
Source: (State Statistics Service, 2022)

In 2020, the number of researchers aged 15 to 70 was 3.2 (3.1 in 2019) per 1,000 working population (State Statistics Service, 2022), the highest values of this indicator according to Eurostat was in

Luxembourg – 40.9; Finland – 34.1, Belgium – 31.0 (European Innovation Scoreboard, 2021).
Of the 55,136 employees performing research work, 85.3% have higher education (Table 3).

Table 3. The number of employees involved in the implementation of the R&D, by level of education, in the equivalent of full-time employment in 2020

Total	Including education degree					
	Higher education	Among which				Other than the higher one
		Doctor of Science	Doctor of Philosophy / Candidates of Sciences	Masters	Bachelors	
55,136	47,037	4,564	12,067	26,427	3,980	8,100

Source: (State Statistics Service, 2022)

8.3% of the total number of researchers are Doctors of Science, 21.9% are candidates of science/doctors of philosophy, 47.9% are masters, 7.2% are bachelors, 14.7% have other levels of education apart from the higher one (Fig. 8).

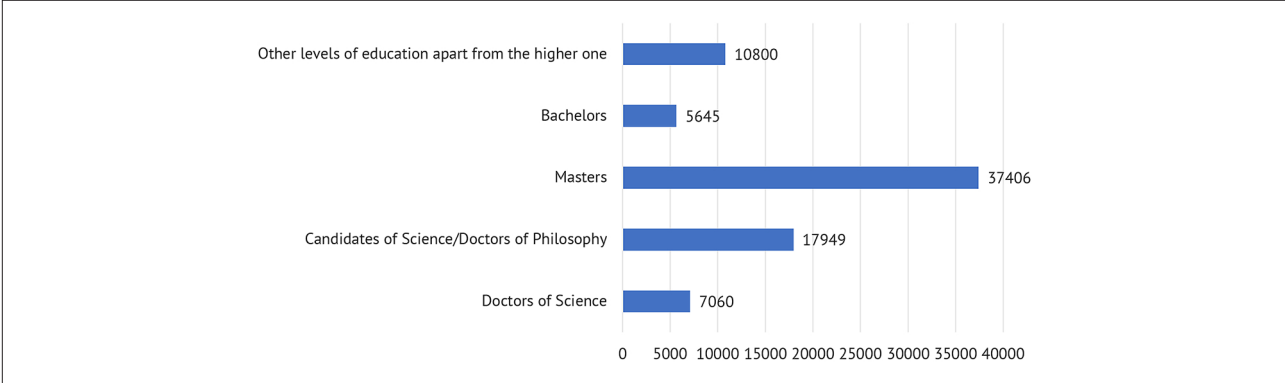


Figure 8. The structure of employees involved in the implementation of R&D work, in the equivalent of full-time employment by education level in 2020, people

Source: (State Statistics Service, 2022)

Characteristic of modern scientists is their approach to innovative activity: with a conventional decrease in the number of employees involved in the implementation of scientific research work, in 2020, compared to 2019, there was an increase in the number of women by 512 people (Fig. 9).

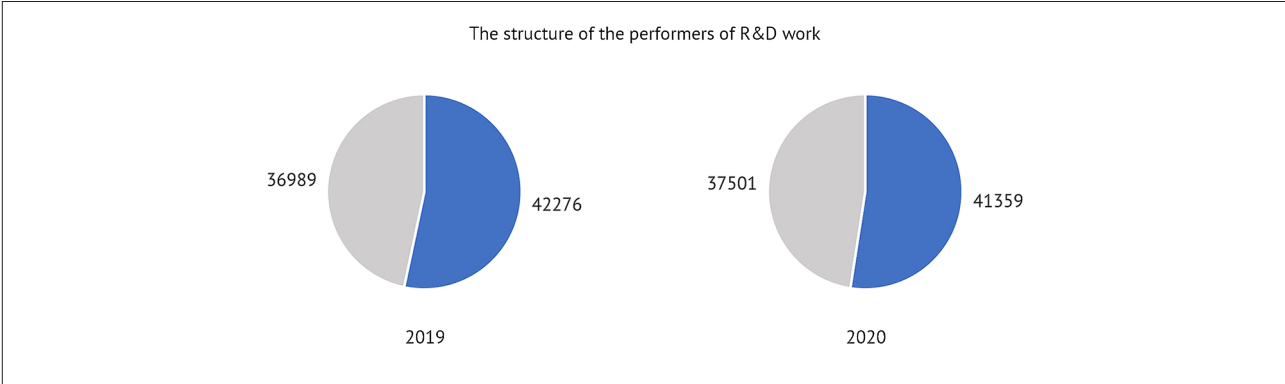


Figure 9. Trends of changes in the structure of the performers of R&D work in 2020

Source: (State Statistics Service, 2022)

Accordingly, in 2019, among the performers of research work, women accounted for 46.7%, and in 2020-47.6%, and therefore, a trend towards the formation of gender parity is observed.

At the same time, among the performers of research work in 2020, there are 2.5 times fewer female doctors of science than men, and 1.13 times more among bachelors (Fig. 10).

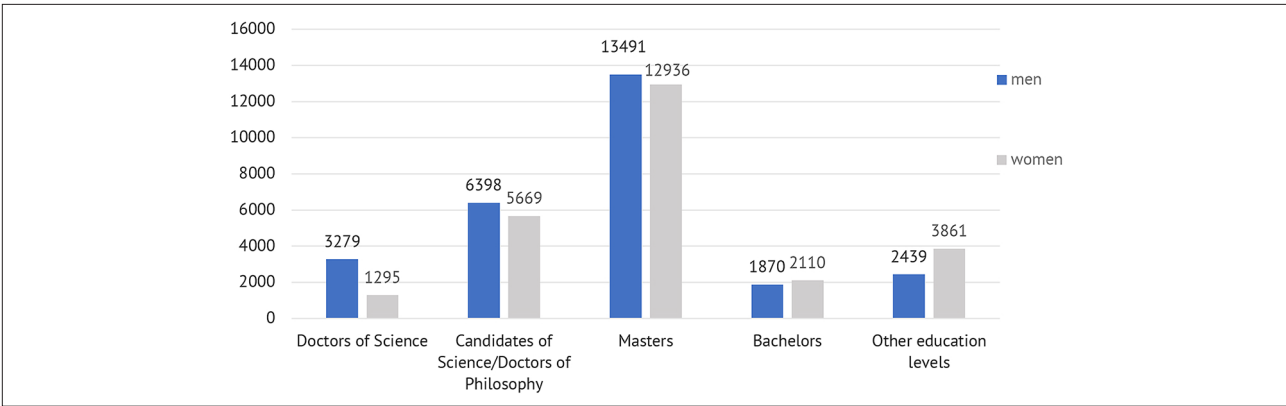


Figure 10. The structure of the performers of R&D work in 2020

Source: (State Statistics Service, 2022)

Conventionally, the scientific potential is characterised by the age structure of researchers involved in the implementation of R&D work: in 2020, 19.5% of researchers are aged “65 years and older” (Fig. 11).

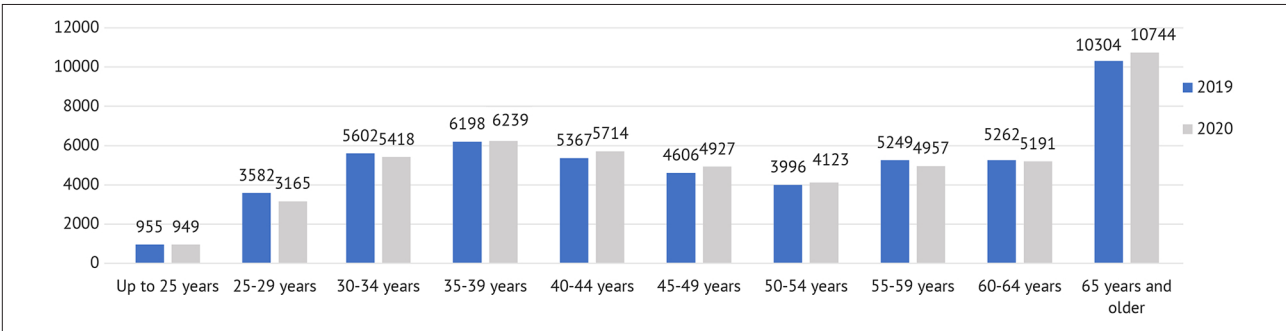


Figure 11. Dynamics of changes in the structure of R&D work performers in 2019–2020, people

Source: (State Statistics Service, 2022)

With a general decrease in the number of performers of the R&D, compared to 2019, their number increased in some age categories: by almost 7% (45-49 years old), by 6.5% (40-44 years old), by 4.2% (65 years and older), by 3.2% (50-54 years), 0.6% (35-39 years).

A reduction in R&D spending helps to reduce the attractiveness of such activities for young scientists.

More than 44% of workers involved in the implementation of R&D work in Ukraine in 2020 developed topics in the field of technical sciences (Table 4), among them 36.5% were women.

Table 4. The number of R&D workers in 2020, equivalent to full-time employment by field of science

Total	Including					
	Natural sciences	Technical sciences	Medical sciences	Agricultural sciences	Social sciences	Humanities
55,136	16,587	24,349	3,641	4,591	4,090	1,879

Source: (State Statistics Service, 2022)

The largest percentage of women is 62.5% among the performers of R&D works in the field of humanitarian sciences.

According to the information presented in the report World Intellectual Property Indicator 2021 of the World Intellectual Property Organisation (hereinafter referred to as WIPO), in 2020 the trend of increasing the activity of filing applications for patents

on a global scale resumed again in 2020, namely the number of applications for registration of trademarks increased by more than 13% brands, for 1.6% of patent applications; for industrial samples – by 2%. China’s intellectual property office received nearly 2.9 million applications in 2020, followed by Germany (12,318), the Russian Federation (9,195), Japan (6,018) and Ukraine (5,281) in fifth place (WIPI, 2021). Furthermore, in 2022,

the Ukrainian ecosystem of startups is the regional leader in innovation, occupying the 50th position in the world ranking, although it shows negative dynamics – by 16 positions compared to 2021. Ukraine also ranks 12th among startups in Eastern Europe (StartupBlink, 2022).

Such indicators are evidence that, despite the economic downturn, despite the decrease in research and development costs, in Ukraine there is an inherent increase in the field of innovative activity and an increase in the costs of enterprises for innovative activity. The outlined dynamics are trending in the future as well (Fig. 12).

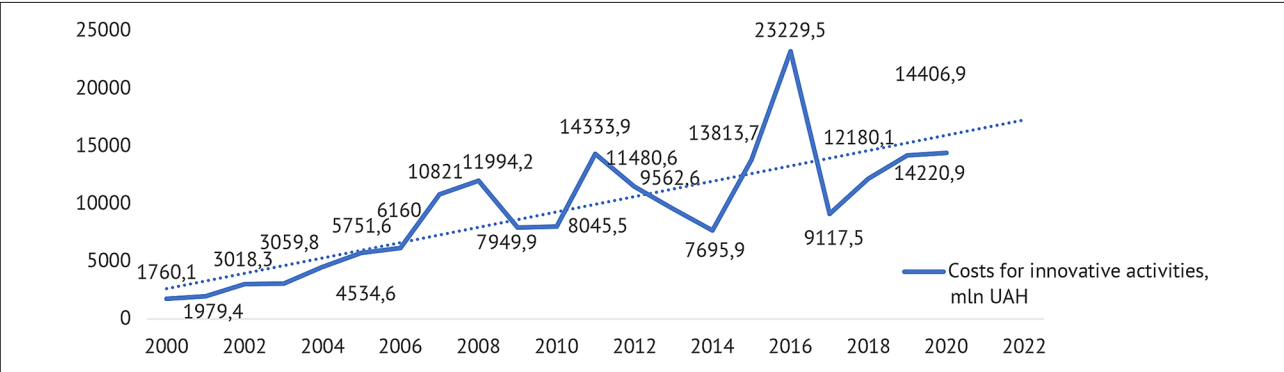


Figure 12. The dynamics of changes in the costs of enterprises for innovative activities and the trend of the trend
Source: (State Statistics Service, 2022)

And yet, the reduction of R&D spending contributes to the insufficient level of innovation infrastructure development, the limitation of tools to support innovators, etc. Even though “the importance of innovation for the manufacturer means the conformity of the product to its innovative development strategy, determining its place on the market and prospects for further activity” (Fedulova *et al.*, 2021), the indicated trends are also observed in the dynamics of changes in the number of innovative enterprises, which during 2016 – in 2018 they were 28.1%, and from 2018 to 2020 – 8.5%, in the city of Kyiv there was a considerable reduction in their number – from 387 to 233 units. During this period, among innovative enterprises, a slight decrease occurred precisely among enterprises introducing new or significantly improved products, 1,899 and 1,832, respectively (State Statistics Service, 2022).

A decreasing trend in the number of industrial enterprises implementing innovations during 2010-2017

is observed. In 2018-2019, although there was an increase in their number, they were more than twice as small as in 2012, and in 2020 there was a decrease again compared to 2019 by 8.2% (Fig. 13).

The recession of the world economy, which occurred as a result of the adverse impact of pandemic restrictions, contributed to the emergence of new risks and threats to the efficiency of enterprises (Patyka *et al.*, 2021). Considering these trends and the modern conditions of operation of enterprises under martial law, the need for the development of an innovative personnel component of enterprises has intensified, which is conditioned upon the need to foresee risks, identify threats, and eliminate or neutralise adverse consequences of their influence.

Improving methods of using solar energy can become an essential vector of innovative activity of enterprises in modern conditions of limiting conventional energy resources (Hongyue *et al.*, 2022).

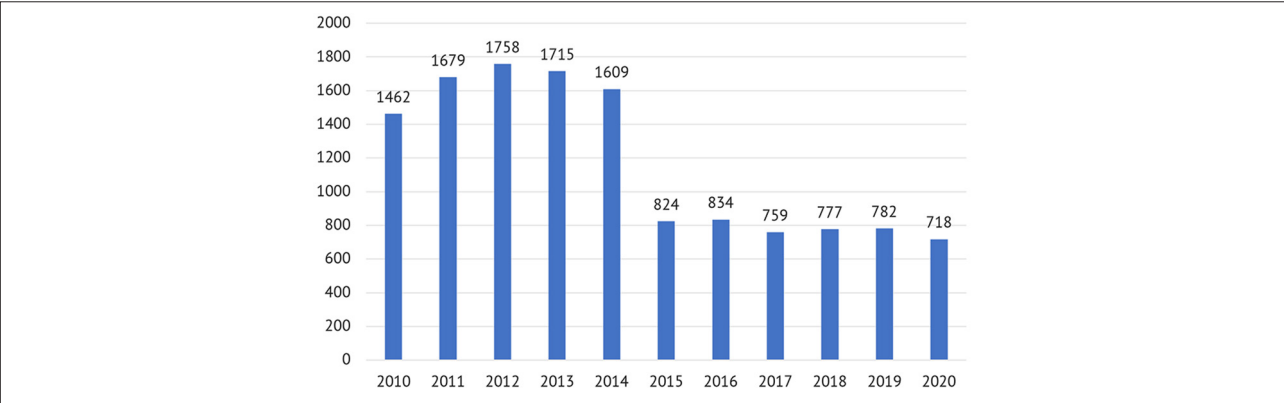


Figure 13. Dynamics of changes in the number of industrial enterprises implementing innovations during 2010-2020
Source: (State Statistics Service, 2022)

The main problems for business entrepreneurs are the occupation of territories, the loss of stores or warehouses, disruptions in the work of logistics service departments, long delivery, which definitely affects the efficiency of operations and the desire/need to implement innovations.

Considering present-day challenges, several regulations have been adopted in Ukraine to support the national economy in general and small and medium-sized businesses in particular. An essential step was the reduction of the tax burden during the period of martial law (Law of Ukraine "On Introducing Changes to the Tax Code...", 2022). It is provided that business entities of groups I and II have the right not to pay the single tax.

Institutions of higher education and R&D institutions got accustomed to working under martial law: researchers and scientists are invited to take part in three free webinars held by Clarivate (Scientific..., 2022) in Ukrainian during July-August, during which will consider the issues of familiarisation with the possibilities of the "Web of Science" platform and the methods of their use in the R&D activities of scientists and institutions, the establishment of international scientific cooperation, and the search for sources of funding for scientific research, including alternative ones.

CONCLUSIONS

As a result of the conducted research, the modern trends of innovative activities to ensure the growth and sustainable development of the economy of Ukraine were determined as follows:

- the formation of legal frameworks for supporting the national economy in general, and small and medium-sized businesses in particular;
- promotion of the national innovation policy to direct scientists, designers, and entrepreneurs to interaction in the field of innovative activity, to the realisation of personal potential and commercialisation of intellectual property objects;
- activation of Ukrainian scientists in the field of innovative activity, as well as an increase in the costs of enterprises for innovative activity;
- increasing efficiency of the impact of scientific research results on the transformation of scientific inventions into objects of know-how;
- modernisation of mechanisms for establishing international scientific cooperation, finding sources of funding for scientific research, including alternative ones.

The post-war recovery of Ukraine's economy will also confirm modern global trends in innovative activities to ensure growth and sustainable development, which mostly concern countries with developed economies – the USA, China, Japan, Germany, South Korea, etc. – a combination of the process of transnationalisation of the economy with innovative activities, which is the basic factor of international economic interaction.

Therewith, the factors for the deterioration of the ratings of innovative activity in Ukraine were identified, which is confirmed by the information of the State Statistics Service of Ukraine, which states that during 2010-2020, the number of scientific institutions and

institutions of higher education that carried out R&D work significantly decreased. The main factor slowing down the of intensification of innovative activity was the decrease in national support for R&D. There is a decrease in the number of employees engaged in R&D work; however, the achievement of gender parity is determined for the period from 2019 to 2020. The largest number of employees involved in the implementation of the R&D is observed in technical and scientific areas.

The implementation of an effective model of innovative development, which involves the introduction of innovations, modernisation of production processes, goods and services, increasing their competitiveness, requires the development of a new Concept of Innovative Development of Ukraine because the current Concept, approved on July 13, 1999, does not correspond to the present-day realities. In the new Concept, it is necessary to make provision for urgent effective measures to preserve and multiply the scientific and technical potential, to form the market for the commercialisation of intellectual property objects, to attract investments in the field of innovation implementation.

Upon developing the Concept, it is necessary to involve scientists, innovators-practitioners, civil servants, independent experts who, in cooperation, could consider all the features of the modern state of innovative activity in Ukraine, consider the risks arising in connection with the challenges of martial law, and identify vectors post-war recovery by creating the foundations of an innovative economy.

Since, according to the forecast of the World Bank, it is assumed that by the end of 2022, the economy in Ukraine will shrink by 45.1%, and therefore the priority conditions for the effectiveness of the post-war recovery and modernisation of the economy are Ukraine's receipt of reliable security guarantees and credit and financial support, as well as personnel provision of enterprises, which is determined by the need to predict risks, identify threats and eliminate or neutralise adverse consequences of their impact. Therewith, ensuring the growth and sustainable development of Ukraine's economy in the post-war transformation will be determined by public administration, which is developed and implemented based on a dual approach, namely: a harmonious combination of current practices of priority state support of budget-forming and export-oriented industries, which determine the raw nature of Ukrainian economy and supporting innovative activities of small and medium-sized businesses in the field of processing industry, in particular agricultural products. Thus, Ukraine, from a country that exports raw materials for the processing industries of other countries, will turn into a country that exports products, goods and services, which will contribute to the creation of new jobs, specifically in rural areas, and therefore, the growth and sustainable development of the country's economy.

Further research should consider modern trends in innovative activity, factors affecting it, and contain specific proposals for the new Concept of Innovative Development of Ukraine.

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Сучасні тенденції інноваційної діяльності забезпечення зростання та сталого розвитку економіки України

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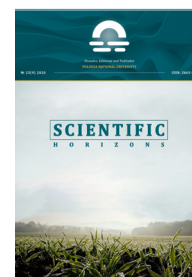
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Анотація. Актуальність пошуку шляхів та можливостей інтенсифікації інноваційної практики сучасності, зумовила мету цієї публікації, що полягає у висвітленні результатів дослідження тенденцій інноваційної діяльності забезпечення зростання та сталого розвитку економіки України, а також виявленні чинників, що гальмують цей процес. Дослідження базується на тезі, що у сучасних реаліях для отримання комерційного чи соціального ефекту необхідно інтенсифікувати інноваційну діяльність, як сукупності процесів, що спрямовані на творчий пошук, формування, оприлюднення та впровадження в практику інновацій. Така діяльність передбачає вкладення інвестицій в об'єкти інноваційної діяльності. Методологічні аспекти дослідження враховують концепції виявлення закономірностей впливу обсягу витрат на наукову, дослідну та конструкторську діяльність на кількість залучених до такої діяльності дослідників, на результативність їхніх досліджень, а відтак, на стан інноваційного розвитку держави. Досліджено зміну позицій України у рейтингових оцінках щодо інноваційного розвитку, здійснено порівняльний аналіз витрат на дослідження та розробки передових країн світу та України у 2020 році, виявлено низхідну динаміку змін кількості, організацій та чисельності працівників, що здійснювали НДР, витрат на виконання таких робіт та частки цих витрат у валовому внутрішньому продукті України впродовж 2010–2020 років. З-поміж основних чинників, що гальмують процес інтенсифікації інноваційної діяльності є зменшення державного фінансування науково-дослідних та дослідно-конструкторських робіт, а відтак, зменшення кількості організацій та дослідників, які займаються творчою діяльністю наукового пошуку. Виявлено позитивні тенденції до формування ґендерного паритету у середовищі виконавців науково-дослідної роботи (47,6 % – жінки), зростання активності у сфері інноваційної діяльності та збільшення витрат підприємств на інноваційну діяльність у 2020 році. Запропоновано формування ефективної державної інноваційної політики розпочати з визначення концептуальних положень інноваційного розвитку. Результати дослідження можуть бути корисними для широкого кола науковців, які вивчають питання інноваційного розвитку, фахівців управлінських структур, які аналізують стан інноваційного розвитку та опікуються питаннями розробки стратегій відновлення та подальшого розвитку національної економіки

Ключові слова: інновації, інноваційний розвиток, наукові дослідження, інвестиції, науково-дослідна діяльність, чинники, тенденції, економіка



UDC 330.341:004.9]:316.3(477)

DOI: 10.48077/scihor.25(7).2022.43-54

Assessment of the Impact of Digital Skills on the Level of Satisfaction with Digital Transformation Processes in Ukraine

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Article's History:

Received: 13.08.2022

Revised: 12.09.2022

Accepted: 11.10.2022

Suggested Citation:

Ligonenko, L., Antoniuk, L., Ilnytskyy, D., & Tsyrukun, O. (2022). Assessment of the impact of digital skills on the level of satisfaction with digital transformation processes in Ukraine. *Scientific Horizons*, 25(7), 43-54.

Abstract. The digital transformation of the leading countries towards the neo-economy effectively uses the potential of digital competences, which remain insufficiently explored in Ukraine, but it is already clear that they are the key to the inclusive economic growth of any country, namely the post-war revival and development of Ukraine at a highly competitive level. The purpose of this study was to find the specific features of the influence of the level of digital competences (according to DigComp 2.1) on the evaluation of the prospects for building a digital economy by Ukrainian citizens, and the perception of the processes of digital transformation of the economy by stakeholders. The information base of this study included online survey data, processed using the SPSS package. Found regularities were verified using standard statistical parameters of the relationship. At the first stage, the influence of the level of digital skills on the judgments, attitudes, and expectations of respondents on the prospects of digital transformation in Ukraine and the world was found. Depending on the attitude towards the development of ICT, the archetypes of the respondents were distinguished (optimist, pragmatist, agnostic, rationalist/cautious pessimist, and sceptic). The second stage investigated the impact of digital skills on various aspects of the life of Ukrainian citizens, namely on their daily life, on them as consumers and as workers. It was found that a higher level of digital skills contributes to improving the quality of respondents' everyday life; there is an increase in the share of respondents who use Internet resources in everyday life. The key conclusions are as follows: 1) focused efforts on the development of digital skills will contribute to an increase in the share of optimistic and pragmatic assessments of digitalisation; 2) the detected digital gap between the possession of skills and the need for them (2-3 times) actualises the implementation of policies aimed at overcoming it; 3) the awareness of the impact of the level of digital skills on the development of citizens and satisfaction with the products of the digital economy is growing; 4) the digital transformation of the economy radically changes its structure, the landscape of the labour market, and has a major impact on every citizen. Foremost, those who have an elevated level of digital skills will be able to benefit from digitalisation

Keywords: ICT, digital economy, digital divide, competence, employee, consumer, social stratification, DigComp



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INTRODUCTION

The post-war recovery of Ukraine's economy should be based on the existing achievements and further development of the potential of digitisation of the economy and social life. Successful examples of countries gaining high international competitive positions prove the importance of highly developed technological infrastructure and people capable of using it (Lukyanenko *et al.*, 2019). The Marshall Plan and similar strategies made provision for the renewal of the technological potential of countries – this refers to Germany and France, Japan, and South Korea. Therefore, it is the mass digitalisation of all aspects of life that can become a powerful factor in recovery and restructuring of the economy of Ukraine; will allow removing spatial limitations of involvement of the entire circle of stakeholders (employees, partners, consultants, investors); will ensure the acceleration of the development and implementation of innovative solutions and technologies. The prerequisite for these processes is the proper level of digital skills of Ukrainian citizens – both consumers and employees of government bodies, civil society, economic entities, and businesses.

In the conditions when digitalisation processes are a factor of international competitiveness for Ukrainian enterprises, and for the state – a prerequisite for the adoption and implementation of modern tools for ensuring socially oriented sustainable economic development, their impact on employees and consumers turns out to be understudied. Research support for the implementation of the necessary transformations, namely the study of Ukrainian cases in scientometric databases (Scopus, Web of Science), is insufficient. There are no publications investigating the digital competences of Ukrainian citizens, assessing the influence of the level of proficiency in digital skills on the perception of digital transformation processes.

The questions discussed above can be divided into several groups. How objectively necessary and useful are projects and programs aimed at promoting the development of digitalisation for all interested parties? What determines the social and business benefits of digitisation and the development of digital skills? How can the perception of the usefulness of digital skills be increased, which would motivate individuals to actively acquire and improve them; employers, state and public institutions – to support these processes, specifically by taking part in the financing of relevant programs and activities? The search for answers to these questions is of interest to many researchers.

Digitalisation has a positive effect on economic growth, which has been proven in the EU based on a study of the relationship between the Digital Economy and Society Index (DESI) and the macro indicators of their manufacturing sector (using linear correlation coefficients and multiple regression analysis) (Lastauskaite, & Krusinskas, 2021). The level of skills is recognised

as a critical factor in dynamic digitalisation, and it is also statistically confirmed that as their level increases, so does the rate of development of the neo-economy.

Technological development offered the world community the opportunity to promptly minimise pandemic risks. One can agree that the spread of the COVID-19 pandemic has demonstrated the relevance of digital competence at all educational levels (Núñez-Cana *et al.*, 2022). If before the pandemic, the spread of digital competences was most actively taken care of in developed countries, now such interest can be observed in most countries.

Many researchers emphasise the vital role of teachers, which I. Darazha *et al.* (2021) update on the example of adaptation to pandemic conditions, and V. Siddoo *et al.* (2019) – employee competencies. However, digital competence should be supported, so training should also include lifelong learning, personal development, teamwork, reliability, and IT fundamentals.

The European Framework for the Digital Competence of Educators proposed in 2017 showed the complexity of digital competence (22 components grouped into 6 groups and 6 levels of proficiency) on the example of educators who perform the function of spreading and improving the contribution of the digital economy to social development (Punie & Redecker, 2017). Therefore, its content continues to develop, becoming an integral part of professional, social, and personal life.

Differences in countries' assessment of sectoral development priorities can lead to digital divides and international confrontations. This can be proved by many examples. First, Russia's military aggression against Ukraine has a competence dimension because the former hoped that Ukraine would not have enough qualified specialists, namely in the digital sector, to defend its sovereign territory. Secondly, if the risks of digital inequality and the inability to ensure cybersecurity were considered by the experts of the World Economic Forum (WEF) as such that they could become critical in a period of up to two years, then the issue of physical security, in their opinion, has now lost its relevance because geo-economic confrontations had to be delayed for 5 years (McLennan *et al.*, 2022). Thirdly, the development of high-tech industries, e.g., the space sector, can balance the digital and material dimensions because it involves the simultaneous and balanced consideration of digital and physical competencies. That is why digital security is now receiving much more attention than physical security, which dominated before.

The processes of digital transformation rely primarily on the entrepreneurial activity of many individuals, and therefore it is important to understand what factors most contribute to the fact that a person resorts to entrepreneurship. The use of sociological approaches allowed approaching such an understanding and revealing the existence of differences between countries. An analysis of respondents from Spain, Taiwan, and Kosovo found that personal attitudes and behavioural content

are the main determinants of entrepreneurial intentions in the digital economy (Liñán, & Chen, 2006).

Digital transformation faces sectoral and industry specificities that determine the effectiveness of this process and consumer satisfaction. Factors deciding customer behaviour in mobile retail U. Akram *et al.* (2021) refer to ease of use, trust, mobility, and consumer engagement rather than usefulness or customisation. At the same time, conclusions often arise not only about the critical impact of the digital divide, but also about the age gap, which should be overcome primarily by managing the literacy and digital competencies of the population (Soroya *et al.*, 2021). As noted by I. Denisov *et al.* (2021) in the higher education sector, the dissatisfaction of teachers and students with the quality of digitalisation processes led to the radical digitalisation of university management processes. On the other hand, digitalisation processes in certain industries and attitudes towards them remain understudied, as evidenced by the practices of the agricultural sector, namely regarding pesticides, nanotechnologies, cloning, etc. (Pfeiffer *et al.*, 2021). Therewith, the practices of rendering social services with the use of digital technologies indicates that service providers should have better digital skills than consumers who trust them (Schlenger *et al.*, 2022).

One of the examples of evaluating the manifestations and benefits of digitalisation at the level of individual organisations is the study of relationships between business process management (BPM) models and direct and indirect benefits of digitalisation. Y. Antonucci *et al.*, (2020) based on data obtained from 165 BPM professionals from 4 continents, empirically studied the relationships between 8 groups of conventional and dynamic business process management capabilities and 20 benefits of digitalisation. Using the Kendall correlation coefficient, a positive but varying degree of relationship between BPM capabilities and the benefits of digitalisation is proven, digitalisation has different effects on increasing employee efficiency and improving employee engagement.

One of the digitalisation scenarios is the active implementation of artificial intelligence, which has sectoral differences. For the safe and effective development of this process, it must be preceded by a study of the attitude of employees towards these processes. For instance, procurement employees have a positive attitude towards innovative digital technologies. Therewith, there is a need to support such an attitude with certain factors (Blessing & Kiefer, 2021). C. Meske and I. Junglas (2021) proved that a positive attitude towards digital transformation increases as employees are convinced of the need to be more autonomous, competent, and communicatively connected to the workplace.

The positive dimensions of digitisation are recognised as one of the prerequisites for achieving the UN Sustainable Development Goals. M. Mondejar *et al.* (2021) described the possibilities of digitalisation to build a sustainable society of the future based on

elements of the food-water-energy nexus, as well as ways to solve the planetary problems of climate change and endangered biodiversity; the advantages of digitisation as a catalyst for the transition to sustainable production methods and improving the health of citizens through the digitisation of medical services are determined. Thus, ideas about the positive impact of digitalisation on the formation of a fair, ecologically sustainable, and healthy society are outlined. However, all the above is currently possible only based on an adequate level of digital skills.

Research on the digital competences of various social groups is becoming relevant and widespread, along with the growth of the share of the digital economy in GDP (6% in the narrow sense of the digital economy and 20-30% in the broad sense of the neo-economy). Therewith, the level of proficiency in digital competences is one of the signs according to which social groups with different attitudes towards phenomena and processes can be formed.

The gender dimension is quite clear even in the digital economy, although digital transformation has significant potential to reduce the gender gap. However, the share of female researchers in most countries and their dynamics reduce optimism on this issue (Kurchenko *et al.*, 2021). Furthermore, attitudes and beliefs, as well as self-perceptions of management skills and the effectiveness of digital competences, vary significantly across genders, even among those with higher education (Bandrés *et al.*, 2021).

Therefore, in society and business, there is a growing awareness of the need to consider the interests of all stakeholders, which can be achieved both through sociological research and theoretical research and applied experiments. Digital competencies are being studied at all levels – international organisations, national governments, companies and educational institutions. It will suffice to mention the International Computer and Information Literacy Study, which has been conducted since 2010 by the International Association for the Evaluation of Educational Achievement, and the PISA 2021 ICT Framework, which will be conducted in 2022 at the initiative of the OECD.

Individual researchers are limited to an extremely narrow base of respondents or subject of research. An example is a recent focus group survey of 251 professors of business administration at the universities of Madrid, which was limited to the characteristics of educators and their attitudes towards technology (Núñez-Cana *et al.*, 2022), or the study of the opinion of 300 exclusively representatives of Generation Z (Tolstikova *et al.*, 2021). Therewith, the attitude of even ordinary employees towards digitalisation processes can have a decisive influence on the development of supply chains (Ruiner & Debbling, 2021).

Sometimes researchers resort to testing hypotheses for which there is a lack of objective data, and

therefore conclusions are drawn based on the opinion of limited groups of respondents. In the study of M. Vasilescu *et al.* (2020), conducted based on Eurobarometer 87.1 survey data, the subject of analysis was the self-assessment and perceptions of respondents (citizens, employees) regarding the digitalisation of the economy and various spheres of life. Based on the use of a joint methodology that includes several statistical and econometric methods, two-stage cluster analysis (TSCA), the following hypotheses were tested and statistically confirmed:

- H1. The digital divide can lead to the creation of digitally vulnerable groups and even digitally vulnerable countries.

- H2. The effective use of modern technologies (both in everyday life and at work) depends on perception and skills, which are primarily determined by the level of education and income.

- H3. The general perception of digitalisation among EU citizens is positive, but some categories feel insufficiently prepared to master modern technologies, especially in the workplace.

- H4. People are generally positive about robots, but there are serious concerns, especially about the impact of digitalisation on the labour market and jobs.

Proceeding from this, further research should consider that among digitally vulnerable groups (elderly, low-educated, manual workers or unemployed, with relatively low income, who do not use the Internet much, and possess minimal digital skills), pessimistic attitudes predominate assessments and moods, predict the possibility of job loss and difficulties in performing everyday tasks. Accordingly, digitally vulnerable countries should include those with a high proportion of the population that does not possess digital skills. In addition, specific regularities of the perception of digitalisation and their impact on the formation of a “smart” labour market, which would ensure a better match between supply and demand, as well as increase people’s confidence in their qualifications and create the prerequisites for the widest possible development of the digital ecosystem, were revealed. An important conclusion of the researchers is that for the rapid and effective mastering of digital skills, the development of a positive attitude towards digitalisation in general is of paramount importance. The research results presented above were considered when figuring out the purpose, tasks, and choosing the methodology of this study.

The purpose of this study is to find the specific features of the influence of the level of digital competences on Ukrainian citizens’ assessment of the prospects for the development of the digital economy, as well as to identify stakeholders’ perception of the processes of digital transformation of the economy. To fulfil this purpose, *the following tasks were defined*:

- to identify the influence of the level of digital skills on the judgments, attitudes, and expectations of Ukrainian – citizens regarding the future of digitalisation

in Ukraine and the world by identifying certain archetypes of respondents;

- to investigate the impact of the level of digital skills on the lives of Ukrainian citizens, namely in terms of 3 aspects: on their daily life, on them as consumers and as employees.

MATERIALS AND METHODS

The information base of this study was the answer bank of respondents to the survey “*Digital economy, impact of ICT on human capital and formation of future competencies*”, which was conducted in November 2020–February 2021 within the framework of the research project of KNU – HUAWEI “Digital economy, impact of ICT on human capital and formation of future competencies”.

The survey was conducted online using a specially designed questionnaire that was posted on the Google Forms online survey platform. The survey was conducted anonymously using the Computer Assisted Web Interviewing (CAWI) method using the functionality of the Google forms survey toolkit. 1,181 experts took part in the survey (representatives of the academic community, civil service, business and entrepreneurship, the public sector, and the temporarily unemployed), which allowed obtaining the necessary set of data (13 general and 40 special questions), which comprehensively represent the features of the development of the digital economy in Ukraine. Detailed information on the content of the questions and answers is presented in (Antoniuk *et al.*, 2021). Quantitative and qualitative characteristics of the respondents (socio-demographic profile, territorial distribution) ensured the relevance of the research and the validity of the conclusions. Statistical processing of empirical data was carried out using the Statistical Package for the Social Sciences (SPSS).

One of the key questions of the second block was self-assessment by respondents of the level of digital skills, which are determined according to the European Digital Competence Framework DigComp 2.1 (Carretero Gomez *et al.*, 2017). It is known that it distinguishes 5 areas of digital skills – information literacy and skills for working with data; communication and cooperation; creation of digital content; problem-solving; cybersecurity. Based on the self-assessment of the level in each of the defined areas, the overall indicator of the level of digital skills was calculated, which was calculated as the lowest score among the defined areas of digital skills, regardless of the level of proficiency in other areas. Thus, a “hard approach” is applied, which is based on the principle of balanced proficiency in all areas of skills and the importance of each area to ensure quality mastery, as well as the ability to use the gains and advantages of ICT in full.

RESULTS AND DISCUSSION

Digital archetypes. At the first stage of the research, the impact of the level of digital skills on the judgments, attitudes, and expectations of the respondents regarding

the future of digitalisation in Ukraine and the world was identified. Depending on the confirmation of the attitude towards the development of ICT in Ukraine (the questionnaire holds 5 meaningful statements that describe the attitude, the sixth statement is undecided), 5 archetypes

of respondents were selected (optimist, pragmatist, agnostic, rationalist/cautious pessimist, and sceptic). (An-toniuk *et al.*, 2021). Analysis of the cross-tabulation re-sults showed that the level of digital skills has a positive effect on attitudes towards ICT development (Table 1).

Table 1. Cross-tabulation and assessment of the interrelationship of factors “archetypes of respondents – digital skills”, %

Respondent archetype	Questionnaire statement	Level of digital skills				On average	Statistical parameters for assessing the interrelationship of factors		
		Minimum	Low	Basic	Above basic		Pearson's chi-squared test	Test of homogeneity (chi-squared probability)	Cramér's V (φc)
Optimist	I expect positive consequences for the economy (society, myself personally)	77.6	82.5	83.3	76.2	80.5	15.134	0.019	0.080
Pragmatist	ICT development is inevitable, Ukraine must use its own advantages	67.5	74.1	80.3	85.7	73.5	23.675	0.001	0.097
Agnostic	The impact of ICT on the economy and society is exaggerated	44.0	46.9	50.4	52.4	46.8	15.805	0.015	0.082
Rationalist/ cautious pessimist	The development and use of ICT is associated with many problems	24.2	28.1	25.4	33.3	26.4	11.638	0.071	0.070
Sceptic	This question is irrelevant	16.8	14.5	13.6	12.7	15.1	11.748	0.068	0.071

Source: calculated by the authors using SPSS

As can be seen from the following cross-tabulation results:

- 1) the optimism of the assessment of the consequences of digitisation for the economy of Ukraine depends on the level of digital skills. Respondents with basic and higher levels of digital skills are more optimistic than respondents with no or low skills – respectively: 81.8% vs. 77.6%.
- 2) pragmatic assessments of the positive consequences of digitisation for the economy of Ukraine also clearly correlate with the level of digital skills. It is possible to follow a direct relationship that the higher the level of digital skills, the higher the share of pragmatists among the respondents. If, on average, 73.5% of respondents have pragmatic expectations, then for respondents with a basic level of digital skills, this indicator is 80.3%, with a higher level of skills – 85.7%.
- 3) respondents with a higher level of digital skills more actively express an agnostic position, supporting the statement that the impact of ICT on the economy and society is exaggerated. If, on average, this position belongs to 46.8% of respondents, then it is shared by 50.5% of respondents with a basic level of digital skills and 52.4% with a level of digital skills above the basic

- level. This is probably since an elevated level of digital skills allows them to more realistically and diversely assess the positives and expected consequences of digitalisation for the economy and its individual sectors.
- 4) higher professional awareness in the field of ICT causes a greater prevalence of pessimistic assessments. If on average 26.4% of respondents support the thesis “The development and use of ICT is associated with many problems”, then among people with basic competencies the level of support for this statement is lower – 25.4%, and among people with digital skills it is higher basic level, reaches 33.3%.
 - 5) sceptical assessments decrease as the level of digital skills increases: 13.6% – basic level of digital skills, 12.7% – above the basic level, against 15.1% – on average for the population.
- Named trends and regularities were verified by conducting an examination of the statistical parameters of the relationship (Table 2). The presence and closeness of the connection is not proved and depends on the archetype of the respondent, namely regarding the “rationalist” and “sceptic” archetypes, the connection is not statically significant; null hypothesis about the independence of the variables “in question”.

Table 2. The results of the examination of the statistical parameters of the interrelationship of the factors “archetypes of respondents – digital skills”

Respondent archetype	Pearson's chi-squared test	Test of homogeneity (chi-squared probability)	Cramér's V (φc) according to Rea&Parker recommendations
Optimist	Significant relationship at p=0.05	Rejected – the relationship is available	The relationship is insignificant
Pragmatist	Significant relationship at p=0.01	Rejected – the relationship is available	The relationship is insignificant
Agnostic	Significant relationship at p=0.05	Rejected – the relationship is available	The relationship is insignificant
Rationalist	Non-significant relationship	Difficult to determine	The relationship is insignificant
Sceptic	Non-significant relationship	Difficult to determine	The relationship is insignificant

Source: compiled by authors according to criteria defined in (Rea & Parker, 2014)

The second stage of the research was the study of the impact of the level of digital skills on the lives of citizens. The impact was investigated in terms of 3 aspects: on everyday life, on survey respondents as consumers and as employees.

Digital life of citizens. The availability and level

of possession of digital skills is a source of demand for goods and services offered in the digital economy and is a factor in its growth. As the research confirmed, the presence and level of digital skills helps improve the quality of life of the respondents (Table 3).

Table 3. Share of respondents who regularly use ICT opportunities in everyday life, %

Manifestation of influence	Level of digital skills				On average	Statistical parameters for assessing the interrelationship of factors		
	Minimum	Low	Basic	Above basic		Pearson's chi-squared test	Test of homogeneity (chi-squared probability)	Cramér's V (φc)
Information sources	54.4	62.7	68.0	79.4	61.6	75.516	0.000	0.179
Search for information, goods, and services	66.6	76.5	81.6	88.9	74.5	35.993	0.000	0.123
Electronic communications	66.6	79.6	87.3	92.1	77.0	70.297	0.000	0.173
Cloud services	30.4	48.0	63.6	74.6	46.0	113.787	0.000	0.219
Online purchases of goods, tickets, food, etc.	37.1	51.1	61.4	71.4	49.0	69.291	0.000	0.158
Electronic payments, transactions with cryptocurrencies, etc	31.8	44.7	56.1	73.0	43.7	73.117	0.000	0.176
Entertainment	19.6	32.9	38.6	66.7	30.9	96.23	0.000	0.202
Distance learning	21.4	35.3	43.4	60.3	33.1	35.05	0.000	0.122
Online access to government services	26.7	39.9	41.2	60.3	36.4	55.368	0.000	0.153
Organisation and self-organisation	21.4	35.3	43.4	60.3	33.1	82.746	0.000	0.187

Source: calculated by the authors using SPSS

The availability of digital skills positively affects the level of demand for digital economy products. A stable trend towards an increase in the share of respondents who use Internet resources in everyday life was

found, depending on the level of possession of digital skills, namely:

1. The share of respondents who always use ICT as a source of information (any, including news) is 68% for

respondents with basic skills, 79.4% for respondents with above-average skills, which is substantially above the average level (61.6%) or the level of use by people without skills (54.4%); a similar situation exists in relation to the search for information, goods, and services.

2. Respondents with a higher level of digital skills more often use electronic communications as a means of communication (with family, with authorities, social infrastructure, etc.). If only 66.6% of people without skills use electronic communications, the share of respondents with skills above the basic level is 92.1%. A comparable situation, but with a lower share of respondents, also occurs regarding the use of cloud services: 63.6% (basic level of digital skills), 74.6% (above the basic level), 30.4% (by people without skills) with an average prevalence of use – 46%. Less activity regarding cloud services can be explained by the relative novelty of this opportunity and the current low demand for the corresponding services (so far, there is a lack of awareness of the need and potential for further use of this opportunity).

3. The dependence of the frequency of use on the level of digital skills was also found in relation to the intensity of Internet purchases (goods, tickets, food), which considerably speeds up the implementation of these transactions, allows freeing up time, choosing goods and services of a more acceptable value, etc. Respondents with skills above the basic level do this twice as often as people without skills: 71.4% and 37.1%, respectively. An analogous situation was found regarding the implementation of electronic payments and other financial transactions: 73% of respondents with skills above the basic level against 31.8% – respondents without skills.

4. The presence and level of digital skills contributes to the development of individuals, as they are more likely to use distance learning opportunities, which are becoming more widespread and in demand, especially in the context of the COVID-19 pandemic. In Ukraine, there is a stable direct relationship between the level of digital skills, and the growth of the share of respondents who will systematically use ICT for distance learning: 55.8% – respondents without skills; 81.0% – respondents with skills above the basic level.

5) The increase in the level of digital skills substantially eases and accelerates online access to government services, helps to save time and effort in obtaining them. Thus, 60.3% of respondents with skills above the basic level use electronic capabilities (bots, websites, mobile applications) for communications with state structures, while only 26.7% of respondents with minimal skills do so, which is 2.25 times less.

Organisation and self-organisation of everyday life is improved through electronic services and other ICT. A direct relationship between the growth of the level of digital skills and the systematic use of ICT opportunities for the organisation and self-organisation of everyday life was revealed: 60.3% (respondents with digital skills above the basic level) compared to 21.4% (respondents without digital skills). People with skills above the basic level are almost 3 times more likely to use ICT for entertainment compared to people without such skills – 66.7% vs. 19.6%, respectively. The identified trends and regularities are confirmed by the assessment of the statistical parameters of the relationship between the considered manifestations of the impact of digitalisation on the everyday life of Ukrainians and their digital skills according to the rules defined in (Rea & Parker, 2014):

1. A check was made for a statistically significant relationship (by comparing the real value of Pearson's χ^2 with critical values, a significant relationship was confirmed at $p=0.01$ for all manifestations of influences.

2. Hypotheses about the independence of variables based on the homogeneity test (the chi-square probability is rejected for all manifestations of influence.

3. The evaluation of the correlation coefficient V according to Kramer suggests a weak relationship regarding all manifestations of influence

Digital consumers. There is a strong connection between the level of digital competences of people and consumer choice. The conducted research allowed obtaining statistical confirmation of the positive impact of the level of digital skills on respondents as consumers, their consumer behaviour, and priorities in consumption (Table 4).

Table 4. The share of respondents who note the maximum impact of digitalisation on themselves as a consumer (in terms of the consequences of the impact), %

Manifestation of influence	Level of digital skills				On average	Statistical parameters for assessing the interrelationship of factors		
	Minimum	Low	Basic	Above basic		Pearson's chi-squared test	Test of homogeneity (chi-squared probability)	Cramér's V (φ_c)
Development of digital skills	32.49	42.76	45.61	52.38	40.05	50.562	0.000	0.146
Higher quality of services received	39.40	44.74	52.19	65.08	45.30	13.922	0.001	0.101

Table 4, Continued

Manifestation of influence	Level of digital skills				On average	Statistical parameters for assessing the interrelationship of factors		
	Minimum	Low	Basic	Above basic		Pearson's chi-squared test	Test of homogeneity (chi-squared probability)	Cramér's V (φ _c)
Improving the quality of communication	47.00	52.63	58.77	60.32	52.16	21.39	0.002	0.095
Increase in choice, ease of customisation of products	47.24	54.39	60.09	73.02	53.85	36.917	0.000	0.125
Decrease in consumer prices	12.44	14.69	17.11	22.22	14.73	13.922	0.031	0.077
Emergence of new goods and services	41.01	49.56	57.02	58.73	48.35	29.737	0.000	0.112
Speeding up access to products and services	48.39	59.21	63.16	65.08	56.31	23.908	0.001	0.101

Source: calculated by the authors using SPSS

The obtained results allow outlining the specific features of the impact of digitalisation on consumers. The following dependences and influences were identified and statistically confirmed:

1. A stable relationship between the level of digital competences of respondents and the share of respondents who feel the maximum impact of digitalisation on the formation of new digital skills was found. Thus, if for respondents with a minimum level of skills, this share is 32.5%, then for respondents with skills above the basic level, it increases to 52.5%.

2. The dependence between the level of digital competences and the possibility of obtaining higher quality services was confirmed. The share of respondents who note the impact of changes in the quality of services systematically increases with the increase in the level of digital skills: from 39.4% for respondents with a minimum level of skills to 65.1% for respondents with skills above the basic level. Digital skills also have an impact on the assessment of the quality of communication: 60.3% of respondents with digital skills above the basic level mark it as maximum; among respondents with a minimum level of skills, the share of such respondents is only 47%.

3. With the growth of digital skills, respondents increasingly feel the positive consequences of digitalisation, specifically in terms of increased choice, ease of customisation of products (goods, services). The share of respondents who experience for themselves as a consumer the maximum impact of this consequence of digitalisation, but have the minimum level of digital skills, is only 47.2%. Among respondents with skills above the basic level, 73% of respondents note the positive effect of the increase in choice and ease of product customisation.

4. Respondents with a higher level of digital competence also receive more benefits from digitalisation in terms of lower consumer prices. If on average less than 15% of respondents determined the maximum impact

of this factor for themselves as a consumer, then the share of such respondents with basic digital skills is 17.1%, and among respondents with skills above the basic level – 22.2%. As the level of digital competences increases, the share of respondents who note the maximum positive impact of such a consequence as “acceleration of access to products and services” increases: 48.4% (minimum level) – 65.1% (above basic level).

5) A positive assessment of the impact of digitalisation on the expansion of consumer supply, the emergence of new goods and services also depends on the level of digital skills. A constant increase in the share of respondents who determined the impact of this consequence of digitalisation on themselves as the maximum, with the increase in the level of their digital skills, was revealed. It is confirmed by only 41.0% of respondents with a minimum level of digital skills, and among respondents with skills above the basic level, the share of support is already 58.7%.

Identified trends and regularities are confirmed by the assessment of the statistical parameters of the relationship (Pearson's chi-squared test); testing of the hypothesis about the independence of variables based on the test of homogeneity (Test of homogeneity (chi-squared probability); (Cramér's V (φ_c) according to the rules defined in (Rea & Parker, 2014)) between the considered manifestations of the impact of digitalisation on consumers and their digital skills, except for such manifestations as “improvement of communication quality” and “reduction of consumer prices”. The hypothesis regarding the dependence between the level of digital skills and these manifestations of digitalisation was statistically rejected.

Digital economy employees. The increase in the level of digital skills substantially influence the respondents as employees (Table 5). It contributes to improving the flexibility of labour relations, as it positively affects the possibility of using new forms of employment:

remote employment, the advantages of which have become well understood in the context of the COVID-19 pandemic; freelancing is important for creative professions and individuals; women with children and other

people who combine work with social responsibilities or have special work needs. However, the sectoral structure of the neo-economy can considerably affect both the demand for digital skills and the valuation of workers.

Table 5. The share of respondents who note the maximum impact of digitalisation on themselves as an employee (in terms of the consequences of the impact), %

Manifestation of influence	Level of digital skills				On average	Statistical parameters for assessing the interrelationship of factors		
	Minimum	Low	Basic	Above basic		Pearson's chi-squared test	Test of homogeneity (chi-squared probability)	Cramér's V (φc)
Emergence of new employment opportunities	41.3	40.9	50.0	25.8	41.7	9.277	0.159	0.101
Job loss	7.6	8.1	7.5	7.9	7.8	4.057	0.669	0.041
Emergence of new forms of employment (remote, freelance, etc.)	50.0	58.1	68.9	65.1	57.6	59.944	0.000	0.159
The possibility of a flexible work schedule	48.4	60.1	64.0	68.3	57.0	32.004	0.000	0.116
Development of new digital skills	49.1	60.7	65.8	55.6	57.2	64.956	0.000	0.234
Expansion of the scope of professional duties	39.9	45.6	48.7	42.9	43.9	26.092	0.000	0.105
Increase in labour productivity	35.0	43.2	50.9	52.4	42.2	37.78	0.000	0.126
Decrease in labour productivity	35.0	38.2	43.9	38.1	38.1	20.554	0.002	0.093
Increase in load intensity	25.8	25.9	25.4	28.6	25.9	7.993	0.239	0.058
Change of work environment brings new challenges	35.0	38.2	43.9	38.1	38.1	12.277	0.056	0.072

Source: calculated by the authors using SPSS

Digital transformation brings new opportunities for the employment of employees. Thus, if, on average, 41.7% of respondents noted the emergence of new employment opportunities, then for respondents with a basic level of digital skills, this indicator increases to 50%. Unexpectedly, there are lower ratings in other groups (only 25.8% of people with digital skills above the basic level rated the impact of this factor on themselves as maximum), which can probably be explained by the relatively small number of positions that specifically require digital skills above the basic level and can be of interest to respondents with this level.

On average, 7.8% of respondents noted the risk of job loss because of digital transformation. Respondents with a basic level of digital skills, as well as with a basic and higher level of digital skills, feel more protected (only 7.5% and 7.6%, respectively). The same level (7.6%) is possessed by the respondents who lack digital skills, probably because their positions do not require it. Without digital competencies, only 50% of respondents feel the maximum impact on themselves as an employee, and the growth of digital skills to the basic level leads to an increase in the share of respondents to 68.9%; for respondents with a basic and higher level of digital competence, it is 68%. A clear trend of increasing the

share of respondents who feel a positive impact of ICT with increasing level of digital skills also occurs regarding the possibility of a flexible work schedule (48.4% – people without skills, 68.3% – respondents with skills above the basic level).

Respondents with a higher level of digital skills benefit more from digitalisation in terms of “building new digital skills”: 60.7% of respondents with a low level of skills and 65.8% with a basic level of skills noted this effect for themselves, i.e., with the increase in the level of skills, mastering new ICT opportunities becomes easier and faster. A variety of special educational literature, videos, and webinars are available to users on the Internet, which substantially ease the process of acquiring digital skills. The share of respondents with a level of digital skills above the basic level who noted for themselves the positive impact of “forming new digital skills” is somewhat lower (55.6%), probably considering the greater difficulty of mastering professional versions, tools, software, etc., compared to those who are widely used.

The active use of ICT also leads to conditional negative consequences. One of them can be the expansion of the range of professional duties, if this does not lead to an adequate increase in the level of material reward. The prevalence of this factor is directly related to

the level of digital skills. 39.9% of respondents without digital skills noted the maximum impact of this factor, among respondents with a basic level of digital skills, their share increases to 48.7%, basic and higher – 47.4%. As the level of digital skills increases, work becomes (or has every reason to become) increasingly diverse; better opportunities for career growth appear, which, in the case of positive circumstances and financial prerequisites, creates a better potential for salary growth.

The growth of digital skills of employees has a definite positive impact on increasing their work productivity. The share of respondents who noted the maximum impact on themselves as an employee increases from 35% (minimum level of digital skills) to 52.4% (digital skills above the basic level). The share of respondents who noted a decrease in labour productivity because of digitalisation tends to decrease, but only to the basic level of digital skills (8.1% – minimum level, 5.3% – basic level). The opposite situation was found among respondents with digital skills above the basic level: 19% of respondents noted this negative circumstance as having an impact on them. This can probably be explained by the expansion of their professional responsibilities, excessive administration of activities or the need to duplicate information in digital and paper form, etc. A final understanding of the reasons requires more research.

Attention should also be paid to such a factor as the increase in load intensity. The fact that almost 80% of respondents assessed the impact of this factor on themselves as average and maximum deserves awareness and in-depth analysis; 25.9% is the maximum. It is a genuine problem that needs recognition and a solution. Analysis of the prevalence of maximum exposure by level of digital skills does not reveal a clear relationship. The increase in the level of digital skills to the basic level is somewhat counteracted by the increase in the intensity of the workload (the share of respondents decreases to 25.4%), but for the group of respondents with skills above the basic level, the share of respondents who feel the maximum impact is higher than for respondents with an average level. The level and variation of the indicator cause interest in further research to find out the reasons and develop management measures for such situations.

A third of employees (38.1% of respondents) consider the impact on themselves of such a factor as “change in the working environment, which causes new challenges” to be maximum, which indirectly characterises their uncertainty in their future (possibility of continuing to work and performing job duties) due to new elements of work environment that should be learned and/or adapted to. Among respondents with basic and above basic levels of digital skills, the share of such respondents is substantially higher – 43.9% and 42.6%, respectively.

Identified trends and regularities are confirmed by evaluating the statistical parameters of the relationship (Pearson's chi-squared test); test of homogeneity (chi-squared probability); Cramér's V (φ_c) according to the rules defined in (Rea & Parker, 2014)) between the considered manifestations of the impact of digitalisation on the personnel of organisations and their digital

skills, except for such manifestations as “emergence of new employment opportunities”, “job loss”, “increase in load intensity”, “the change of working environment brings new challenges”. The hypothesis regarding the dependence between the level of digital skills and the conditional negative perception of digitalisation is statistically rejected.

Thus, the conducted research is relevant because it is part of the general global flow of research aimed at finding features and regularities of satisfaction with digital transformation processes and attitudes towards their components (Darazha *et al.*, 2021; Punie & Redecker, 2017; Siddoo *et al.*, 2019). The research methodology was developed based on a creative combination and development of methodological approaches to assessment, namely those that were used (Ben Youssef *et al.*, 2014; Liñán & Chen, 2006; McLennan *et al.*, 2022) and prescribed by EU regulations (such as the European Digital Competence Framework DigComp 2.1 (Carretero Gomez *et al.*, 2017)). However, the obtained conclusions and tested hypotheses are more representative compared to (Núñez-Cana *et al.*, 2022; Tolstikova *et al.*, 2021) due to a wider range of respondents (1181 representatives of the academic community, public service, business and entrepreneurship, public sector and temporarily unemployed) and questions (13 general and 40 special), which comprehensively represent the peculiarities of the development of the digital economy in Ukraine. Conducting such a study in Ukraine once again proves that countries where the share of the digital economy is significant tend to more actively study citizen satisfaction because trust in the authorities is consciously identified as an essential part of social capital.

CONCLUSIONS

Based on the results of the statistical testing of the put forward hypotheses about the dependence of factors, targeted efforts to form digital skills will contribute to an increase in the share of optimistic and pragmatic assessments regarding the perception of the consequences of digitalisation in Ukrainian society.

The discovered differences (sometimes 2-3 times) in the frequency of use of certain digital services depending on the level of digital skills prove a digital gap between the possession of skills and the need for them (based on self-assessment of their importance). This requires the implementation of a targeted policy to eliminate it.

Future research should also look for explanations for the phenomenon of digital pessimism, which is observed in numerous instances. Even among archetypes such as the optimist and the sceptic, individuals with above-basic levels of digital skills have more pessimistic views than those with lower levels of competence. Moreover, such digital pessimism is often observed among workers regarding employment issues, new forms of employment, competencies and professional responsibilities, work productivity and work environment.

There is a clear relationship between the level of digital skills, and the share of respondents who feel a considerable impact of digitalisation on personal

development, education, and satisfaction with the digital economy products. An increase in the level of digital skills enables better experience of the positives of digitalisation, provides positive effects, improves consumer attitudes and contributes to the development of a higher quality consumer basket at a more reasonable price and with less time spent because the following effects take place: an increase in learning and development opportunities, an increase in quality and variety of goods and services, price reduction, reduction of time costs.

Thus, on the example of Ukraine, it was confirmed that the digitalisation of the economy radically changes

not only its macroeconomic structure and the landscape of the labour market, but also has a considerable impact on every employee and consumer. The intensity of the impact of digitalisation and the share of people who experience it are dictated by the level of digital skills.

The clearest advantages of digitalisation and the development of digital skills are that it enables better solutions for security issues, increases the defence capability of the country and the competitiveness of the economy, influences the quality of life, work in any epidemiological situation, reduces resource consumption, improves social equality, and brings closer other ideals of sustainable development.

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Оцінка впливу цифрових навичок на рівень задоволеності процесами цифрової трансформації в Україні

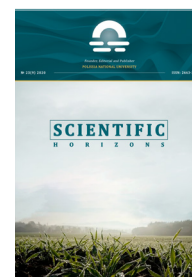
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Анотація. Цифрова трансформація країн-лідерів у напрямку неоекономіки ефективно використовує потенціал цифрових компетенцій, які в Україні залишаються недостатньо дослідженими, але вже зараз зрозуміло, що вони є запорукою інклюзивного економічного зростання будь-якої країни, зокрема післявоєнного відродження і розвитку України на високому конкурентному рівні. Метою дослідження є виявлення особливостей впливу рівня цифрових компетенцій (відповідно до DigComp 2.1) на оцінку українськими громадянами перспектив розбудови цифрової економіки, сприйняття стейкхолдерами процесів цифрової трансформації економіки. Інформаційним базисом роботи є дані он-лайн опитування, оброблені з використанням пакету SPSS. Виявлені закономірності перевірені за допомогою стандартних статистичних параметрів взаємозв'язку. На першому етапі ідентифіковано вплив рівня цифрових навичок на судження, настрої та очікування респондентів щодо перспектив цифрової трансформації в Україні та світі. Залежно від ставлення до розвитку ІКТ виділено архетипи респондентів (оптиміст, прагматик, агностик, раціоналіст / обережний песиміст та скептик). Доведено, що оптимістичність оцінки наслідків цифровізації залежить від рівня цифрових навичок. На другому етапі вивчався вплив цифрових навичок на різні аспекти життя українських громадян, зокрема на їх повсякденне життя, на них як на споживачів та як на працівників. Виявлено, що вищий рівень цифрових навичок сприяє покращенню якості повсякденного життя респондентів; спостерігається зростання частки респондентів, які використовують інтернет-ресурси у повсякденному житті. Ключовими висновками є: 1) цілеспрямовані зусилля з формування цифрових навичок будуть сприяти збільшенню частки оптимістичних та прагматичних оцінок цифровізації; 2) виявлений цифровий розрив між володінням навичками та потребою в них (2–3 рази) актуалізує реалізацію політики, спрямованої на його подолання; 3) зростає усвідомлення впливу рівня цифрових навичок на розвиток громадян та задоволеність продукцією цифрової економіки; 4) цифрова трансформація економіки кардинально змінює її структуру, ландшафт ринку праці та чинить домінуючий вплив на кожного громадянина. Отримати корисний ефект цифровізації зможуть передусім ті, хто має високий рівень володіння цифровими навичками.

Ключові слова: ІКТ, цифрова економіка, цифровий розрив, компетенція, працівник, споживач, соціальна стратифікація, DigComp



UDC 65.011.56

DOI: 10.48077/scihor.25(7).2022.55-64

Improving Control Accuracy in Multi-Connected Digital Systems

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Article's History:

Received: 20.08.2022

Revised: 19.09.2022

Accepted: 20.10.2022

Suggested Citation:

Repnikova, N., Berdnyk, Yu., & Hnyp, V. (2022). Improving control accuracy in multi-connected digital systems. *Scientific Horizons*, 25(7), 55-64.

Abstract. The presented scientific research is relevant, because currently it is necessary to develop and implement modern control systems for technological processes. This allows increasing the accuracy of control in multi-connected digital systems, the mathematical models of which are built on the platform of the state space method. The purpose of this study is to develop a new method for improving control accuracy in multi-connected digital systems. The methodological framework of this study, determined directly for the qualitative solution of the problem, included analytical expressions that functionally not only eliminate the influence of each state and control on the rest, but also ensure high accuracy of control processes. In this scientific study, the results were obtained, standing for a methodical approach to the synthesis of vector-matrix models of regulators using feedback on the state. The vector-matrix model of the controller, combining the function of monitoring and control of feedback on the state was formed. By using computational capabilities of the mathematical apparatus adopted in the study, the matrices of the system regulators and correction coefficients were calculated. The formulated conclusions affect various aspects of the practical application of the method of determining the feedback matrix by state, deriving an analytical formula for determining the correction coefficients to ensure zero steady-state control error, as well as performing the decomposition of a digital system with the definition of a vector-matrix model of a regulator combining the functions of regulation and supervision. The materials and methods of paper fully correspond to the stated subject and can serve as a qualitative methodological basis for following research in this area

Keywords: state space method, quality of control processes, vector-matrix models, feedback



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INTRODUCTION

Nowadays, there are many publications (Lenzen & Vollmering, 2020; Wen *et al.*, 2019) where the authors solve the problems of creating control systems based on the state space method. Each author finds their niche for solving urgent problems of developing and researching various classes of control systems on the mathematical platform of the state space method, synthesis of multidimensional systems. The scientific monographs on the presentation of a wide range of tasks for the design of vector-matrix models of digital systems are published (Repnikova, 2017). This article uses a well-founded method for the synthesis of feedback systems (Fadali & Visioli, 2019). But if for continuous systems there are clear recommendations for finding the desired roots, then for digital systems, if such recommendations exist – they are not generalized, and a control error is observed as a result of synthesis.

The problems of pragmatic, structural synthesis of automatic control systems for technological processes occurring in various environments and digital systems are found by criteria of multidimensionality, multi-connectivity, as well as the nonlinearity of mathematical models of these systems (Yang & Sun, 2021). Considering the specified characteristics of the designated objects, it should be noted that until recently, the management of complex technological processes supported the practical application of traditional linear systems formed based on standard mathematical algorithms. The synthesis of systems of linear type, whose operation is based on the practical application of the input and output models, does not assume the accounting multidimensionality, and the relative position of the coordinate system status and influence on the process itself. An increasing influence of the signal and parametric perturbations is on the quality of initial management processes in systems of this kind (Wen *et al.*, 2019). In a situation where there is a constant increase in the volume of requirements for the efficiency of management of modern technological processes, it should be considered fully justified and technologically expedient to use control principles using vectors of the object's state. While considering the use of inertia-free state regulators in calculations, as well as joint regulators of this state.

Today, a prerequisite for obtaining a qualitative and objective solution to the problem of modeling a control system for a multidimensional object based on the principles of managing its states should be considered obtaining a qualitative solution to the problem of parametric and structural synthesis of automated control systems for multi-connected, nonlinear, and multilevel objects. A qualitative solution to this problem has not yet been obtained that can meet *all* the technological requirements of the construction of a multidimensional object management system (Giraud & Giraud-Audine, 2019). This dictates the importance and significant prospects for finding effective algorithms

for controlling multi-connected digital systems and improving the accuracy of this control, which is essential from the point of view of practical operation of modern technological devices. The control systems that exist today show high efficiency with stable parameters of the object, the absence of a clear structural relationship between its basic states and without pronounced links to the quality of its management. In the presence of any changes in the state of the object and the loss of relationships between them, the control system malfunctions, due to the inability to control processes in the changed multidimensional conditions (Szederkenyi *et al.*, 2018).

The main purpose of this study is to develop a new method for the synthesis of multi-connected digital systems. This technique is based on the analytical derivation of an expression to determine the correction coefficients that ensure high quality control with subsequent modelling. Such a technique does not need the task of figuring out the specific values of the desired roots, which simplifies its use for practical engineers when creating digital control systems of any field of use.

MATERIALS AND METHODS

The basis of the methodological approach in this research work is the practical application of a set of analytical expressions that functionally not only eliminate the influence of each state and control on the rest, but also ensure high accuracy of control processes. The basic procedure for conducting scientific research was preceded by the creation of a qualitative theoretical base, which is the basis for the later implementation of the chosen model of scientific research, involving the appropriate mathematical platform of research methods.

Theoretical framework of this study included the investigation of the available publications of several Ukrainian and international researchers on problems directly or indirectly related to issues of improving control accuracy in multi-connected digital systems, with the involvement of an optimal mathematical platform for implementation of the entire set of research tasks.

To achieve this task, the study was performed in five areas using the following methods:

- a mathematical platform of state-space method using the classical theory of synthesis of systems with feedback;
- attraction analytical formulas for junction channels of R. Iserman (2018);
- conclusion analytical expressions for the correction factors to ensure zero steady-state error control using a theorem of Z-transform on finite value of the function;
- the use of monitored devices;
- attraction formula decomposition of the system with the calculation of controller that combines the functions of control and observation.

The developed technique was tested on models using the Matlab/Simulink application package for control

objects whose dynamics are described by vector-matrix equations of state and output.

During this scientific research, scientific experiments were carried out designed to simulate: transients in the initial multi-connected digital system, transients with a feedback controller, transients in the initial multi-connected digital system, transients with a feedback controller, transients using the derived formula for calculating correction coefficients, as well as transients in a system with a combined controller providing high control accuracy. The three experiments were accompanied by the display of graphical dependencies of the quantities obtained during the simulation of the processes under consideration, as well as digital display of the parameters obtained during their simulation.

RESULTS AND DISCUSSION

The study of the main problematic aspects of improving control accuracy in multi-connected digital systems has given the following results. Multidimensional digital systems are considered, which are described by equations (1), (2):

$$x[n+1] = Ax[n] + Bu[n], \quad (1)$$

$$y[n] = Cx[n], \quad (2)$$

where A , B , C are the diagonal matrices; x , y , u are the initial variables; n is the reference number.

The general view of the matrices of a multi-connected object (3-5):

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, \quad (3)$$

$$B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}, \quad (4)$$

$$C = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}. \quad (5)$$

The equation of a closed digital system $x[n+1] = [A - BK]x[n] = Fx[n]$, where K is the state feedback matrix. A multidimensional system with a state controller, the initial variables of which do not affect each other, is

described by the following Iserman equation (6):

$$y[n+1] = Ty[n] + TCx[n] \quad (6)$$

where $T = \text{diag}(z_i)_{i=1,2,\dots,1}$.

For the moment of reference $[n+1]$, one can write (7):

$$y[n+1] = Cx[n+1] = C[A - BK]x[n]. \quad (7)$$

From where the equation of the state regulator is obtained (8):

$$K = [CB]^{-1} [CA - TC]. \quad (8)$$

For an n^{th} order system, the regulator matrix (8) for diagonal matrices B and C is calculated as (9):

$$K = \begin{bmatrix} \frac{a_{11} - z_1}{b_{11}} \frac{a_{12}}{b_{11}} \dots \frac{a_{1n}}{b_{11}} \\ \frac{a_{21}}{b_{22}} \frac{a_{22} - z_2}{b_{22}} \dots \frac{a_{2n}}{b_{22}} \\ \frac{a_{n1}}{b_{nn}} \frac{a_{n2}}{b_{nn}} \dots \frac{a_{nn} - z_n}{b_{nn}} \end{bmatrix} \quad (9)$$

where z_i are the desired roots.

Studies have shown that although such a technique provides dilution of control channels by condition, there is a regulatory error. To eliminate the control error, a formula for determining the correction coefficients is proposed. To derive the formula for finding the correction coefficients, the z -transformation theorem of the final value of the function was used. Authors derive an analytical dependence for the matrix of correction coefficients K^* with dimension $l \times l$ of a multidimensional digital system (10):

$$K^* = \begin{bmatrix} k_{11}^* & \dots & k_{1l}^* \\ \dots & \dots & \dots \\ k_{l1}^* & \dots & k_{ll}^* \end{bmatrix} \quad (10)$$

For this, authors define the matrix transfer function of a closed control system (11).

$$W_3^*(z) = \frac{Y(z)}{U(z)} = C(zE - A + B)^{-1}B, \quad (11)$$

where Y , U are the initial variables; z is the desired root.

The expression $W_w(z)$ was written in parentheses for the original two-dimensional system in matrix form (12), (13).

$$\begin{aligned} & \left(z \cdot \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} + \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \cdot \begin{pmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{pmatrix} \right)^{-1} = \\ & = \left(\begin{pmatrix} z - a_{11} & -a_{12} \\ -a_{21} & z - a_{22} \end{pmatrix} + \begin{pmatrix} b_{11} \cdot k_{11} + b_{12} \cdot k_{21} & b_{11} \cdot k_{12} + b_{12} \cdot k_{22} \\ b_{21} \cdot k_{11} + b_{22} \cdot k_{21} & b_{21} \cdot k_{12} + b_{22} \cdot k_{22} \end{pmatrix} \right)^{-1} = \\ & = \begin{pmatrix} z - a_{11} + b_{11} \cdot k_{11} + b_{12} \cdot k_{21} & -a_{12} + b_{11} \cdot k_{12} + b_{12} \cdot k_{22} \\ -a_{21} + b_{21} \cdot k_{11} + b_{22} \cdot k_{21} & z - a_{22} + b_{21} \cdot k_{12} + b_{22} \cdot k_{22} \end{pmatrix}^{-1} = \\ & = \begin{pmatrix} \frac{D}{a_{21} - b_{21} \cdot k_{11} + b_{22} \cdot k_{21}} & \frac{D}{z - a_{11} + b_{11} \cdot k_{11} + b_{12} \cdot k_{21}} \\ \frac{D}{z - a_{22} + b_{21} \cdot k_{12} + b_{22} \cdot k_{22}} & \frac{D}{a_{12} - b_{11} \cdot k_{12} + b_{12} \cdot k_{22}} \end{pmatrix} \end{aligned} \quad (12)$$

$$\begin{aligned} D(z) = & z^2 + (-a_{22} + b_{21} \cdot k_{12} + b_{22} \cdot k_{22}) \cdot (-a_{11} + b_{11} \cdot k_{11} + b_{12} \cdot k_{21}) \\ & \cdot z + (-a_{22} + b_{21} \cdot k_{12} + b_{22} \cdot k_{22}) \cdot (-a_{11} + b_{11} \cdot k_{11} + b_{12} \cdot k_{21}) + \\ & + (-a_{12} + b_{11} \cdot k_{12} + b_{12} \cdot k_{22}) \cdot (-a_{21} + b_{21} \cdot k_{11} + b_{22} \cdot k_{21}). \end{aligned} \quad (13)$$

Since the following equality is fulfilled in the synthesized system by a matrix of K coefficients of linear stationary feedbacks (14):

$$\det[zE - A + BK] = \det[zE - F], \quad (14)$$

where F is the transition matrix of the state of the closed system.

That is, $D(z) = D^*(z) = (z - z_1)(z - z_2)$ one can replace the expression for the characteristic polynomial of the original closed-loop system is $D(z)$ as the desired characteristic polynomial is of the form: $D^*(z) = (z - z_1)(z - z_2)$. Because of the performed substitution, authors obtain the following expression for the matrix transfer function of a closed system (the case of diagonal matrices C and B) (15), (16).

$$W(z) = \begin{bmatrix} \frac{c_{11}b_{11}}{z - z_1} & 0 \\ 0 & \frac{c_{22}b_{22}}{z - z_2} \end{bmatrix} = K_h \begin{bmatrix} \frac{1}{z - z_1} & 0 \\ 0 & \frac{1}{z - z_2} \end{bmatrix} \quad (15)$$

For the general case of an n -dimensional system:

$$K_h = \begin{bmatrix} k_{h11} & 0 & \dots & 0 \\ 0 & k_{h22} & \dots & 0 \\ 0 & 0 & \dots & k_{hnm} \end{bmatrix} \quad k_{hij} = c_{ii}b_{jj}, \quad (16)$$

where h, i, j are the system state variables.

Authors determine the final values of the vector function of the output of the system under study $y[n]$, with n tending to infinity. For this, the following formula to calculate the final value of the function was used (17):

$$\lim_{n \rightarrow \infty} y[n] = \lim_{z \rightarrow 1} \frac{z - 1}{z} Y(z) \quad (17)$$

With an incoming action represented as $g(z) = z/z - 1$, the function $Y(z)$ can be represented as (18):

$$Y(z) = W_3(z) \frac{z}{z - 1}, \quad (18)$$

then (19),

$$y[n] = \lim_{z \rightarrow 1} \frac{z - 1}{z} W_3(z) \frac{z}{z - 1} TK^* K_h \begin{bmatrix} \frac{1}{z - z_1} & 0 \\ 0 & \frac{1}{z - z_2} \end{bmatrix} = E, \quad (19)$$

To ensure zero adjustment error, the matrix of correction coefficients K^* , considering formulas, is calculated by the formula (20):

$$K^* = T^{-1} K^{-1} \begin{bmatrix} \frac{1}{z - z_1} & 0 \\ 0 & \frac{1}{z - z_2} \end{bmatrix}^{-1} = E \quad (20)$$

To generalize the method and the logical finale, authors use general analytical formulas for the synthesis of the observed device (21):

$$\begin{aligned} A_{CP} &= [A - HC] \\ B_{CP} &= [B \ H] \\ C_{CP} &= [E] \\ D_{CP} &= [0] \end{aligned} \quad (21)$$

Or the commands of the MatLab application package: $H = \text{place}(A^T, C^T, P)$, where $P = \{-z_1, \dots, -z_n\}$ is the matrix of the desired roots of the characteristic equation. The vector-matrix model of the controller, combining the function of monitoring and control of feedback on the state, has the form (22):

$$\begin{aligned} A_P &= [A - HC - BK_P] \\ B_P &= [B \ H] \\ C_P &= [-K_P] \\ D_P &= [1 \ 0] \end{aligned} \quad (22)$$

The developed technique was studied for different orders of digital control systems, which were set by vector-matrix models. The trajectory of experimental studies confirming the reliability of the results obtained was created using the Matlab/Simulink package according to the following logic:

- modelling of the initial digital system (illustration of the poor quality of regulation and the influence of the states of one channel on the other);
- determination of feedback coefficients by formula (8) or (9) (illustration of the possibility of channel dilution and confirmation of the occurrence of a significant control error);
- calculation of correction coefficients according to the new formula (20) (confirmation of achievement of the scientific goal - improvement of control accuracy);
- the formation of a vector of states that cannot be obtained on real objects (21) and the definition of a vector-matrix model of a regulator combining the functions of observation and control (22), (the final steps of the proposed methodology);
- the input signal is $G = (1 \ 3 \ 4)$ for all experiments.

Experiment 1.

System model (Fig. 1)

SS1 =				C =			
					x1	x2	x3
A =				y1	3	0	0
	x1	x2	x3	y2	0	1	0
x1	-0.3	3	-1	y3	0	0	9
x2	-0.1	-0.5	0				
x3	0.3	-0.7	-0.1				
				D =			
					u1	u2	u3
B =				y1	0	0	0
	u1	u2	u3	y2	0	0	0
x1	2	0	0	y3	0	0	0
x2	0	1	0				
x3	0	0	3				
Sample time: 0.1 seconds							

Figure 1. System model

The selected desired roots and matrices of the regulator (Fig. 2):

The simulation results of Experiment 1 are shown in Figure 3.

```
>> [K1,Kg1] = Calc_Mat(SS1,T1)

>> T1 = [0.1 0 0;0 0.2 0;0 0 0.3] K1 =

T1 =
    0.1000    0    0
         0    0.2000    0
         0    0    0.3000

Kg1 =
    1.5000    0    0
         0    4.0000    0
         0    0    0.0864
```

Figure 2. Correction factors

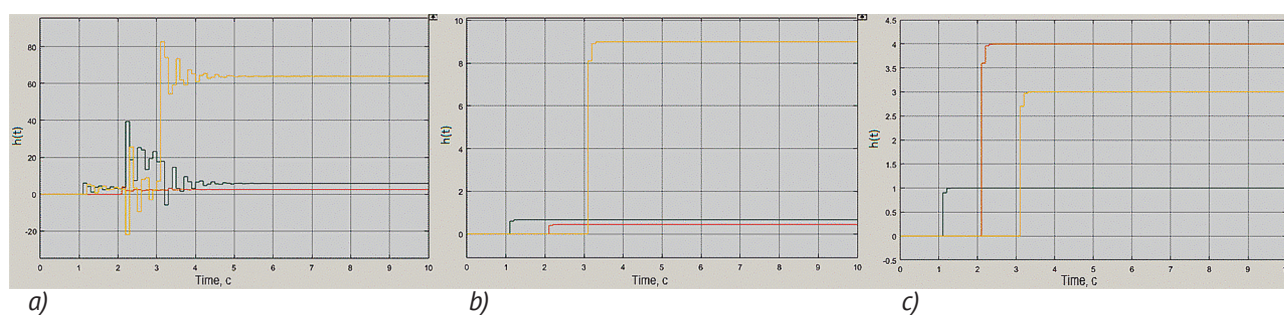


Figure 3. Simulation results of Experiment 2: a) transients in the initial multi-connected digital system by state and output; b) transients with a feedback controller by state; c) transients using correction coefficients

Experiment 2. The model of the initial system (Fig. 4).

Selected desired roots (Fig. 5).

```
SS1 =
    A =
        x1    x2    x3
    x1 -0.3    3    -1
    x2 -0.1  -0.5    0
    x3  0.3  -0.7  -0.1
    B =
        u1    u2    u3
    x1  2    4    3
    x2  2    1   -1
    C =
        x1    x2    x3
    y1    3   -2    7
    y2    0   -1    2
    y3   -3    0.1  9
    D =
        u1    u2    u3
    y1    0    0    0
    y2    0    0    0
    y3    0    0    0
```

Figure 4. Model of the source system

```
>> T1 = [0.1 0 0;0 0.1 0;0 0 0.1]

T1 =
    0.1000    0    0
         0    0.1000    0
         0    0    0.1000
```

Figure 5. Selected roots

Calculated matrices of the regulator and correction coefficients (Figure 6).

The simulation results of Experiment 2 are shown in Figure 7.

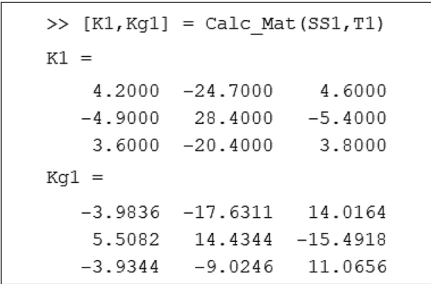


Figure 6. Results of calculations of the matrix of correction coefficients

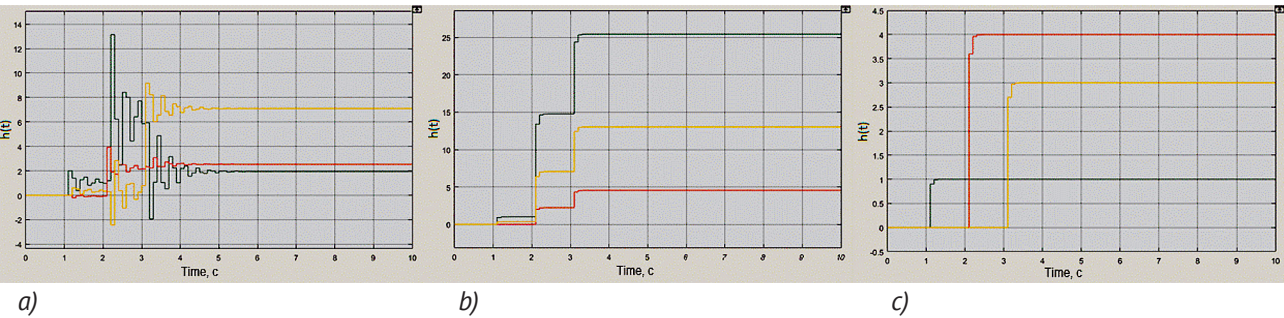


Figure 7. Simulation results of Experiment 2: a) transients in the initial multi-connected digital system by state and output; b) transients with a feedback controller by state; c) transients using correction coefficients

Experiment 3.

Calculation of the joint regulator is the final step of the proposed methodology (Fig. 8).

Results of the synthesis of a multi-connected digital system that provides high precision control of various technological processes (Fig. 9).

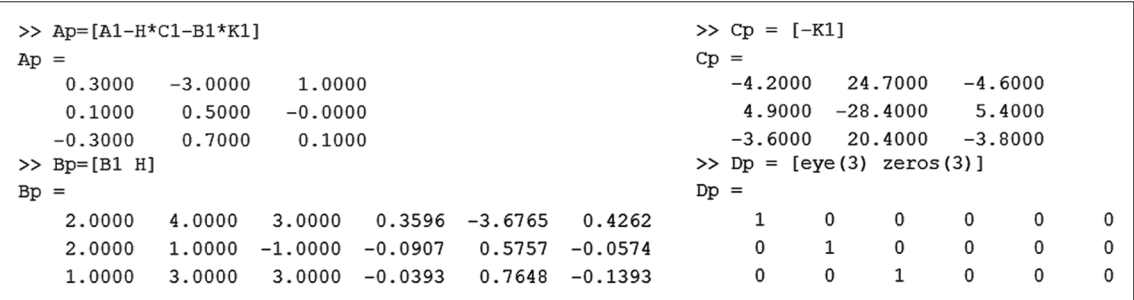


Figure 8. Calculation of the joint regulator

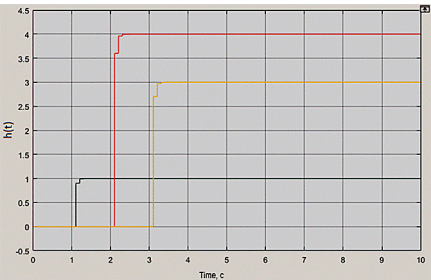


Figure 8. Transients in a system with an integrated controller providing high control accuracy

The conducted experiments suggest the following conclusions:

- practical application of the methodology to determine the state feedback matrix makes it possible to

- eliminate completely the mutual influence of channels;
- derivation of algebraic formulas for determining correction coefficients to ensure zero stable control error contributes to obtaining a qualitative solution to the

problem of designating the desired roots of the characteristic equation;

- practical implementation of the decomposition of a digital system with the designation of a vector-matrix model of the regulator is necessary to combine the functions of regulation and supervision.

Described aspects of method of synthesis of multi-connected digital systems are necessary to understand the essence of the functioning of the system, which provides an increase in control accuracy using the feedback method. At the same time, M. Haidekker (2020) in his research concluded that a joint regulator that ensures high quality parameters of system management characterizes the most stable system.

To date, the issues of designing a multi-connected digital control system should be considered one of the key issues in assessing the degree of importance of the problems of theory of automated process control. Cross-links in the model of the desired object significantly reduce its overall resistance to environmental fluctuations, as well as reduce the quality indicators of the entire system when implementing tasks related to stabilization of main technological processes. According to K. Wu (2016), in systems characterized by presence of finite delays, such problems become significantly more complicated, since presence of any uncertainties in setting coefficients or key parameters of the model and delay values (up to 50% of the nominal value) negatively affects sensitivity of the output to uncertainty, causing its decrease, which is associated with a finite margin of stability.

Following key principles of the theory of multi-connected systems, the higher the dynamic quality of a system with many interrelated parameters, the more accurate the incoming signal is processed inside the system, directly in all control channels. At the same time, each output value, and the degree of influence of control in each channel on all other output variables, interaction of which is due to existing mutual connections, must be considered. The presented scientific concept by A. Azar (2021) allows considering an autonomous type system as optimal, where mutual, direct influence of individual, private channels should be completely excluded by compensating for cross-links. This approach is most often used in practice when implementing projects on automation of technological processes, giving predictably high practical results.

The problems of matrix mode distribution have already been sufficiently covered in the scientific literature (Giraud & Giraud-Audine, 2019; Van Horssen, 2020) and have a qualitative base of algorithmic support. At the same time, it should be considered that the formalism of the spatial state, which holds the algebraic characteristics of matrix-vector components, model representations regarding the technologies of building control processes, has not fully exhausted all the possibilities of its expression. Modern technologies of discharge-pulse

treatment of surfaces of products and materials involve the use of an electric explosion as the main source of dosed exposure to a given concentration in specific local zones, with high values of specific electrical parameters. According to A. Lenzen & M. Vollmering (2020), the high-voltage discharge channel directly in the liquid layers converts the energy of the charged field of a capacitor bank into mechanical work, which is a clear illustration of the elementary interaction of individual elements of multi-connected digital systems. The main advantages of technological impact of this kind should be considered the prospects of achieving a prominent level of specific energy indicators, in the context of ensuring high controllability of this process. It is quite possible to realize the main advantage in the case of a comprehensive study of the features of an electric explosion, as well as the formalization of this phenomenon, which involves the construction of a mathematical model for the synthesis of automated process control systems.

Stable regulation of the electric explosion process, as one of the processes of expressing various aspects of the functioning of a multidimensional digital system, implies the need to ensure effective control of the discharge mode, due to the stochasticity of the processes of creating channels of this discharge, uncertainties in the parameters of the external environment, as well as processing objects and disturbing influences that arise at various technological levels of processing. K. Vamvoudakis & S. Jagannathan (2016) convinced that the process of technological processing of the results is associated with some uncertainty caused by the presence of discharges on the contour of the object being processed, when the electrode moves directly over the surface being processed. In turn, C. Mollay *et al.* (2021) considered that its unpredictable relief is explained by the destruction of molding mixtures during the purification of castings, as well as random changes in the shape parameters of products.

The process of growing crystals from melts involves moving the hot melt into a cold zone with strictly defined thermal conditions created and supported by a control system. According to D.-K. Kim & D.-H. Kang (2021), this system is designed to provide a given parameter of the crystallization rate, the shape of the front itself, as well as the axial and radial temperature gradient directly near this front. The currently accepted parameter for the accuracy of controlling the temperature characteristic of the vicinity of the crystallization front is 0.1°C over the entire crystal growth cycle. However, W. Fang *et al.* (2021) noted that the process of growing crystals by traditional methods does not always allow for compliance with such management quality standards. Among main reasons, the difficulties in measuring the internal zone of the crystallization temperature by a direct method should be noted, as well as the inability to adjust the temperature measurement by the capabilities of the control system. The height of

the crystal growth unit and the features of its design do not allow the placement of temperature sensors and control system heaters only at a certain distance from the object. The result is the need to figure out the best program for controlling changes in temperature regime at some distance from crystal growth zone, which can ensure creation of an optimal temperature regime in the zone itself. This example clearly proves the difficulties of improving control accuracy in multi-connected digital systems with a considerable number of initial parameters.

High-quality development, design and implementation of effective digital control system to monitor the quality of implementation of the calendar of modern production, characterized by the presence of multiple structural relations in management and departmental levels is of great importance from the point of view of the ability to monitor quickly all the structural changes of the production system and to make timely adjustments to the schedule of production (Van Horssen *et al.*, 2020). The development should be carried out in strict accordance with the requirements imposed on the system, with the disclosure of its main functions and the study of the main information flows between the divisions of the production system.

In general, the essence of the strategic task of drawing up a high-quality schedule for the functioning of a multi-connected digital management system for modern production is to find the main types of products produced by a given, specific enterprise, with a sequence of operations for their release per unit of working time. Improving the accuracy of the control of the main parameters of such a system result in a long-term improvement in the quality of manufactured products and an increase in the manufacturability of the production operations performed, which has a positive effect on the production culture. Each part or product must be provided with a technological description of the manufacturing process, per the available production capabilities. Also, a mandatory aspect in this context is the accounting of material resources necessary to perform production tasks in each case (Kim & Kang, 2021).

Management objects in various spheres of modern industry and economy are characterized by the presence of non-standard dynamic characteristics that tend to deteriorate over time due to technological wear of equipment and loss of quality of production operations performed. The quality of the indicators of the technological process of production is significantly reduced, which causes the urgent need to reconfigure the control system and automation of the workflow. Improving control accuracy in multi-connected digital systems of the production process requires considering the nature of the relationships between all objects included in the system and acting as an integral part of it, which implies the need to consider this factor when designing a production management system (Bhogaraju *et al.*, 2021).

According to M. Convertino *et al.* (2019), adaptive systems, made using the methods of automatic identification of parameters, to improve the fundamental principles of invariant, autonomous control, do not make it possible to achieve a qualitative improvement of the control system throughout the technological cycle of the operational use of equipment, which negatively affects the stability of the entire production management system as a whole. This fact is explained by the high degree of sensitivity of autonomous, invariant systems even to weakly expressed changes in the dynamics of objects. The implementation of planned identification for objects characterized by the presence of many connections, which represent the foundation for managing the activities of these objects, is a complex technological problem that has not been fully solved to date.

C. De Souza *et al.* (2021) believed that the main tasks of digitalization of the production schedule formation are determined by the need to increase the rhythm of work processes, as well as reduce the likelihood of occurrence and development of emergency situations associated with equipment failures and forced downtime, and interruptions of the production process. The program for the implementation of such tasks should be embedded in the digital management system of production activities. According to W. Fang *et al.* (2021), this indicates an urgent need to develop a management system with the possibilities of optimization of the structure of the technological production process, adapting to changes in production conditions and evaluation of the correctness of the operation and the desired accuracy of models for capacity planning of production equipment, depending on the implemented operating conditions, and also extremely minimized costs in the implementation directly into the production process.

The digital management system for the activities of a manufacturing enterprise is the main core of the management system for the activities of production systems of various scales and classes. Improving the accuracy of control of processes occurring in multi-connected digital production systems allows achieving high-quality integration into a single whole of automated technological preparation of the production process, including calendar planning and centralized quality control of processed products and parts. The main parameters of multi-connected digital systems, distributed directly in management and practical operation, as a rule, are subject to significant structural changes, if the multiple connection of the bulk of the operated technological facilities is observed (Medus *et al.*, 2021). The development of control options for such objects involves a consistent change in the basic settings of the control system over time. The reconfiguration process involves the mandatory clarification of information on the parameters of a specific object model, which implies the need for mandatory identification, which is not always realistic in a situation with multi-connected objects.

When introducing the principles of robust management of objects that are integral elements of the system, it allows guaranteeing the preservation of proper quality parameters and stability throughout the entire period of technological management. At the same time, the selection and justification of the main criteria for the management of a multi-connected digital system and the optimization of the entire system management complex should be carried out according to pre-defined quality parameters of in-system management, which is essential from the point of view of the subsequent functioning of a multi-connected digital system.

When using methods of synthesis of digital systems with feedback, it is necessary to find the desired characteristic polynomial by state. For systems with one input and output, one can use the Check Step Response Characteristics block of the Simulink toolkit of the MatLab software environment, which simplifies the task of finding the desired roots of the characteristic equation and allows determining them in a short period of time and a method for selecting the desired characteristic polynomial using an analytical formula derived in the literature (Repnikova, 2017). But for control systems with multiple connections, the problem of finding the desired polynomial stays. The derived formula (20) for finding the correction coefficients of the proposed method allows to solve this problem by arbitrarily selecting the desired roots according to certain instructions.

For diagonal matrices B and C, the desired roots for the characteristic equation are chosen arbitrary, for non-diagonal ones, the desired roots are arbitrary, but must be multiples. At the same time, the only limitation in the use of the proposed method are the types of matrices – they must be square, although it should be noted that during the experimental studies, the task was set to test the proposed method for irregular matrices. Curiously, for

some cases of digital systems, the desired results were obtained. But it was not possible to generalize the proposals for such matrices today. This is an important scientific experience for subsequent research and publications.

CONCLUSIONS

In this scientific paper, an improved method of synthesis of multi-connected digital systems is proposed, which provides an increase in control accuracy using the feedback method by state and is implemented by:

- using the method of determining the feedback matrix by state, which made it possible to exclude the mutual influence of one control channel on another;
- derivation of an analytical formula to determine the correction coefficients to ensure zero stable control error, which solves the problem of determining the desired roots of the characteristic equation;
- performing the decomposition of a digital system with the definition of a vector-matrix model of a regulator combining the functions of regulation and supervision.

In the future, the task is to expand further the method of digital control systems with non-square matrices. It is expected to create an analytical concept for finding the dependence of the ratio of the dimensions of matrices B and C on the choice of the desired roots of characteristic equations. Further expansion of the method of digital control systems based on the practical application of non-square matrix contributes to improving the accuracy of the tasks being solved and is extremely important from the point of view of the prospects to ensure high control accuracy in digital systems characterized by multiple connections.

In general, the theoretical and practical results obtained during this study can be used in the future as the best methodological framework for further research on improving control accuracy in multi-connected digital systems. This is essential for high quality debugging of the functioning of modern high-tech devices.

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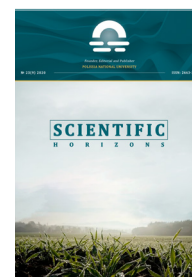
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Підвищення точності керування в багатозв'язних цифрових системах **Наталія Борисівна Репнікова, Юрій Михайлович Бердник, Владислав Віталійович Гнип**

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Анотація. Представлене наукове дослідження є актуальним, оскільки в даний час необхідно розробляти та впроваджувати сучасні системи керування технологічними процесами. Це дозволяє підвищити точність керування в багатозв'язних цифрових системах, математичні моделі яких побудовані на платформі методу простору станів. Метою даного дослідження є розробка нового методу підвищення точності керування в багатозв'язних цифрових системах. Методологічна основа даного дослідження, визначена безпосередньо для якісного вирішення поставленої задачі, включала аналітичні вирази, які функціонально не тільки усувають вплив кожного стану та керування на інші, але й забезпечують високу точність процесів керування. В даному науковому дослідженні отримані результати, що становлять методичний підхід до синтезу векторно-матричних моделей регуляторів з використанням зворотного зв'язку за станом. Сформовано векторно-матричну модель регулятора, що поєднує функцію контролю та управління зі зворотним зв'язком за станом. З використанням обчислювальних можливостей математичного апарату, прийнятого в дослідженні, розраховано матриці регуляторів системи та коефіцієнти корекції. Сформульовані висновки зачіпають різні аспекти практичного застосування методу визначення матриці зворотного зв'язку за станом, виведення аналітичної формули для визначення коефіцієнтів корекції для забезпечення нульової помилки усталеного керування, а також виконання декомпозиції цифрової системи з визначенням векторно-матричної моделі регулятора, що поєднує функції регулювання та контролю. Матеріали та методи роботи повністю відповідають заявленій тематиці і можуть слугувати якісною методологічною основою для наступних досліджень у цьому напрямі

Ключові слова: метод простору станів, якість процесів управління, векторно-матричні моделі, зворотні зв'язки



UDC 334.722.3:38.432

DOI: 10.48077/scihor.25(7).2022.65-73

Assessment of the Impact of the Activities of Agricultural Enterprises on the Economic Development of the Regions of Ukraine in the Period from 1990 to 2020

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Article's History:

Received: 13.08.2022

Revised: 14.09.2022

Accepted: 13.10.2022

Suggested Citation:

Sabii, I., Matviienko, A., Mazurenko, O., Usata, N., & Nemchuk, P. (2022). Assessment of the impact of the activities of agricultural enterprises on the economic development of the regions of Ukraine in the period from 1990 to 2020. *Scientific Horizons*, 25(7), 65-73.

Abstract. The relevance of the subject under study is due to the disquietude of the society, because currently the term "land market" is actively introduced in Ukraine; because of this, monopoly rent is appropriated and redistributed to the enrichment of several heavy duty plot landlords and land users, who already control more than half of the agricultural lands of Ukraine. This paper is aimed at realization of objective analysis of economic processes and covering the regional development of the territories of Ukraine, where agricultural enterprises and farms operate. The leading methods of the study were a dialectical method of cognition of economic phenomena with the review in the historical and economic aspect, and an abstract-logical method, based on the formation of proposals and conclusions. The has showed that agricultural holdings not only support the social sphere formed in the economy but also can implement programs focused on the development of employees and the growth of their social protection. The practical value of this study is also conditioned upon the fact that the progressive principles of governance, management, and transfer of a part of the social benefits available to the population of the cities to the village, which contribute to the economic development of the communities, are involved in the innovative technologies in agricultural sector. The results of this study prove that there are preconditions for development of agribusiness in Ukraine. Specifically, sufficiency of land resources; the necessary production infrastructure and social sphere have been formed; production of highly efficient agricultural machinery and equipment for target production in different edaphoclimatic conditions has been organized, which is evidenced by growth of the number of agricultural holdings annually in most regions of Ukraine. The functioning of farming is an alternative opportunity to share agricultural lands that helped create an economic basis for the system of agricultural enterprises

Keywords: land, farm, regional development, holding, economic relations



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INTRODUCTION

A corporate system in the agricultural sector was created based on the former communal farms and state farms under the influence of the processes of denationalization and privatization in the village in the 1990s (Chernenko *et al.*, 2021). A deep crisis on the territory of village communities – the loss of fullness of agricultural production, unemployment, lack of sustainable sources of income, as well as degradation of soils and the rise of ecological problems – was the result of Soviet heritage (Voznyak *et al.*, 2021). The Soviet system of organization of agricultural production in the form of communal farms showed low efficiency in Ukraine (Zelinska *et al.*, 2020). Therefore, after Ukraine gained independence, it was allowed to organize various kinds of economy management in the villages, among which national support was directed towards agricultural holdings (Marunyak *et al.*, 2020). Many Ukrainian scientists (Reznik *et al.*, 2020; Alekseieva *et al.*, 2020; Rushchyshyn *et al.*, 2021) have conducted research on the formation of agricultural holdings. For example, according to F. Götmarm & M. Andersson (2020), successful agricultural enterprises provide working places for community residents, pay taxes to local budgets, support and sometimes develop the infrastructure sector of the rural territory.

According to F. Cappellano & A. Rizzo (2019), under current conditions, agricultural holdings reflect not only a new structure of production organization, but also a new type of production relations, new connections within the framework of the agricultural sector with industry. However, agricultural holdings are usually business-oriented projects aimed at raising the capital of their beneficiaries and supporting and developing rural infrastructure is not their function (Hudáková, 2020; Fyliuk *et al.*, 2019). The founders of agricultural enterprises and agricultural holdings can live in a completely different place and do not use agricultural infrastructure. In the view of the conflicting opinions, I. Arakelova (2018) is confident that a development and mechanisms of creation of agricultural institutions in the state, methods of influence of the government on their activity, and arguments of the foundation of creation of effective coexistence of the corporate sector and the state need the follow-up study and generalizations.

For historical reasons, the main part of natural and resource potential in Ukraine is land resources, and the concentration of many lands in the ownership of proprietors can have an impact on socio-economic development and environmental conditions. As of 2020, about 4 mln ha that are recommended for agricultural cultivation are concentrated by investors. According to the website “Latifundist” (2022), 117 agricultural holdings of Ukraine process 16% (or 6.45 mln ha) of agricultural land of the country. Among them are more than 10 agricultural holdings from other countries, which hold control of about 3-4 mln ha of agricultural land. Because the economic development of the agricultural

sector should be intricately connected with the development of rural regions, it should be noted that the development of agricultural holdings is an effective tool for attracting investments into agriculture (Lemishko, 2020; Bei, 2018). In this case, farmers and enterprises are now making a significant contribution to its production unlike the period of the communal farms’ existence (Carus & Dammer, 2018).

Due to the above-mentioned issues, the range of the given subject research is relevant. However, despite the lively discussions on land relations, land degradation and land problems, as well as rural development, the interest of researchers was not directed at large, regional, and local agricultural holdings, as well as at results of their functioning. This aspect becomes even more important in the context of decentralization, in the view of the influence of communities on the activities of large agricultural enterprises or farms.

The main purpose of this scientific research is the fundamental analysis of data concerning objective consideration of economic processes of regional development of Ukrainian territories, where agricultural enterprises and agricultural holdings operate.

MATERIALS AND METHODS

The theoretical framework of this study included the conceptual issues and results of the research conducted by some scientists, who investigated problems of organizational and economic substantiation, origin, occurrence and development of agricultural holdings, and their influence on the development of economy in the regional aspect. The dialectical method of cognition of economic phenomena and the economic theory regulations with consideration of problems in the historical and economic aspects formed the methodological framework of this study. The method of scientific abstraction was used to substantiate the specific features of the agricultural sector from post-Soviet approaches to present conditions. The development under the influence of modern trends of economic globalization was investigated according to the method of induction and deduction.

The following methods were used in the study: systematic – for comprehensive review of the stages of formation and development of agricultural enterprises and agricultural holdings; historical – used for analysis of practices of agricultural holdings formation and functioning and their chronology; statistical and economic – based on analysis of the current state of agricultural holdings development, processes of property transformation; monographic – for observation of economic activity of agricultural holdings; abstract-logical – for theoretical generalizations and conclusions. The regulations and proposals formulated and substantiated in this paper form the basis for the solution of research-to-practice base on organizational and economic

substantiation of agricultural holdings formation. The obtained conclusions can also be applied to finding the predicted indicators regarding economic development and the wealth of local territories.

This study was conducted in three main stages. At the first stage, theoretical analysis of existing methodological approaches was performed, namely the study of scientific publications, articles, monographs covering the issue of the agricultural enterprises' origin in territories of communal farms; the problem, the purpose, and the methods of the study were identified; the plan of the scientific research was drawn up. At the second stage, the issue of gradual development of agricultural enterprises and farms was discussed, their formation and economic impact on adjacent regional territories was analysed, the economic and production activities of agricultural holdings were monitored. At the third stage, based on the results obtained at earlier stages, final conclusions of the study were formulated, which formed the final reflection of the results and determined the main trends of further research on the influence of large agricultural holdings on economic development of territories and communities. Theoretical and practical conclusions were clarified, the results were summarized and systematized.

RESULTS AND DISCUSSION

The communities in rural regions were met with reorganizing of the Soviet communal farms after Ukraine gained independence. The farming was an alternative to the possibility of agricultural land sharing, and an economic foundation was created for the formation of a system of agricultural enterprises. The privatization and the transfer of land to the citizens of Ukraine in free cost were the first step in the transformation of the agricultural sector. The Verkhovna Rada of Ukraine has adopted several documents aimed at solving this issue (Resolution of the Verkhovna Rada..., 1992; Decree of the Cabinet of Ministers..., 1992; Decree of the President of Ukraine..., 1995). The transfer of land to collective ownership of agricultural enterprises has become an intermediate stage of land reform in Ukraine (Khodakivska & Mohylny, 2017a; 2017b). This ensured a gradual, nonconfrontational transfer of land intended for agricultural usage from state ownership to private ownership (Shulga, 2019).

In general, the reform processes at this stage were terribly slow, incomplete, and inconsistent, which was highlighted by most scientists and researchers (Khodakivska & Mohylny, 2020; Nicholls *et al.*, 2020). Adoption of the Law of Ukraine No. 400-XII "On the Priority of Social Development of Rural and Agro-Industrial Complex in the National Economy" (1990) did not supply the progress in the development. In the middle of this stage, the structure of the rural population of Ukraine saw significant positive changes. A positive migration balance was seen due to the increase of living expenses,

the decline of employment problems and the closure of housing programs in 1992-1993. However, the potential for return migration was exhausted in 1994, and the balance has been negative since 1998 (Dankevych *et al.*, 2022). In the 1990s, a private farm has taken a leading role in rural regions and has begun to provide about 50% of the total resources of the rural population (Babenko *et al.*, 2020). The second stage, which took place in 2000-2004, was characterized by the completion of the restructuring of agricultural enterprises by the transfer of land and property into private ownership. The regulatory environment was gradually formed. Several legal acts were adopted (Land Code of Ukraine (2001); the Law of Ukraine No. 962-IV "On Land Protection" (2003); the Law of Ukraine No. 858-IV "On Land Management" (2003); the Law of Ukraine No. 1378-IV "On Land Valuation" (2003)) regarding the formation of the land market and its impact on the development of land relations.

The aims of the agrarian reform period were mainly achieved: new legal forms of enterprises were created, especially agricultural holdings, limited liability companies, agricultural cooperatives and private farms, while collective enterprises were liquidated. The main objectives of this stage were the factual establishment of a private land owner and the formation of an independent agrarian business entity, and there was no adequate support in rural regions since there was no integral system aimed at the development of rural regions, and the pressing methods of introducing reforms limited the interest of rural people in the business in agriculture. After the adoption of the Decree of the President of Ukraine No. 1529/99 "On Urgent Measures to Accelerate the Reform of the Agricultural Sector" (1999) was a certain breakout in attitudes towards farming, as well as reforms in general, since the process of encouraging citizens to register private ownership of land started.

The third stage of the transformation of the agricultural sector began in 2004 and is still going. It is focused on reducing the influence of state barriers on agribusiness and intensification of agricultural production. This period is characterized by several positive changes: 1) increase in agricultural production; 2) improvement of the institute of land lease; 3) formation of the sphere of labour motivation; 4) the stimulating value of tax introduction; 5) creation of opportunities to attract investments in agricultural sector. Introduction of the Land Cadastre (the Law of Ukraine No. 3613-VI..., 2011) became the basis of these changes. Every proprietor had the right to freely leave the agricultural enterprise and freely dispose of his or her own land. In the conditions of decentralization of resources and powers, rural communities became key stakeholders in the policy of development of rural regions. Community partnership is becoming the main aspect of rural development policy instead of rigid hierarchy and ineffective state paternalism. The importance of the leader's

activity in rural communities is growing. The powers of local self-government are being increased. The development of agricultural enterprises is the result of a combination of land, material, information, and human potential, which provides production and processing of agricultural products, providing services for the needs of consumers, creating jobs and the revival of rural communities.

The tendency to increase the number of agricultural holdings, the area of farmlands and increase

their wages to employees during the period of 1990-2020 was established (Fig. 1; Table 1). Different legal forms of management are developing in the modern agricultural sector of Ukraine. Market relations and agricultural potential of the country gave impetus to creation of new agricultural formations which in functioning were integrated into the holding-type union. Modern agricultural holdings work on principles of specialization, concentration, automation, diversification with closed cycle of production.

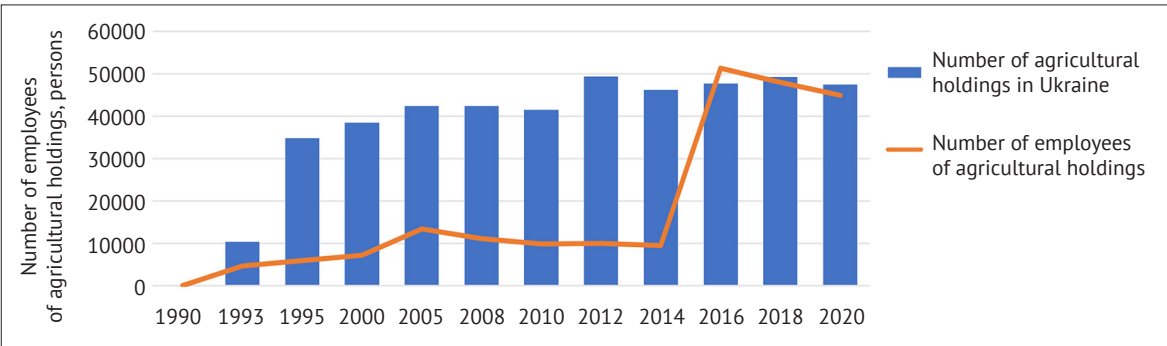


Figure 2. Number of agricultural holdings in Ukraine and number of their employees for the period 1990-2020

Table 1. Dynamics of development of farming in oblasts of Ukraine (1995-2020)

Oblasts	Stages of development of farming in Ukraine (number of agricultural holdings by the end of the period)				
	1995-2000	2000-2005	2005-2010	2010-2016	2016-2020
Vinnitsia Oblast	846	+128	+400	+296	+315
Volyn Oblast	595	-67	+226	-48	+68
Dnipropetrovsk Oblast	2,549	+478	+378	-64	+72
Donetsk Oblast	2,089	+65	-352	-233	+61
Zhytomyr Oblast	310	+191	+185	+55	+196
Zakarpattia Oblast	1,054	+400	-7	+159	-9
Zaporizhzhia Oblast	1,695	+496	+146	-54	+19
Ivano-Frankivsk Oblast	697	-65	-101	+30	+143
Kyiv Oblast	923	+299	+257	-84	+271
Kirovohrad Oblast	1,792	+424	+369	-128	+175
Luhansk Oblast	1,293	+239	-58	-73	-7
Lviv Oblast	1,186	-25	0	-238	+133
Mykolaiv Oblast	4,981	-721	+185	+110	-191
Odesa Oblast	4,095	+772	+1346	-447	-652
Poltava Oblast	1,343	+50	+134	+130	+234
Rivne Oblast	347	+148	+10	+45	+57
Sumy Oblast	956	-159	-69	+2	+91
Ternopil Oblast	753	-57	-40	+117	+51
Kharkiv Oblast	1,035	+144	+135	-118	+150
Kherson Oblast	2,783	+230	-484	-136	-144
Khmelnyskyi Oblast	522	+262	+415	+68	-106
Cherkasy Oblast	509	+204	+389	+30	+173
Chernivtsi Oblast	695	-3	+55	+93	-101
Chernihiv Oblast	575	-100	-14	+20	+175

Rural regions, where agricultural holdings were developing and functioning, received new workspaces, local budgets were being filled, and, as a result, social projects were being implemented, which helped revive agriculture, improve trade balance, and increase incomes of the rural population. During the study, it was noted that the system of mutually beneficial economic relations in agro-industrial complex is gradually improving in agricultural holdings, increasing financial interest of employees aimed at improvement of manufacturing, increasing of its quality and profitability of production, economic mechanism of economic management is introduced.

According to L. Simkiv *et al.* (2021), the agricultural sector of Ukraine during the Soviet period was oriented towards a stable increase in production to meet the dietary needs of other Soviet republics. However, the earlier elements of the functioning of agricultural sector and its structure of the organization have changed significantly, which has influenced the development of rural regions under the conditions of transition to market economy and restructuring of the social and political regime. In the 20th century, the economic development of the world's advanced countries, driven by farming, provided a significant contribution to poverty reduction and the transformation of these countries into industrial developed countries (Simkiv *et al.*, 2021). The results of this study confirm the data that under existing conditions, the tendency towards large concentration of capital, land, and advanced technologies in agricultural sector is being revived. In Ukraine, the largest agricultural holdings have built a leadership model on the domestic market of production and supply of agricultural products and on the world market.

The comprehensive study of literature and regulatory documents showed that after Ukraine gained independence, communities of rural regions were met with reorganization of Soviet communal farms. Farming was considered as an alternative to the sharing of agricultural land, and economic grounds for the formation of a system of agricultural enterprises were created. According to O. Mulska *et al.* (2020), at the end of 1990s, the activity of communal farms was a catalyst of the crisis economic situation, and the leaders of these communal farms were not ready for efficient conduct of matters. Their financial indicators were positive mainly in paper form, because the loan debt was stable, which was constantly elongated or written off. These findings coincide with the results of the presented study, as the formation and development of new forms of economic activity in the agro-industrial complex of Ukraine relates to transition of a part of the land of a public property in the private by the state privatization through transfer to collective ownership and sharing between employees.

According to E. Nicholls *et al.* (2020), the important goal of the activities of agricultural holdings is to obtain profit – economic effect, and for the society – provision of the benefits of local community. Promoting

the revision of local taxation as the main form of financial resource mobilization concerns the development of agricultural holdings and the improvement of agricultural production efficiency on their basis. The creation of agricultural holdings is a certain element of output of agricultural production from the crisis by means of creation of modern competitive agro-industrial complex, which is characterized by the following features: production of high-quality competitive products; application of scientific and technical achievements, new agricultural resources and technological systems in production; development of agricultural market infrastructure; rational usage of land, with introduction of resource saving and restoration technologies; elevated level of environmental safety. Therefore, the current state of economic development is set by several specific requirements for agricultural holdings. The authors of the presented study agree with this statement, because along with the restoration of resource potential, optimization of production structure, territorial allocation, familiarization of investment, they should focus their attention on the formation of labour potential of enterprises, restoration of social infrastructure and realization of social programs.

I. Irtyshcheva *et al.* (2021) consider that the development of agricultural holdings is a factor of revival of agricultural production and a model of provision of food for the population of Ukraine at the level of established norms of nutrition, supply of industry with raw materials, growth of labour employment of rural people, growth of their wages, improvement of wellness and prosperity, and social development of rural regions. The practice of forming agricultural holdings in agricultural sector of Ukraine indicate that it is a long and laborious process. At the same time, N. Popadynets *et al.* (2020) believe that the advantages of such farming are found by combining the function of ownership, labour, and management in one person, which stimulates added impulse to efficient agricultural production. Holding-type companies are full-scale and equal manufacturers of agricultural products; they occupy a leading place in the Ukrainian food market. Conditions and time are necessary for their formation and development, they depend to a large extent on the following factors: improvement of financial, credit and taxation policy; creation of appropriate land legislation; formation of appropriate infrastructure of services, agricultural service, processing and sale of products; state support of holding companies in creation of production facilities; conducting special training events based on secondary and higher educational institutions and promoting the development of integrated structures in mass media (Khodakivska & Mohyl'ny, 2020).

In the activities of agricultural holdings, the main task is to consolidate long-term, stable and sustainable production, organizational, economic, technological and other types of connections that ensure maximum

reduction of products losses in the process of transition from one sphere to another, well-coordinated functioning of the remanufacturing link and stable provision of food facility (Hou *et al.*, 2017). M. Bil *et al.* (2021) argue that the aim of creation of agricultural holdings are the following: provision of raw materials of own production, since the organization of own production is less expensive in conditions of imperfect market, compared to operations on free market; fixing on the market of land lease in expectation of the moratorium annulment; reduction of property risks; control over processes of agricultural production; expansion of sales markets for products of own production; preferential tax treatment; effective assets management of local self-government along with cooperative property. The authors of this study agree with the opinion of M. Bil *et al.* (2021) regarding the purpose of formulating an agricultural holding. It was established that the goal of the agricultural holding formation is to supply the coordinated activity of all legal economic structures involved in organizational technological cycle of production of certain types of final products; economic and social interest of each partner in obtaining a high final result; qualitative organization of the agrarian market. N. Key (2019) believe that in comparison with small agricultural enterprises, agricultural holdings have better opportunities to attract investments, experienced and skilled staff, developed infrastructure and ability to diversify risks.

The analysis of literature allowed making the conclusion that the transition of agricultural sector to market economy in the system of agricultural enterprises development is a significant prospect for the development of agricultural production in Ukraine. The functioning and effective production management is impossible without solving acute social issues, cutting social tension, and establishing partnership relations between farms and territories they are located at. The degree of scientific and practical elaboration of social aspects of change and transformation of agricultural production will determine the development of the economy of agriculture sector. The functioning of farms and agricultural enterprises that have the leading role in solving provisions issues in the state, occupy one of the important positions of economic activity in the effective flow of the agricultural sector. The attractiveness of agricultural sector in the view of investment helps to attract significant financial resources to agricultural production, which actively introduces innovative technologies and quality management systems, improves the qualification of employees, improves the management system of agricultural enterprises.

The importance of rural communities' development is also related to Ukraine's performance of its obligations to harmonize the current legislation of Ukraine and the European Union. The important principles of the state policy implementation should be the reduction of the level of economic development division in

the territories and social provision of the population. In addition, the possibilities of territorial communities and local self-government bodies to solve the issues should be established, related to socio-economic development and improvement of property inter-budgetary relations independently. Opening new possibilities for rural community and local governments, the creation of preconditions for the suspension of the social sector decline, reducing the intensity of the process of depopulation, promoting the agricultural production growth, increasing the employment of the population in the agricultural sector – all of this can ensure the development of holding structures in agricultural sector. In conditions of change of the rustic lifestyle and production relations, which will ease the formation of an employee interested in the results of his/her work, the solution of economic issues and revival of rural regions will be ensured. The promotion of the ability of rural people to provide adequate employment, income level, appropriate household and social and cultural services can be ensured by the creation of integrated structures and the growth of agro-industrial production, which determine the level of development of rural social sphere and social wellness of rural people. The provision of material benefits to the population: food, industrial goods, services, and conditions that meet certain needs of people and meet their interests depends on the speed and scale of agricultural production growth.

Consequently, generalizing the results of the research, it is concluded that in Ukraine there are certain consequences of functioning of agricultural holdings: the increase of competition on the market of land lease and increase of the size of rent; the promotion of investment attraction into agricultural sector; the growth of productivity and volume of production; the usage of skilled staff; the usage of resources in development of the village; the growth of competitiveness of agricultural production; the growth of innovation processes in agricultural sector; growth of revenues to local budgets. By the aid of the historical transformation of the established forms of economic activity which existed before 1990s, insistence and hardworking of small farms owners and large agricultural holdings, the agricultural sector of Ukraine became a locomotive of the national economy. And it concerns not only territorial level, but also the country in general, because it has the largest crop and volume of increasing of agricultural exports annually.

CONCLUSIONS

As a result of detailed analysis of formation of agricultural holdings and coordination of interests of their participants, it was possible to determine that agricultural holdings allow restoring the economic relations between economic entities (structural-organizational aspect), to explicit distribute functions of financial-economic activity (functional aspect), to increase incomes

and reduce expenses on production and sale of products by tools of building a full production cycle (economic aspect), to provide equalization of incomes of employees of all participants of integration structure, to manage the social conflicts between agricultural and industrial staff, and to increase motivation to increasing of the productivity (social-psychological aspect). In addition, the expansion of processes based on creation of various agro-industrial formations allows solving the following issues: the provision of the population with the necessary final products; the coordination of business activity of the members of the association; the protection of common property interests, their financing and crediting; the carrying out marketing researches on production and delivery of the final product to the final consumer; the ensuring stronger competitive positions in the food market. The most stable are the agro-industrial associations, which create a closed cycle "production-processing-realization" that allow them to restore inter-branch price imbalance, to overcome monopoly of industrial structures and their dictates in the formation of prices for raw materials and to strengthen cooperation and coordination of the activity of structural units.

The functioning of agricultural holdings is a model of restoration of agricultural production and provision of food wellness of the population of Ukraine at the level of sustainable consumption standards, the provision of industry with raw materials, the increase of employment opportunities of people living in the village, the increase of their wages and incomes, and social development of the territory of rural region. Generalization of the above facts of functioning of agricultural holdings allows establishing the main competitive advantages (the growth of budget revenues, creation of new jobs and implementation of public programs). In summary, creation of agricultural holdings has generated favourable starting conditions in the regions for revival of agricultural production, its transfer to intensive way of management, the beginning and active development of entrepreneurship and renovation of social sphere of infrastructure. The main vectors for further research on this subject are the investigation of the activity of agricultural holdings and their concrete results that can become an effective tool for building the model of the future development of agro-industrial complex.

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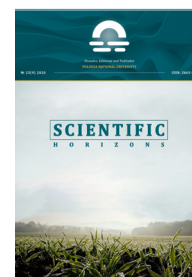
Оцінка впливу діяльності сільськогосподарських підприємств на економічний розвиток регіонів України в період з 1990 по 2020 роки

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Анотація. Актуальність досліджуваної теми зумовлена занепокоєнням суспільства, адже нині в Україні активно впроваджується термін «ринок землі», завдяки чому монополюю привласнюється і перерозподіляється рента з метою збагачення кількох потужних землевласників і землекористувачів, які вже контролюють більше половини сільськогосподарських угідь України. Метою даної роботи є здійснення об'єктивного аналізу економічних процесів та висвітлення регіонального розвитку територій України, на яких функціонують сільськогосподарські підприємства та фермерські господарства. Провідними методами дослідження були діалектичний метод пізнання економічних явищ з розглядом в історико-економічному аспекті та абстрактно-логічний метод, який покладено в основу формування пропозицій і висновків. Показано, що агрохолдинги не тільки підтримують сформовану в економіці соціальну сферу, а й можуть реалізовувати програми, орієнтовані на розвиток найманих працівників та зростання їх соціальної захищеності. Практична цінність дослідження обумовлена також тим, що в інноваційних технологіях в аграрному секторі залучаються прогресивні принципи управління, господарювання та перенесення частини соціальних благ, доступних населенню міст, на село, які сприяють економічному розвитку громад, що сприяє підвищенню рівня добробуту населення. Результати дослідження свідчать, що в Україні існують передумови для розвитку агробізнесу. Зокрема, достатність земельних ресурсів; сформовано необхідну виробничу інфраструктуру та соціальну сферу; організовано виробництво високоефективної сільськогосподарської техніки та обладнання для цільового виробництва в різних едафокліматичних умовах, про що свідчить щорічне зростання кількості фермерських господарств у більшості регіонів України. Функціонування фермерських господарств є альтернативною можливістю паювання земель сільськогосподарського призначення, що сприяло створенню економічного підґрунтя для системи сільськогосподарських підприємств

Ключові слова: земля, фермерське господарство, регіональний розвиток, холдинг, економічні відносини



UDC 631.152

DOI: 10.48077/scihor.25(7).2022.74-81

Farm Size and Technology Implementation: A Comparison between Canada and Ukraine

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Article's History:

Received: 16.08.2022

Revised: 15.09.2022

Accepted: 17.10.2022

Suggested Citation:

Khodakivska, O., Pugachov, M., Pugachov, V., Mamchur, V., & Yurchenko, I. (2022). Farm size and technology implementation: A comparison between Canada and Ukraine. *Scientific Horizons*, 25(7), 74-81.

Abstract. Many factors play a vital role in the development of agriculture, which include the technology of production, the size of farms in the country and the national policy (including trade policy) in relation to producers of these products. Therefore, the analysis of the above-mentioned factors in Ukraine stays relevant. The purpose of this study was to investigate the situation in the agricultural sector of both countries to form methods of further development of the sector in Ukraine based on the Canadian practices. The leading research method is analysis, thanks to which the agricultural sector was studied. In addition, the comparison method was used in the study of agriculture in Ukraine and Canada. Canada uses the latest methods of growing and tending produce, while in Ukraine there is still manual labour in some enterprises. It was proved that the main reason for this difference in development is the limited ability of Ukrainian companies to attract investment or use credit. The authors concluded that there are fundamental differences in agricultural development in Ukraine and Canada, the reasons for which are explained not only by different geographical, but also by institutional and historical conditions. Meanwhile, the level of agricultural development in Canada is much higher than in Ukraine, showing the need to borrow some principles of the sector. The main ones among them include active attraction of investments, emphasis on technology development, minimal state interference in the sector and others. A more detailed consideration of finding new opportunities to attract investment in the agricultural sector of Ukraine will remain relevant in the future. The article can be useful for studying the specific features of economic development of the agriculture in Canada and Ukraine; for formation of national policy in this sector; for entrepreneurs to make their investment decisions

Keywords: Ukrainian economy, Canadian economy, agricultural products, agricultural sector, export



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INTRODUCTION

The role of agriculture in country's development is enormous. A well-developed agricultural sector allows a country to be not only less dependent on international prices for certain resources, but also to be much more resilient in case of disasters, wars, and cataclysms (Kurdyumov, 2021). Agriculture stays important for achieving the Sustainable Development Goals, in particular Goal 2 – eradicate hunger (Viana *et al.*, 2022; Chen *et al.*, 2022;). However, for some countries, agricultural development is still particularly important for the development of their economies because of the international specialisation of their economies in producing this type of product (Morkunas & Labukas, 2020; Jouan *et al.*, 2020). Among them are developing countries (e.g., India, Ethiopia, Nepal, etc.) and some developed countries (e.g., Australia and Canada). However, such developed countries tend to specialise in resource exports, with agricultural production occupying a small share of foreign trade (Mirzoieva *et al.*, 2021; Fafurida *et al.*, 2019). The reason that the agricultural sector has the potential to grow primarily in developing countries is that agriculture is a good start for such countries to overcome poverty; in addition, it can supply a good foundation for building other sectors (Nugroho, 2021; Sarkar *et al.*, 2018; Kupalova *et al.*, 2021).

Ukraine is one of the countries specialising in agricultural production and exports (Skrypnyk *et al.*, 2021). Although considered to be a country in transition, in fact it can be considered a developing country, especially since most countries have long recognised that Ukraine is a market economy (Heldak *et al.*, 2018). One of the characteristics of the modern Ukrainian economy is its instability. According to H. Chen *et al.* (2022), the riskiness and instability of agriculture is one of the reasons for constant fluctuations within the whole economy: after all, the income of the state in case of its specialisation in agriculture is affected not only by the price of these resources in the foreign market, but also by the yields within the country. However, J.W. Amanullah *et al.* (2019) believed that there are opportunities to stabilise the income of the country and enterprises from agriculture. The main of them are the use of the latest technologies in creating products of the agricultural sector, which allows achieving its sustainable development (Jia, 2019). Thus, it stays particularly important for the Ukrainian state to ensure technological progress in the sector. In addition, K.M.M. Adnan *et al.* is convinced that monitoring the development of farms (including their size) and current trends in farming and trade opportunities for farms, including in foreign trade, plays a significant role. These factors differ from country to country. According to S.S. Kamble *et al.* (2020), the Australian development system with many small households differs a lot from the European system, where large holdings dominate the market. Each system has advantages and disadvantages that will affect agricultural development differently.

In Canadian agriculture the central figure is the producer and their economic and social interests (Morris & Bowen, 2020). Producers form and manage industry unions, producers' associations, and create cooperative verticals of production from agricultural inputs to the final consumer product. The only rule for becoming a farmer in Canada is to have an agricultural education or to have completed an apprenticeship related to working on a family farm (Nugroho, 2021). Thus, Canada, in setting up its single agro-industrial complex as a unified system, is incredibly careful to take advantage of the possibility of government intervention in the industry. It runs strictly within the framework of laws and is a partner for both producers and consumers of products (Viana, 2022). Hence, it is relevant to consider the development of agriculture in Ukraine, how the three factors outlined above affect it. For clarity, the analysis in the study is based on a comparative characteristic with Canada, which also specialises in the export of resources, including agricultural products.

The purpose of this paper was to investigate the agricultural sector to form methods of development of the sector in Ukraine based on the Canadian practices. The object of the study is agriculture in Canada and Ukraine, and their current state. The originality of this paper lies in the fact that in economic science no capacious comparison of agriculture of these two countries is found, although such an analysis will be useful for the formation of future national policy in this area.

MATERIALS AND METHODS

The entire study can be divided into two parts: the first one analyses Canadian agriculture, in particular the level of technology development on local farms, their size, and the characteristics of agricultural trade in the country; the second part analyses related concepts in Ukraine with a parallel comparison with Canada. The paper concludes with a summary of what features of agricultural sector development in Canada Ukraine can apply to local agricultural development. The analysis of the agricultural sector is focused on the period after the collapse of the Soviet Union, due Ukraine gaining independence and thus the emergence of an independent agricultural sector in the country (only briefly mentioning features of the pre-Soviet period). However, most attention is paid to the period of the last 10-15 years, especially in statistical studies, because at this time the last trends of the branch development are formed, which are characterised by enlargement of farms and reduction of their numbers.

The analysis of agricultural development in Canada is based on foreign sources, while the studies of Ukrainian authors were used to describe the situation in Ukraine. The main source of statistical information, namely the analysis of exports of both countries, their products of the agricultural sector, was the TradeMap (2022a)

Internet resource, which provides detailed information about the countries' foreign trade by year in terms of goods, services and countries, which makes the analysis of foreign economic activity particularly effective. However, the types of products on this resource are divided into categories, which sometimes complicates the analysis. Thus, in researching Canadian foreign trade, the authors had to exclude an item in the resource that reads "Wood and wood products; charcoal". The problem is that while the extraction and sale of wood is related to agriculture, the sale of wood products and charcoal is not. Thus, the paper decided not to include this category, as it significantly distorted the agricultural sector output figures. Thus, the countries' foreign trade figures approximate the real picture, which, however, can be considered quite plausible, which is also confirmed by the data obtained from the analysis of information from other sources. In addition, some data was too big to be described in the tables or was not fully highlighted on the website. Such categories in the table are marked accordingly. Another important source

of statistical information was the website of the State Statistics Service of Ukraine (Derzhstat, 2022). It was used to analyse the size of farms in the country.

RESULTS AND DISCUSSION

Main priorities in Canadian agricultural sector policy can be formulated as follows: creating conditions that will ensure producers' income; protecting producers' interests; saturating domestic market for products; and maximising exporters' profits from selling products on foreign markets. The government is trying to secure farmers' activities so that they are conducted within a framework of sustainable development and constant change, reflecting a rapid response to any changes affecting the industry. This should help the industry to better cope with changes in the climate and leads to greater diversification of the sector through the constant transformation of the products grown.

It is important to look at Canada's foreign trade in agricultural products. The evolution of the agricultural sector's share of the country's total exports is showed in Fig. 1.

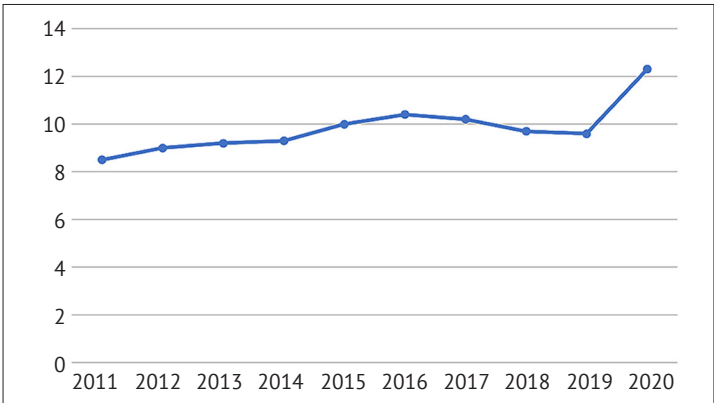


Figure 1. Share of agriculture in Canada's exports from 2011 to 2020, %

Source: TradeMap (2022a)

According to Figure 1, there is a clear upward trend in the share of agricultural products in Canadian exports. This also indirectly indicates the increasing role of the sector in country's economy. The evolution of

the main types of agricultural products that are exported is showed in Table 1. To fully investigate the dynamics of the share of agriculture in the country's exports, the authors chose a decade (from 2011 to 2020).

Table 1. Ratio of exports of selected agricultural products to total agricultural exports of the country from 2011 to 2020, %

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cereals	21.58	18.57	19.67	20.11	17.87	13.92	14.74	16.47	15.69	16.50
Seeds and fruits	20.94	20.70	17.83	17.55	16.56	17.77	18.46	17.38	13.07	16.03
Meat co-products	14.64	11.35	11.17	12.07	11.19	11.63	11.77	11.71	13.08	13.20
Fish co-products	11.32	9.13	9.03	8.81	9.72	10.37	10.36	11.00	11.46	10.97
Vegetables	11.23	7.82	10.42	10.22	11.89	11.96	10.55	9.36	10.19	11.69
Other	11.51	32.43	31.88	31.24	32.76	34.35	34.12	34.08	36.51	31.60

Source: TradeMap (2022a)

Table 1 shows that the share of the first two main categories in agricultural exports is gradually decreasing, while that of meat is gradually increasing. Moreover, the share of export products other than the first five (category “Other”) is also gradually increasing. All these factors point to a gradual diversification of agriculture, which has been mentioned before.

Studies show that in Ukraine, as in Canada, the average farm size has gradually increased over time (Graubner & Ostapchuk, 2017). According to the State Statistics Service of Ukraine (Derzhstat, 2022) the average

farm size in 2018 was approximately 351.84 ha, in 2019 – 366.22, in 2020 – 385.83. The number of small enterprises is gradually decreasing (there was a particularly large decline in 2020 due to the COVID-19 crisis), while the number of large companies is mostly increasing. It is also important to note that individual enterprises in Ukraine are particularly large (over 10.000 ha), as shown in several studies (Graubner & Ostapchuk, 2017). It is also relevant to consider Ukraine’s foreign trade. Figure 2 shows the dynamics of the share of agriculture in the country’s exports from 2011 to 2020.

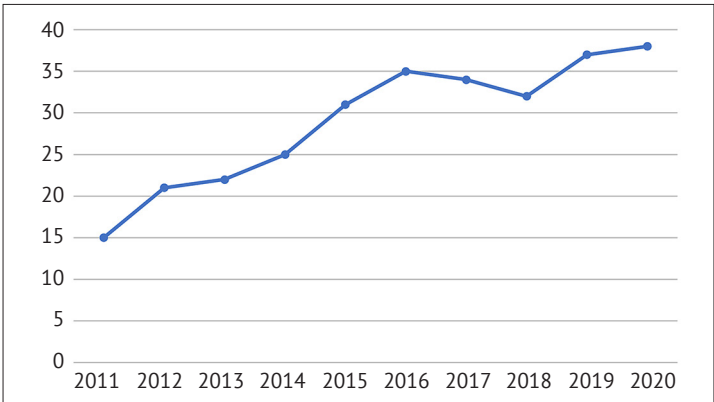


Figure 2. Share of agriculture in Ukraine’s exports from 2011 to 2020, %
Source: TradeMap (2022b)

Figure 2 shows that the share of the agricultural sector in Ukraine has increased significantly over the last 15 years – almost fivefold. This reflects the increasing specialisation of the country in the international arena as an exporter of resources. It is also related to

the gradual recovery of the sector due to the problems that arose after the collapse of the Soviet Union, associated with changes in the state system and forms of power. Changes in exports by agricultural sector are provided in Table 2 below.

Table 1. Ratio of exports of selected agricultural products to total agricultural exports of the country from 2011 to 2020, %

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cereals	35.15	47.33	46.29	48.02	50.29	47.85	44.25	47.10	51.44	50.36
Animal or vegetable fats	33.01	28.32	25.48	28.06	27.39	31.22	31.39	29.25	25.27	30.80
Oilseeds and oil-bearing fruits	13.94	11.91	14.88	12.39	12.25	12.09	14.02	12.71	13.69	9.85
Meat and edible meat co-products	1.92	2.14	2.53	2.80	3.13	3.05	3.62	4.20	3.80	3.49
Dairy products	6.84	4.16	5.03	4.22	3.21	2.60	3.37	3.13	2.42	2.28
Other	9.14	6.14	5.79	4.51	3.73	3.18	3.36	3.60	3.37	3.22

Source: TradeMap (2022b)

The authors established that in terms of Ukrainian agricultural exports, cereals (apparently wheat of different varieties) and the products related to vegetable oil (apparently sunflower oil) dominate considerably. These two categories account for more than 80% of all agricultural exports in 2020, which is a dangerous factor for the economy as it significantly increases its exposure to the prices of these products. Furthermore, the trend towards specialisation appears to be continuing – this is proved by the fact that the rest of the

sector’s exports are taking a smaller share each year and by the gradual increase in the weight of agricultural products in the country’s exports. In Canada, the opposite is true with increasing diversification of the country’s agricultural exports. The product composition of agricultural exports in both countries is quite similar. Therefore, in the first five of the export commodities three are converging: cereals, meat, and oilseeds. However, as mentioned above, the agriculture of both countries is still different from each other.

S. Kozlovskiy *et al.* (2018) studied the introduction of technologies and the attraction of investments in the agricultural sector of Ukraine. The researchers found that the problems in the technological environment are related to the fact that Ukrainian enterprises mostly fall behind foreign enterprises in introducing innovative technologies; most farms, especially small ones, use outdated machinery and often even manual labour. The data of the presented study confirm the results of the work by L.B. Gnatyshyn (2018) on the use of the technological potential of Ukrainian enterprises. L.B. Gnatyshyn (2018) proved that the excessive cost of borrowing is associated with high interest rates on loans in Ukraine; high rates will also be demanded by foreign investors despite the high attractiveness of agriculture in the country in general. According to V. Onegina & Y. Vitkovskiy (2021), the main problem with the actions of the state and the agricultural holdings themselves has been their focus on short-term goals rather than long-term ones.

According to O. Kuzmenko *et al.* (2020), the introduction of innovative technologies into production allows for lower variable costs in exchange for higher fixed costs (which is particularly helpful given that farmers mostly have exceptionally low fixed costs, and in some cases none). Innovation in the country's agricultural sector over time leads to the creation of new jobs in the industry (Loizou *et al.*, 2019; Patyka *et al.*, 2021). The authors of this study confirm this statement because it was investigated that to increase the efficiency of farms, they need more information to make their decisions, more research, and more diagnostics, which also requires added funds. The technologies that are being introduced to large farms to increase their efficiency include the creation of large databases with all relevant information (on individual plots on the farm, on crops, nutrients, etc.); automatic control technologies; use of drones; remote sensing, etc. Absolutely all types of farms are gradually changing from wheat to canola (a Canadian variety of rapeseed and suet) (Brown *et al.*, 2020).

The development of nanotechnology is enabling new agrochemical elements and new delivery mechanisms to improve crop yields and promises to reduce the use of pesticides (Sekhon, 2014). According to L. Pronko *et al.* (2020), nanotechnology can be used for precision farming, to increase crop yields without compromising soil, water resources, improving long-term nutrient uptake by soil microorganisms. There are also technologies related to microbiota that can protect production from heterogeneous stresses (Berg, 2009). They can be used to transfer genes, DNA or to treat produce to increase food storage. In turn, C. Parisi *et al.* (2015) believes that with the help of nanotechnology, Canadian farms significantly increase their competitiveness compared to farms in other countries.

Soil degradation is one of the biggest problems that Canadian scientists have been working on (Awada

et al., 2014). To reduce the effects of soil erosion, the government tried to implement measures whereby a certain crop (e.g., wheat) was planted in the first year and nothing was planted at all in the second year. However, practice has shown that this approach did not prevent land degradation. Therefore, modern Canadian agronomists are working on new methods to combat this problem. According to W. Morris & R. Bowen (2020), the most popular tillage method stays No-till, i.e., zero-tillage, in which seeds and fertilisers are applied to the soil in one time (in one operation), allowing less soil disturbance, and its surface is covered with specially shredded plant residues – mulch. This allows for efficient harvesting every year (instead of having to take breaks to plant every 2 or 3 years), which significantly increases farmers' income (Hamel and Saindon, 2017). The adoption of no-till technology has increased the size of cropped area on the prairies from 8% to 59% between 1991 and 2011 (Brown *et al.*, 2020). Technological innovations carried out by Canadian agronomists also allow new crop species and hybrids to be grown in harsh climates.

It is predicted that the next 60 years will see an increase in temperature in Canada, which could significantly affect agriculture through droughts and severe storms, resulting in lower yields (Stalhammar & Thoren, 2019). Such changes are forcing farmers to adapt to them at an accelerated pace, enlisting the help of specialists from various fields. To respond effectively to the incoming changes in climate, Federal ministry of agriculture and agri-food of Canada is constantly working with researchers in academia and industry organisations to find innovative and transformative solutions to this problem. An added challenge is also the fact that Canada is a large country by area, which complicates adaptation processes, which must vary according to soil type and natural conditions (Sarkar *et al.*, 2018).

In Ukraine agriculture also plays a vital role in economic development, even more than in Canada. During the Soviet era, Ukraine was one of the main suppliers of agricultural products for all union republics. After the collapse of the Soviet Union, the sector began to rank second in importance after metallurgy, and after 2014 it became country's main supplier again (Bakulina *et al.*, 2019). In the 1990s, the country had many small enterprises, which appeared from the privatisation of collective and state farms. Their functioning in the fragile and unstable post-Soviet economy was difficult, but over time some enterprises were allowed to merge, leading to the formation of agricultural holdings (Jiang & Chen, 2020; Suder & Kahraman, 2018). This had a mixed effect on the development of country at that time. However, it is worth recognising that without farm consolidation in today's economy, the existence of such enterprises is virtually impossible. Therefore, this process was and still is unavoidable and became an objective reaction to the existing conditions of the agrarian market (Dub, 2017; Burachek & Mikhailenko, 2018).

Hence, compared to Canada, Ukraine has significant problems in introducing technology into the agricultural production. This applies even to machinery, not to mention nanotechnology, which is rapidly gaining popularity in Canada. As mentioned above, the main reason is the excessive cost of funds for Ukrainian enterprises. This reduces the production capacity of the country and its competitiveness on the market. A possible short-term solution to the problem is the government's subsidising of loans for enterprises. Nevertheless, in the long term, it is necessary to attract foreign investment into the industry, for which existing problems destabilising the economic situation in the country, especially corruption, need to be addressed. Another option for attracting investment is the creation of a more favourable investment climate by the state, which may involve lower tax rates, simplification of the investment process, and other methods.

CONCLUSIONS

The study analysed the agricultural sector in Canada and Ukraine and compared them. In general, the agricultural

sector itself differs in both countries: Canadian one is more diversified by type, while the Ukrainian one is very concentrated (primarily on cereals and vegetable oil). It is difficult to say whether Ukraine should move towards diversification in the current unstable conditions of the country's existence. Nevertheless, it is worth remembering that such a high dependence of exports on one type of resource could become a significant danger in case of crisis situations (a drop in commodity prices or environmental disasters).

In terms of technological development, Canada is ahead of Ukraine. Thus, improving the investment climate in the country by combating general economic instability and corruption and providing cheaper credit, especially for small and medium-sized farms, could be helpful. Overall, Ukraine should adopt the Canadian practices in the creation of future national policy in this sector. The main points on which emphasis should be made are attracting investment, increasing the use of the latest technologies in the sector, and reducing the country's role in regulating the sector, especially the land market.

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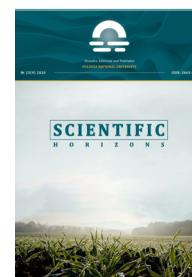
Величина фермерського господарства та впровадження технологій: порівняння між Канадою та Україною

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Анотація. У розвитку сільського господарства життєво важливу роль відіграють багато чинників, до яких належать технологія виробництва, розмір господарств в країні та національна політика (зокрема, торговельна політика) по відношенню до виробників цієї продукції. Тому аналіз вищезазначених факторів в Україні залишається актуальним. Метою даного дослідження було вивчення ситуації в аграрному секторі обох країн для формування методів подальшого розвитку сектору в Україні на основі канадського досвіду. Провідним методом дослідження є аналіз, завдяки якому було вивчено аграрний сектор. Крім того, при дослідженні сільського господарства України та Канади використовувався метод порівняння. У Канаді використовуються новітні методи вирощування та догляду за продукцією, в той час як в Україні на деяких підприємствах все ще зберігається ручна праця. Доведено, що основною причиною такої різниці в розвитку є обмежені можливості українських підприємств залучати інвестиції або користуватися кредитами. Автори дійшли висновку, що існують фундаментальні відмінності у розвитку сільського господарства в Україні та Канаді, причини яких пояснюються не лише різними географічними, а й інституційними та історичними умовами. Водночас, рівень розвитку сільського господарства в Канаді значно вищий, ніж в Україні, що свідчить про необхідність запозичення деяких принципів функціонування галузі. Основними серед них є активне залучення інвестицій, акцент на розвиток технологій, мінімальне втручання держави в сектор та інші. Більш детальний розгляд питання пошуку нових можливостей залучення інвестицій в аграрний сектор України залишатиметься актуальним і надалі. Стаття може бути корисною для вивчення особливостей економічного розвитку сільського господарства Канади та України; для формування національної політики в цьому секторі; підприємцям для прийняття інвестиційних рішень

Ключові слова: економіка України, економіка Канади, сільськогосподарська продукція, аграрний сектор, експорт



UDC 631.151

DOI: 10.48077/scihor.25(7).2022.82-89

Directions of Monitoring the Financial Activity of Agricultural Enterprises

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Article's History:

Received: 11.08.2022

Revised: 10.09.2022

Accepted: 11.10.2022

Suggested Citation:

Krasnostanova, N., Yatskevych, I., Zhuravel, O., Vasyutynska, L., & Akymenko, N. (2022). Directions of monitoring the financial activity of agricultural enterprises. *Scientific Horizons*, 25(7), 82-89.

Abstract. The relevance of this study is conditioned upon the special importance of accounting reports in financial performance assessment of organisations that form the basis of the agricultural sector of the state and the need to find effective ways to improve the procedure for conducting such reporting activities and improve its quality. The purpose of this study is to analyse the principal areas of accounting for the financial aspects of the activities of modern agricultural enterprises. The leading research methods are systematic analysis, analytical comparison, and synthesis. The theoretical framework of this study included the papers on the pressing issues of accounting and analysis of financial results of agricultural enterprises, in the context of assessing profits and losses of these structures. The grouping of financial results by the composition of the elements that form them were considered. The main indicators used to assess the financial stability of an agricultural enterprise are availability of net working capital, coefficient of autonomy, manoeuvrability coefficient, ratio of borrowed and own funds, coefficient of provision of net working capital, financing ratio, financial stability coefficient. The types of current financial stability are absolute, normal, unstable financial condition, budgetary crisis. The real opportunities to improve the procedure for keeping financial statements at enterprises of the agricultural sector of the economy were found, especially in the field of assessing the profits received by these organisations during their activities. The results and conclusions of the article are important for representatives of accounting departments of agro-industrial enterprises, and for representatives of government agencies controlling their activities. It was concluded that there is no single method for assessing the financial condition

Keywords: agriculture, financial condition, accounting (financial) reports, methods of financial analysis, agricultural sector



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INTRODUCTION

The issues of making a profit from economic activity occupy the principal place in the general system of cost instruments and levers of economic management. The financial result is a complex indicator, thanks to which it is possible to summarise the results of the production and economic activities of the organisation and figure out the effectiveness of its operation (Greenbaum *et al.*, 2019). The indicators of financial results affect financial stability, solvency, business activity of an economic entity. In this regard, it is advisable to comprehensively assess the financial condition of the organisation.

Notably, study of these issues is being updated in the context of the development of new accounting standards aimed at bringing the order of income accounting and the establishment of accounting statements as a basis for analysing financial condition to international standards (Kumar, 2016). Information about financial results is necessary for successful operation of any economic entity. For the purposes of making effective management decisions, internal and external users need reliable information about financial results obtained, which can be provided only as a result of an adequate understanding of the essence of the accounting category "financial result".

Economic profit is an accounting profit including implicit costs. In other words, economic profit is the difference between gross revenue and external (explicit) and internal (implicit) costs. Notably, the concept of financial result of activity, in the form of profit or loss, is a certain form of implementation of economic relations in the process of establishment, distribution, and use in the monetary form of the surplus product that has developed at a certain stage of the development of society, in a certain economic system, and implemented through the economic mechanism created in it (Mackevicius, 2016).

The modern theory of financial results consists of a combination of elements of various ideas about the economic content of the result. Each user can choose a certain indicator as a criterion of financial result. In turn, financial information should provide users with transparent and objective information about this indicator. Considering any market relations in different time frames, J. Hill (2018) pays special attention to the results of the activities of the participants of these relations. These are economic entities and their activities, the functioning of which is of interest to a wide range of organisations and persons involved in market relations (Hill, 2018). Certain tools are needed to process information. The main tool for this is financial analysis.

According to Y. Mishura (2016), the main purpose of financial analysis is to find key parameters that allow building an objective and exact picture of the financial condition of the economic entity. Financial analysis allows objective assessment of both internal and external relations (position on market, development prospects, etc.) of the analysed object. S. Neftci (2018) considers

that the main tasks of analysing the financial state of the organization are: assessment of the effectiveness of financial policy of the economic entity; prevention of crisis situations; forecasting the activities of the economic entity. In accordance with C. Jones *et al.* (2018), the analysis of the financial condition allows assessing: the property status of an economic entity; the degree of entrepreneurial risk, in particular, the possibility of repayment of obligations to third parties; capital adequacy for current activities and long-term investments; the need for additional sources of financing; the ability to increase capital; the rationality of borrowing; the validity of the policy of distribution and use of profits, etc.

The purpose of this study is to analyse the principal areas of accounting of the financial aspects of the activities of modern enterprises in the agrarian sector of the economy to find opportunities for improving the procedure for keeping financial statements.

MATERIALS AND METHODS

The main methodological approach in this study is a combination of systematic analysis of the aspects affecting quality of financial accounting at enterprises of the agricultural sector, with an analysis of the characteristics of agricultural enterprises. The chosen combination of methods contributes to the most complete and optimal disclosure of the subject matter, since it involves the combination of the analysis of the issues of profit-making by agricultural enterprises with a practical analysis of the financial results of their activities conducted based on real calculated data.

This study was carried out in several stages.

1. At the first stage, theoretical research on the evaluation of the effectiveness of financial activities of organisations that form the basis of the modern agricultural sector was carried out. In addition, a systematic analysis was carried out, which is essential for obtaining the preliminary results of this study.

2. At the second stage, a study was carried out on the specifics of the activities of agricultural enterprises, in the context of the quality of their assessment of profits and losses of activities and the reflection of these budget items of enterprises in financial reporting materials. In addition, analytical comparison of the preliminary results obtained with the data of researchers of issues directly or indirectly related to the problems of accounting and analysis of agricultural enterprises financial results was carried out.

3. At the final stage, conclusions were formulated according to the results obtained, which summarise the entire complex of research efforts, and act as their final display. In general, results of this study fully reflect all stages of scientific research and are a clear demonstration of the entire complex of accounting and analysis of financial results of agricultural enterprises in the current economic conditions.

RESULTS AND DISCUSSION

Most often, financial results in the economic literature are defined as: profit or loss; increase or decrease in the capital of the organisation; increase in net assets (Hessou, & Lai, 2018). Thus, financial result of the activity of an economic entity and an agricultural enterprise can be considered as a change in capital, as a change in cash (economic interpretation). The view on the essence of financial results depends on which approach is used: accounting one or economic one. Proponents of the accounting approach more often define the financial result as the difference between the income and expenses of the organisation, while distinguishing several components depending on the types of income and expenses (Atstaja *et al.*, 2020):

- 1. Financial result from ordinary activities – is formed when comparing income and expenses for ordinary activities of the organisation, i.e., revenue less reimbursable taxes and cost of sales, commercial and management expenses.
- 2. Financial result from other activities.
- 3. Financial result before taxation – the result of the activities of an organisation before the payment of income tax and other similar payments.
- 4. Net profit (loss) – is formed after payment of all income taxes, other payments from profit before taxation (for example, fines, penalties on taxes).

The financial results of an economic entity, which is an agrarian organisation, are characterised by absolute and relative indicators. Absolute indicators of financial results reflect profit, and relative indicators reflect profitability.

Regarding the activities of organisations in the agricultural sector of economy, now there is a possibility of an ambiguous interpretation of definitions of the type of profit. This, in turn, can cause problematic situations related to the assessment and research of this economic category of various aspects of the activities of agricultural enterprises. The complex of concepts and terms that define profit, as economic theory develops, has undergone

significant changes from the simplest definition, such as income from production and sale to the concept that characterises the final financial results in all the variety of commercial activities.

Next, the study considers the grouping of financial results by the composition of the elements that form them (De Pascale *et al.*, 2021):

- 1. Gross profit – stands for revenue from principal activities reduced by cost.
- 2. Profit (loss) from sales is the difference between gross profit (loss) and commercial and management expenses.
- 3. Marginal profit – the difference between revenue (net) and variable costs.
- 4. Profit (loss) before taxation – found by summing up the above income and deducting expenses related to other activities of an economic entity. This indicator shows the effectiveness of the entire economic activity of the organisation.
- 5. Net profit (loss) – reflects the amount of profit (loss) that was formed by the business entity after deducting all costs and tax payments at the end of the reporting period.
- 6. Retained earnings (uncovered loss) – the final financial result (profit or loss) that was received by the organisation as a result of economic activity, which remained after taxation, but has not yet been divided between the owners or spent on business needs (in case of profit).

The methods of financial analysis, otherwise called stochastic modelling, are, to a certain extent, an addition and extension of deterministic analysis. These methods are most often used to assess the influence of factors that cannot be used to build a model (Jones, 2018). These methods (statistical and mathematical) are quite difficult to use and require certain skills, knowledge, and abilities. The methods of decision theory are also quite difficult to apply and do not allow figuring out the key indicators. Table 1 presents the main indicators that are used to assess the financial stability of an agricultural enterprise.

Table 1. The main indicators used in assessing the financial stability of an agricultural enterprise

Indicator	Calculation formula	Description of the indicator and standard values
Availability of net working capital (NWC)	$NWC = \text{equity} - \text{non-current assets}$	Absolute indicator, the value of which should be positive
Coefficient of autonomy (financial independence) (K_a)	$K_a = \text{equity} / \text{balance sheet total}$	For a financially stable organisation, this coefficient should be greater than 0.5. The lower the coefficient value, the less stable the financial condition is
Manoeuvrability coefficient (K_m)	$K_m = (\text{equity} - \text{non-current assets}) / \text{equity}$	Shows which part of equity is invested in the most manoeuvrable (mobile) part of assets. Recommended value is at least 0.5
The ratio of borrowed and own funds (K_{bo})	$K_{bo} = \text{long-term and short-term liabilities} / \text{equity}$	Standard value for this indicator is no more than 1
Coefficient of provision of net working capital (K_n)	$K_n = (\text{equity} - \text{non-current assets}) / \text{current assets}$	A relative indicator that characterises the provision of an organisation with net working capital. Standard value is not less than 0.1
Financing ratio (K_f)	$K_f = \text{equity} / \text{long-term and short-term liabilities}$	It shows which part of the activity is financed from own funds, and which part is financed from borrowed funds. Recommended value is at least 1
Financial stability coefficient ($K_{fin.stb.}$)	$K_{fin.stb.} = (\text{equity} + \text{long-term liabilities}) / \text{balance sheet total}$	Shows which part of the property is financed from sustainable sources. Standard value is not less than 0.6

Source: TradeMap (2022a)

Thus, it is necessary to determine a set of methods that most fully disclose the financial condition of an economic entity, are easy to use, can describe the values of the corresponding coefficients in dynamics, and also

formulate appropriate conclusions necessary to develop an effective management decision (Hessou, & Lai, 2018). The types of short-term financial stability of an economic entity are showed in Table 2.

Table 2. Types of financial stability of an agricultural enterprise

Type of financial stability	Calculation formula	Characteristics
1. Absolute	$F^{NWC}=NWC-R>0$; $F^{NWC}=OC-R>0$; $F^{AS}=VI-R>0$	The organisation is independent of external creditors, ensures full coverage of reserves and costs with its own resources. Such financial stability is extremely rare in modern practice
2. Normal	$F^{NWC}=NWC-R$; $F^{NWC}=OC-R>0$; $F^{AS}=VI-R>0$	The organisation uses all sources of financial resources to fully cover inventory and costs
3. Unstable financial condition	$F^{NWC}=NWC-R$; $F^{OC}=OC-R$; $F^{AS}=VI-R>0$	Violation of solvency, in which it is still possible to restore equilibrium by replenishing shareholder's equity, reducing accounts receivable and accelerating inventory turnover
4. Financial crisis	$F^{NWC}=NWC-R$; $F^{OC}=OC-R$; $F^{AS}=AS-R$	Lack of "normal" sources of inventory and cost coverage (these may include part of non-current assets, overdue debts, etc.), the presence of losses, outstanding liabilities, uncollectible accounts receivable

Note: *R* – reserves; *NWC* – net working capital; *OC* – operating capital (own and long-term sources minus non-current assets); *AS* – all sources (liabilities minus non-current assets)

Source: authors own research.

To date, financial stability of the enterprise is one of the main indicators of its financial condition. This applies to any enterprise, regardless of its affiliation to economic sector, including enterprises of the agricultural sector. At the same time, in modern economics, there is still no unified approach towards definition of the issues of assessing the essence of financial stability and solvency of any organisation (Atstaja *et al.*, 2020). The financial condition of an enterprise is an economic category that reflects the state of capital at any stage of its turnover and the ability of a business entity to develop at a given time. According to S. De Pascale *et al.* (2021), the results of financial activity of any organisation can be stable, unstable, and crisis, reflecting the negative processes taking place in the organisation at a given time. N. Tintle *et al.* (2018) consider that the results of financial activities of an organisation are related to the results of its economic and commercial activities.

Financial stability today is considered a fundamental category in the system of dynamic characteristics of economic system, assuming the ability of this system to return to a specific state of operating after exiting it due to external influence. Regarding the activities of organisations belonging to the agricultural sector of economy, concept of their economic stability is interpreted as the ability to adapt to sharply changing economic conditions, the property of self-regulation and changes in the financial policy carried out in a particular situation. According to M.F. Malik *et al.* (2021), the stability of financial flow control acts in this context as an obligatory criterion for determining the financial stability of an agricultural enterprise in modern economic conditions.

T. Lagoarde-Segot & E.A. Martinez (2021) convinced that the modern agricultural enterprise needs to conduct a prompt and qualitative analysis of various aspects of its activities to form a correct assessment of its current financial condition. However, according to B. Li *et al.* (2020), modern business entities should pay attention to the issues of improving their methodological support for analytical studies designed to highlight their real financial condition. Accounting, which is the main management tool of any organisation, including agricultural, the main element of which is the preparation of final annual reports, performs the functions of providing complete information about current financial condition of organisation, availability of resources and their competent use, which subsequently allows for a qualitative analysis of economic activity of organisation and making timely and high-quality decisions regarding the various stages of management of organisation.

J. An *et al.* (2022) noted that the financial activity of commodity producers plays a significant role in ensuring sustainable indicators of the development of agricultural production. Problems of market management assume the main aspect, first, an increase in the indicator of financial activity of agricultural producers, which, in general, has a positive effect on the pace of development of agricultural sector. The profit of an agricultural enterprise is considered in this context the main source of financing and ensuring the main activity, and as a basis for distributing investments in the expansion of activities in the future (Greenwood-Nimmo, & Tarassow, 2022).

The main determining criterion for assessing the effectiveness of the financial activities of agricultural enterprises is their solvency, which depends on the

reinforcement of organisation's income with real financial resources (Mukherjee *et al.*, 2021; Aslan, & Kumar, 2016; Nardo *et al.*, 2021). In this case, it appears appropriate to use special indicator coefficients based on the ratio of the amount of financial profit received by the enterprise from conducting its core business and profit from the sale of agricultural products. In addition, ratio of the volume of cash flow from the conduct of core business with its own working capital is also important, which allows for a qualitative analysis of the economic growth rates of an agricultural enterprise. Qualitative financial analysis involves study of relative and absolute indicators of financial stability of an enterprise in current economic realities, solvency of this organisation, liquidity of its products, and an assessment of the structure of assets and quality of accounting reporting (Ding, 2020). Methodology for assessing real financial condition of an agricultural enterprise involves forecasting financial indicators expected in the long and short term, and developing theoretical and practical recommendations for increasing the financial stability of the organisation, to increase the indicators of product liquidity and increase the overall solvency of the enterprise (Scarpellini *et al.*, 2021; Bulavinova *et al.*, 2021; Lehenchuk *et al.*, 2021).

The modern agricultural sector is characterised by a specific course of production processes, which determines the specifics of the preparation of accounting statements of agricultural enterprises. The procedure for organising and keeping accounting records at enterprises of the agricultural sector is regulated by special normative documents that define the principles of accounting in this industry and the procedure for submitting and receiving finished reports. According to O. Pasko *et al.* (2021), prompt and high-quality monitoring of the financial activities of enterprises in the agricultural sector allows effectively obtaining objective and complete information necessary for a comprehensive analysis of various aspects of the financial activities of these organisations.

Unfortunately, not all modern agricultural enterprises can adapt quickly to changes in economic situation, which determines the specifics of financial results from their activities. Some modern researchers (Reinhardt *et al.*, 2022; Olba-Zięty *et al.*, 2021; Shpak *et al.*, 2021) admit the possibility of distinguishing such concepts as "financial stability" of an organisation and its "financial condition". Often, the financial stability of an enterprise is interpreted as the ability of an economic entity to develop and function in conditions of constant changes in the external economic situation, while supporting the equilibrium state of its assets and liabilities. At the same time, the stable investment attractiveness of this organisation and steady growth of economic indicators of its activities are guaranteed. The preservation of solvency in conditions of constant risk from economic activity of an agricultural enterprise is also essential. According to X. Chen *et al.* (2021), the stable

financial condition of agricultural enterprise is not a coincidence but is result of systematic and high-quality work of all the links of this organisation. However, according to C. Charatsari *et al.* (2020), the stability of the financial condition dictates the ability of such a business entity to make prompt payments on the debt obligations assumed, and to plan the development of investment processes.

The financial stability and solvency are closely related to the issues of assessing the financial results of an organisation in a specific period (Chomanov *et al.*, 2019; Lemishko, 2020; Samorodov *et al.*, 2020). To date, international practice and practical activities of modern agricultural enterprises allow forming an assessment of the level of financial stability of agricultural enterprises using several fundamental parameters. According to this concept, the financial stability of an organisation operating in the agricultural sector is determined by the current ratio of borrowed and own finances, the timing of building up its own tangible assets, the available short-term and long-term obligations, the ability to provide the necessary investment injections into activities at the expense of its own financial assets (Makarenko *et al.*, 2020; Vardon *et al.*, 2021). In today's market conditions, every agricultural enterprise should be able to independently plan current market activities, considering the peculiarities of managing its own financial stability under the influence of internal and external factors that can negatively affect the results. The processes of development of the agro-industrial sector in modern conditions require the heads of agricultural enterprises and their financial condition control services to be more independent in making managerial decisions that can have a significant impact both on the development of enterprises as a whole and on the consolidation of their current financial situation (Qin, & Kong, 2021; Panasyuk *et al.*, 2021; Kuzmenko *et al.*, 2021). In the current situation, the prospect of maintaining the financial stability of an agricultural enterprises and subsequent development as a whole depends on the effectiveness of the management of the financial services of an agricultural enterprise, on their ability to correctly assess the financial situation at the enterprise, make adequate decisions and competently implement them into reality (Radchenko *et al.*, 2020; Dzwigol *et al.*, 2019; Taran *et al.*, 2020).

The current economic situation in the agricultural sector requires prompt and professional decisions aimed at the consolidation of the financial situation and ensuring proper conditions for their systematic development. In this context, the issues of assessing the real financial situation of agricultural enterprises, considering the financial results achieved and the problems of ensuring financial activity, require prompt and high-quality solutions that could ensure the development of a reliable system for ensuring the financial needs of these structures in the current economic conditions.

CONCLUSIONS

It was found that the main indicators for assessing the financial stability of an agricultural enterprise are the presence of net working capital, the coefficients of autonomy, manoeuvrability, the ratio of borrowed and own funds, net working capital, financing, and financial stability. Depending on the ratio of certain indicators, the following types of short-term (current) financial stability of an economic entity were distinguished with a certain degree of conditionality: absolute, normal, unstable financial situation, and critical (crisis) financial situation. It was proved that accounting and analysis of financial results of agricultural enterprises are complex procedures

that depend on a whole complex of interrelated factors. Based on the conclusions obtained from the results of the analysis of the financial condition, it is necessary to carry out a consistent development of measures aimed at improving and modernising the work of the agricultural enterprise. To date, there is no universal method of accounting and analysing the financial results of agricultural enterprises, which is conditioned by the complexity of forecasting changes in the main parameters of numerical analysis in a constantly changing economic situation. An approximate estimate characteristic of specific parameters that take place in a certain economic situation may be suggested.

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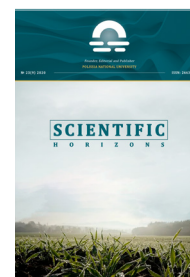
Напрями моніторингу фінансової діяльності сільськогосподарських підприємств

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Анотація. Актуальність цього дослідження обумовлена особливим значенням бухгалтерської звітності в оцінці фінансових результатів діяльності організацій, що складають основу аграрного сектору держави, та необхідністю пошуку ефективних шляхів удосконалення порядку ведення такої звітної діяльності та підвищення її якості. Метою даного дослідження є аналіз основних напрямів облікового відображення фінансових аспектів діяльності сучасних сільськогосподарських підприємств. Провідними методами дослідження є системний аналіз, аналітичне порівняння та синтез. Теоретичною основою дослідження стали праці з актуальних питань обліку та аналізу фінансових результатів діяльності сільськогосподарських підприємств, у контексті оцінки прибутків і збитків цих структур. Розглянуто групування фінансових результатів за складом елементів, що їх формують. Основними показниками, що використовуються для оцінки фінансової стійкості сільськогосподарського підприємства, є наявність чистого оборотного капіталу, коефіцієнт автономії, коефіцієнт маневреності, коефіцієнт співвідношення позикових і власних коштів, коефіцієнт забезпеченості власними оборотними коштами, коефіцієнт фінансування, коефіцієнт фінансової стабільності. Визначено типи поточної фінансової стійкості: абсолютна, нормальний, нестійкий фінансовий стан, бюджетна криза. Виявлено реальні можливості вдосконалення порядку ведення фінансової звітності на підприємствах аграрного сектору економіки, особливо в частині оцінки прибутку, отриманого цими організаціями в процесі їх діяльності. Результати та висновки статті є важливими як для представників бухгалтерських служб підприємств агропромислового комплексу, так і для представників державних органів, що контролюють їх діяльність. Зроблено висновок про відсутність єдиної методики оцінки фінансового стану

Ключові слова: сільське господарство, фінансовий стан, бухгалтерська (фінансова) звітність, методика фінансового аналізу, аграрний сектор



UDC 338.436:338.5:330.123.4

DOI: 10.48077/scihor.25(7).2022.90-100

Industry Structure of Agri-Food Production and Consumer Food Price Index

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Article's History:

Received: 07.08.2022

Revised: 18.09.2022

Accepted: 21.10.2022

Suggested Citation:

Mudrak, R., Lagodiienko, V., & Kordzaia, N. (2022). Industry structure of agri-food production and consumer food price index. *Scientific Horizons*, 25(7), 90-100.

Abstract. It is believed that one of the main conditions for the absence of a shortage and stability of food prices on the domestic market is a sufficient level of food self-sufficiency, calculated as the ratio of the volume of production of this type of food to the volume of its use in the territory of the given country. However, this approach has a weak point: production volumes in the numerator are agricultural raw materials, and not consumer-ready industrial products. Considering the export channel of the extraction of food raw materials, the production volumes of agricultural goods sufficient for food self-supply do not guarantee their availability at national enterprises of the food industry to produce semifinished foods and ready-made food in a quantity sufficient for the food market to function without a deficit. Therefore, the purpose of this study is to test the hypothesis that the violation of industry proportions of agri-food production is one of the reasons for the growth of the consumer price index in the food market of Ukraine. The authors of this study proposed the "coefficient of the ratio of gross value added created in the food industry to gross value added created in agriculture" as an indicator that describes the sectoral structure of agri-food production. It was found that, provided the other factors of influence remain unchanged, an increase in the coefficient "the ratio of gross value added created in the food industry to gross value added created in agriculture" by 1% leads to a decrease in the consumer price index of food products and soft drinks by 0.317%. It was concluded that to ensure the stability of national food prices, such a coefficient should not be less than 1. The prospects of further research include the development of an organisational and economic mechanism for the development of a closed value chain in the system of national agri-food production

Keywords: agriculture, food processing, food products, deficit, inflation, value added, coefficient



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INTRODUCTION

The growth of the Ukrainian economy and the improvement of the living conditions of its citizens are hindered by several factors of internal and external origin – the Russian-Ukrainian war, the COVID-19 pandemic, the monopoly influence of financial and industrial groups that resist the dismantling of the clan-oligarchic model of the economy, sabotaging judicial, anti-corruption, and other important reforms. As a result, the Ukrainian economy has an uncompetitive structure, excessive resource intensity and critical dependence on the import of hydrocarbons, mainly the raw material nature of production, an acute shortage of investment, unjustifiably low modernisation rates and introduction of modern resource-saving technologies, etc.

The external manifestation of the difficult state of the Ukrainian economy is chronic macroeconomic instability – long-term cyclical unemployment and constant price growth (State Statistics Service of Ukraine, 2021). And if the factors that reduce the socio-economic losses of households from excessive unemployment are the growth of self-employment, the shadow labour market and labour emigration, then fixed-income households do not have protection against excessive inflation.

The most popular object of analysis in the study of national inflationary processes is the Consumer Price Index (CPI). This is explained by the fact that the purchasing power of nominal incomes of citizens of the country, i.e., the final demand of households, directly depends on its dynamics. Over the past 22 years (2000-2021), consumer prices in Ukraine have increased 10.9 times with an average annual growth rate of +11.5% (State Statistics Service of Ukraine, 2022). These are signs of galloping inflation, which hinders the formation of national savings and undermines the policy of income growth of the population.

One of the key reasons for the growth of the food CPI is the faster growth rate of food demand compared to food supply, which leads to the emergence of deficits. According to the authors, the violation of the sectoral structure of agri-food production is a factor in the growth of consumer food prices in Ukraine. This violation is caused by excessive exports of food raw materials from Ukraine, which leads to a shortage of food industry products and an increase in the corresponding prices on the internal market.

LITERATURE REVIEW

Considering the outstanding importance of the full functioning of the food market to ensure macroeconomic stability, the subject of food prices, conditions of their formation and factors of influence attracts the constant attention of scientists, representatives of competent state bodies, consumers.

J. Baek and W.W. Koo (2009) believe that the key drivers of rising food prices in the United States between 1991 and 2008 were agricultural prices and the

exchange rate. Scientists also conclude that energy prices have insignificant effect on food prices in the short term – their impact is a long-term factor.

When investigating the causes of the rapid rise in global food prices in 2002-2008, D. Mitchell (2008) focused on three factors – the increase in biofuel production from food raw materials, the devaluation of the US dollar, and the increase in food production costs due to rising energy prices. The scientist believes that the most important of them was the increase in biofuel production in the United States and the EU. The authors find a similar approach in C. Alexander & C. Hurt (2007). Studying the impact of increased biofuel production on food prices, the researchers conclude that the increase in the area under maize and soybeans used for biofuel production in the United States leads to an increase in retail prices for livestock products in the short term.

A group of scientists, including J. Davidson *et al.* (2016), conducted a study on food price factors in the UK between 1990 and 2012. The researchers concluded that the main drivers of food prices included world prices for agricultural products, the exchange rate of the national currency, oil prices, and the duration of the period during which prices rose.

G. Erber, M. Petrick and V. von Schlippenbach (2008) believe that the main reason for the rapid increase in global food prices since 2007 was the abuse of market power by agricultural producers (fertilisers, seeds, etc.) and wholesalers in relation to agricultural producers, which requires an immediate response from international regulatory authorities. These drivers are classified by researchers as short-term impact factors. According to researchers, the factors of the long-term impact of the increase in food prices, include population growth, changes in eating habits, the growing scale of urbanisation, and the increase in the production of biofuels. The authors believe that their effect will manifest itself in an increase in supply shortages.

S. Charlebois *et al.* (2021) from the Universities of Dalhousie, Guelph, Saskatchewan and British Columbia proposed a list of factors driving food price increases in Canada in 2021: increased agricultural production costs, inflation, currency fluctuations and an adverse trade environment, the COVID-19 pandemic, problems in retail and distribution channels, changes in agricultural policy and increased regulation.

In contrast to the developed countries of Europe and North America, the factors of food prices in developing countries in Asia look different. For instance, Huh Hyeon-Seung and Park Cyn-Young (2013) argue that in a given region, the predominant factors for changes in domestic food prices are as follows: 1) own macroeconomic instability, especially in the short term; 2) food price shocks at the regional level considerably affect internal food prices in Asian countries. This effect is particularly pronounced in the medium and long term;

3) global food price shocks have little impact on both general regional food prices and internal prices of Asian countries. Similarly, other global factors, such as oil prices and food futures, according to scientists, do not justify the reasons for variations in the overall regional price and individual internal prices of Asian countries. Researchers believe that the reasons for the low dependence of food prices in Asian countries on changes in global prices are as follows: 1) there is a closer regional integration than the global one; 2) food prices are often prudently controlled and become the target of political intervention, especially in developing countries, given their impact on poverty and household well-being. Concerns about food security, agricultural protection, and food self-sufficiency also mean that food trade is subject to strict administrative and legal regulation. Unlike other manufactured goods, agricultural goods are generally subject to strict protectionist agricultural policies. Researchers believe that the main drivers of food prices in Asia are low transitional food stocks and supply shocks due to unfavourable agroclimatic conditions.

A similar approach was found in the study by A. Henna, I. Zainab and A.K. Muhammad (2011). Scientists investigate the causes of fluctuations in food prices in Pakistan and conclude that the most important variable affecting food prices in both the long and short term is the macroeconomic factor – the supply of money. Therewith, the authors do not consider energy prices to be a key factor determining food prices. However, there is a statement that contradicts the findings of Huh Hyeon-Seung and Park Cyn-Young for Asia – A. Henna, I. Zainab and A.K. Muhammad (2011) believe that global prices noticeably impact food prices in Pakistan. Specifically, the researchers note that even without imports, the growth of world food prices still puts pressure on the internal market, causing an increase in internal food prices. If world food prices rise and there is a need to import said food, imported inflation occurs in the internal food market. The close relationship between food prices on the world and national markets has been indicated by H. Ameye, F.N. Bachewe and B. Minten (2021).

Investigating the reasons for the prolonged increase in food prices in India, R. Anand, N. Kumar and V. Tulin (2016) conclude that the main factor of food inflation is the higher growth rate of food demand compared to food supply, which causes a shortage. The main reason for the accelerated increase in food demand is economic growth in India, which leads to an increase in household incomes. Rising incomes are leading to a shift in food consumption from simple starchy plant-based diets to more nutritious and valuable foods that include a range of dairy products, vegetables, fruits, and meat. But scientists attribute the insufficient rate of increase in food supply to the low level of labour productivity in India's agriculture. The problem is aggravated by inefficient management of transitional food

supplies – their overaccumulation and insufficient use during periods of rapid growth in food prices.

For poor and developing countries, seasonal fluctuations in agricultural production and the competitive structure of the market are key factors in food prices. C.B. Cedrez, J. Chamberlin and R.J. Hijmans (2020) note pronounced fluctuations in food prices in Africa – the lowest prices 2-3 months after harvesting, and the highest just before harvesting. B.L. Falcao and M. Dinerstein (2020) confirmed the assumption that resellers in Africa, using market power, pay farmers prices that are lower than competitive ones, and the consumer prices are higher than the competitive ones. In this context, P. Obie (2019) has also expressed his opinion quite unequivocally. The author notes substantial losses in the welfare of African households due to underdeveloped food supply chains – they are five times higher than anywhere else in the world. The scientist believes that the potential increase in well-being from reducing these losses is significant and is conditioned upon lower food prices. This can be effectively achieved by investing in expanding the supply chain.

Among the current factors of rising food prices around the world, the COVID-19 pandemic should be highlighted separately. J.B. Adewopo, G. Solano-Hermosilla, L. Colen and M. Fabio (2021) note that the spread of the disease and related quarantine measures are destroying supply and demand in the value chains of goods and have led to a sharp increase in food prices. The negative humanitarian and economic impact of COVID-19 will be long-term. J. Hammond *et al.* (2022) note that in poor countries, its most devastating effects will affect small rural owners. L. O'Meara, C. Turner, D.C. Coitinho and S. Oenema (2022) note the urgent need to create food systems that are resistant to chronic stress and future shocks. This, according to scientists, requires a synergistic approach. It must combine innovative responses in food systems and the food environment to ensure access to sustainable, healthy food and the use of positive adaptive behaviours adopted by some consumers in response to the pandemic.

Despite the considerable scientific development of the topic of food price formation, the problem of violation of the sectoral structure of agri-food production in the context of one of the factors of growth of consumer food prices in Ukraine has not been reflected in the research of foreign and Ukrainian scientists. Notably, the focus of research on the sectoral structure of agri-food production in the foreign expert community is considered from a broader perspective of identifying conditions, factors of formation, and development of the value chain. For instance, K. Mausch, A. Hall and C. Hambloch (2020) investigate the value chain development in agri-food production in the context of the problem of achieving the Sustainable Development Goals. A similar approach is found in A.K. Farmery *et al.* (2021).

Researchers explore the possibility of simultaneously accounting for food and food security, added social, economic, or environmental outcomes in different options of value chain creation. S. Allen & A. de Brauw (2018) study the types of interventions in the value chain that can improve the consumption of micronutrient-rich foods in the context of achieving the second Sustainable Development Goal – food security and nutrition improvement by 2030. G. Soullier *et al.* (2020) investigate measures taken by African governments to increase investment in the modernisation of the value chain in the rice industry after the 2008 food crisis. The authors assess the state of modernisation by examining data on rice mill investments in semi-industrial and industrial grinding technologies, contract farming and vertical integration during the post-crisis period of 2009-2019 in West Africa, etc. Therewith, as the authors' earlier studies show, the problem of consumer price growth in Ukraine due to the presence of seasonal shortages of certain types of food products exists (Mudrak *et al.*, 2020) and the authors suggest that it is related to the problem of violations in the sectoral structure of domestic agri-food production. Therefore, such a problem requires more in-depth research and justification of respective solutions.

The purpose of this study is to test the hypothesis that the violation of the sectoral structure of agri-food production is one of the reasons for the growth of the food CPI.

The practical significance of the study lies in the fact that its results constitute a scientifically based argument in favour of changes in the national food policy of Ukraine. It should become further proof that to ensure the stability of the internal food market, it is no longer enough to stimulate the production of agricultural goods. It is necessary to ensure the formation of a closed added value chain.

MATERIALS AND METHODS

The authors of this study propose the “coefficient of the ratio of gross value added created in the food industry to gross value added created in agriculture” as an indicator that describes the sectoral structure of agri-food production.

$$K_{i.s.} = \frac{GVA_{f.i.}}{GVA_a}, \quad (1)$$

where: $K_{i.s.}$ is the ratio of gross value added created in the food industry to gross value added created in agriculture; $GVA_{f.i.}$ is the gross value added created in the food industry, in real prices; GVA_a is the gross value added created in agriculture, in real prices.

To find the likely impact of the sectoral structure of agri-food production on the index of consumer food prices, it is proposed to build two dynamic series: 1) real values of the coefficient for a certain period; 2) real values of the consumer price index of food products and

non-alcoholic beverages for the specified period. It is proposed to use the obtained real values of control indicators for analytical grouping and nonlinear correlation analysis.

When conducting analytical grouping, the grouping attribute “the ratio of food industry GVA to agriculture GVA” for each country is calculated as the average annual value for a certain period:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i = \frac{1}{n} (x_1 + \dots + x_n). \quad (2)$$

The real value of the CPI of food products and soft drinks for each country is calculated as the base price index for a certain period.

The authors of this paper propose nonlinear (curved) correlation analysis and construction of the regression equation based on the power function $Y=x^b$. Its important property is that the regression coefficient b is a ready-made coefficient of elasticity, which shows how many percent the functional attribute will change when the factor attribute changes by 1%. To identify stable relationships of the features under study, the authors used the following long-term statistics:

1) for Ukraine for 2004-2018: a) GVA indicators in agriculture, hunting, forestry in real prices, mln. UAH; b) GVA indicators in the industrial production of food, beverages, and tobacco products in real prices, mln. UAH; c) CPI of food products and soft drinks, %;

2) for the countries of the Organisation for Economic Cooperation and Development (OECD) for 2003-2018: a) GVA indicators in agriculture, hunting, forestry and fisheries, in real prices in the national currency; b) GVA indicators in the industrial production of food, beverages and tobacco products, in real prices in the national currency; c) CPI of food products and soft drinks, %;

3) for individual OECD countries with available static data for 1970-2018: a) GVA indicators in agriculture, hunting, forestry, and fisheries, in real prices in the national currency; b) GVA indicators in the industrial production of food, beverages and tobacco products, in real prices in the national currency; c) CPI of food products and soft drinks, %.

RESULTS AND DISCUSSION

Considering that the population of Ukraine spends more than half of its expenses on the purchase of food products (52.1% in 2020 (State Statistics Service of Ukraine, 2022)), the critical segment of the national consumer market is the food market, and the critical CPI component is the CPI for food products and soft drinks. The last assumption also has factual confirmation – in the weight structure of the CPI, according to the Classification of individual consumption by goals, food products and non-alcoholic beverages account for 44.7% (State Statistics Service of Ukraine, 2022). Thus, the study of the factors that form the CPI of food and non-alcoholic

beverages in Ukraine is an urgent scientific task, the solution of which depends on the ability of the state to guarantee food security to its citizens.

The factors influencing the CPI and prices on the food market, as its most significant part in Ukraine, are monetary and non-monetary in nature. Monetary factors determine core inflation, which is measured by the “core consumer price index” indicator. Its distinctive feature is the exclusion of short-term uneven price changes under the influence of factors that have administrative, random or seasonal properties, and the assessment of price dynamics based on the exchange equation. Non-monetary factors are formed under the influence of changes in production costs, industry structure, administrative regulation of prices and tariffs, etc.

Research by Ukrainian scientists and analytical reports of the National Bank of Ukraine suggest that non-monetary factors are currently the main factors of inflation in Ukraine (Danylyshyn, 2022; National Bank of Ukraine, 2022). According to the authors, one of the least studied non-monetary factors of the CPI for food products is the sectoral structure of agri-food production.

The sectoral structure of agri-food production refers to the ratio between the production volumes of food raw materials in the form of agricultural products and the volumes of food industry products. The authors suggest that the violation of proportions towards increasing the production of agricultural food raw materials and reducing the production of finished goods of the food industry leads to the emergence of periodic or chronic food shortages in the internal market. This causes food inflation. This phenomenon is impossible in conditions of complete or partial closure of the national economy, the exchange of which with the

institutional sector “abroad” is limited by protectionist measures of the national foreign trade policy. However, in the context of the growing openness of national economies, because of the unprecedented expansion of the boundaries of economic globalisation, the export of food raw materials in the form of agricultural products becomes almost unlimited. As a result, there is an increasing potential for situations when, with sufficient volumes of agricultural production to meet internal food needs, the excessive export of food raw materials causes its shortage in the internal market. This leads to the stagnation of the country’s food industry and the galloping growth of consumer food prices.

It is generally accepted that one of the main conditions for the absence of a deficit and the presence of price stability in the internal food market is an elevated level of food self-sufficiency, calculated as the ratio of the volume of production of the given type of food to the volume of its use in the territory of the given country. However, this approach has a weak point – production volumes in the numerator are agricultural raw materials, and not consumer-ready industrial products. Given such a channel of extraction of food raw materials as “export”, the production volumes of agricultural products sufficient for food self-supply do not guarantee their arrival at national food industry enterprises and the internal market in the form of ready-made food or semifinished food products.

Most developed countries, especially the EU, protect their internal food markets by applying the principle of increasing import duties as the degree of processing of imported food products increases. For instance, from zero or minimum values for importing raw materials to maximum values for importing finished products (Table 1).

Table 1. Import duty rates for certain Ukrainian goods when imported to the EU

Goods	Code according to UCG FEA	Basic rate of import duty, %
Live animals for slaughter	0102 90 21 00, 0102 90 51 00, 0102 90 61 00	5
Cattle meat, fresh or refrigerated	0201	15
Cattle meat, frozen	0202	15
Live domestic chickens	0105 11	0
Poultry plucked, half-patted, with a head and legs, the so-called “83% chickens”	0207 11 10 00	15
Wheat and a mixture of wheat and rye (meslin), other	1001 10 00 90	10
Wheat flour or a mixture of wheat and rye (meslin)	1101 00	15
Cereals, groats, and granules from grain crops, from durum wheat	1103 11 10 00	20
Cereal grains, processed in other ways (e.g., hulled, flattened, flaked, cut (kernel) or ground), except for rice of heading 1006; wheat germ, whole, flattened, flaked, or ground	1104 19 10 00	20

Source: Law of Ukraine No. 1678-VII (2014)

Thus, they restrict the import of finished food products, encourage the import of agricultural products and provide cheap raw materials to their processing enterprises, accumulating added value in their economies. As a result, countries exporting raw materials from among the poor or developing countries are experiencing a deterioration in the terms of trade and face the problem of stagnation of the national food industry. For instance, in Ukraine, the level of self-supply in grain products in 2020 was 323.3% (State Statistics Service of Ukraine, 2021). However, its excessive export causes a shortage of feed grains, which leads to seasonal shortages

of primary processed meat and an increase in corresponding prices (Mudrak *et al.*, 2020).

As the results of the analytical grouping show (Table 2), as the real value of the ratio of food industry GVA to agriculture GVA decreases, the CPI of food products and non-alcoholic beverages increases:

- for the first group of countries with an average coefficient of 2.481, the average CPI value is 1.29;
- for the second group of countries with an average coefficient of 1.342, the average CPI value is 1.451;
- for the third group of countries with an average coefficient of 0.728, the average CPI value is 1.571.

Table 2. Analytical grouping of OECD countries and Ukraine by the real value of the ratio of food industry GVA to agriculture GVA

Country	Coefficient	Basic CPI of food products and soft drinks for 2003-2018*
Belgium	2.651	1.39
United Kingdom	2.622	1.48
Japan	2.508	1.16
Switzerland	2.505	1.01
Luxembourg	2.118	1.42
Average for the group	2.481	1.29
Norway	1.987	1.38
Germany	1.864	1.30
Denmark	1.602	1.31
Mexico	1.396	2.42
Austria	1.337	1.44
France	1.301	1.21
USA	1.217	1.37
Netherlands	1.180	1.18
Lithuania	1.093	1.68
Czech Republic	1.059	1.40
Portugal	1.045	1.18
Poland	1.026	1.52
Average for the group	1.342	1.451
Spain	0.903	1.41
New Zealand	0.884	1.34
Italy	0.830	1.32
Australia	0.824	1.39
Latvia	0.780	2.06
Slovenia	0.696	1.53
Slovakia	0.685	1.42
Estonia	0.649	1.77
South Korea	0.608	1.81
Finland	0.595	1.30
Hungary	0.554	1.94
Average for the group	0.728	1.571
Ukraine	0.415	5.74

Note: *for Ukraine for 2004-2018

Source: compiled by the authors based on the data from the State Statistics Service of Ukraine, OECD (2022)

Ukraine closes the table with the real values of the features under study of 0.415 and 5.74, respectively.

To test the results of the analytical grouping, the authors of this study analysed the relationship

between the functional feature “basic CPI of food and soft drinks” and the factor feature “coefficient of the ratio of food industry GVA to agriculture GVA” using a non-linear correlation based on the power function (Fig. 1).

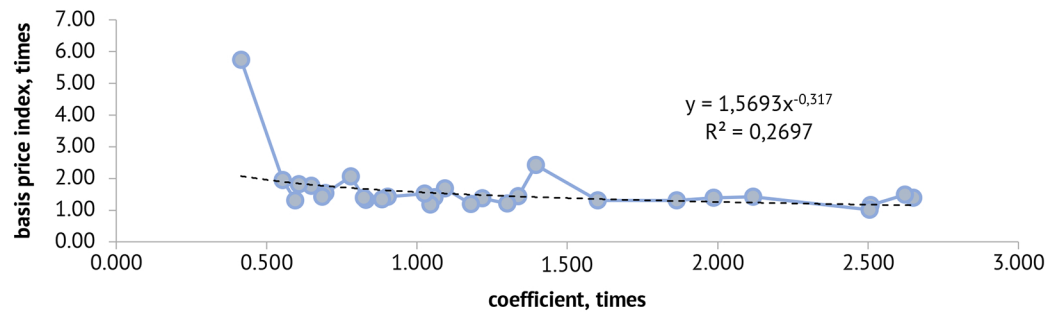


Figure 1. Correlation analysis of the relationship between the functional feature “basic CPI of food products and soft drinks” and the factor feature “coefficient of the ratio of food industry GVA to agriculture GVA” according to statistics from OECD countries* and Ukraine**

Note: * for 2003-2018; ** for 2004-2018

Source: compiled by the authors based on the data from the State Statistics Service of Ukraine, OECD (2022)

Correlation coefficient $r=0.519$. This indicates the average density of the relationship between the function under study and the factor. Given that the CPI of food products and soft drinks is influenced by many other key factors, the result obtained is a good confirmation of the hypothesis formulated at the beginning of the study. Regression coefficient $b=-0.317$. This means that, while other factors of influence stay unchanged, an increase in the coefficient by 1% leads to a decrease in the CPI of food products and soft drinks by 0.317%.

To further verify the results obtained, the authors performed a correlation analysis of the relationship

between the features under study based on statistical data from individual OECD countries for 1970-2018 (Fig. 2).

For this sample of countries (Table 3), the relationship under study occurs in 58.3% of cases. Notably, in all countries the relationship under study is reversed. This suggests that the sectoral structure of agri-food production affects the CPI even in those countries where the relationship under study has a low density ($r<0.5$). Evidently, its impact is difficult to distinguish due to the strong influence of other factors of food inflation.

Table 3. Values of correlation coefficients, relationship density and elasticity coefficients based on the result of correlation analysis of the relationship between the functional feature “CPI of food products and soft drinks, %” and the factor feature “coefficient of the ratio of food industry GVA to agriculture” according to long-term statistics of individual OECD countries

Country	Correlation coefficient, r	Communication density	Coefficient of elasticity, E
Australia	0.432	Low	-0.101
Austria	0.384	Low	-0.024
United Kingdom	0.518	Average	-0.217
Denmark	0.555	Average	-0.078
Italy	0.781	High	-0.118
Mexico	0.471	Low	-0.213
Netherlands	0.251	Low	-0.041
New Zealand	0.283	Low	-0.072
USA	0.816	High	-0.116
Finland	0.708	High	-0.158
France	0.771	High	-0.098
Japan	0.681	Average	-0.071

Source: compiled by the authors based on the data from OECD (2022)

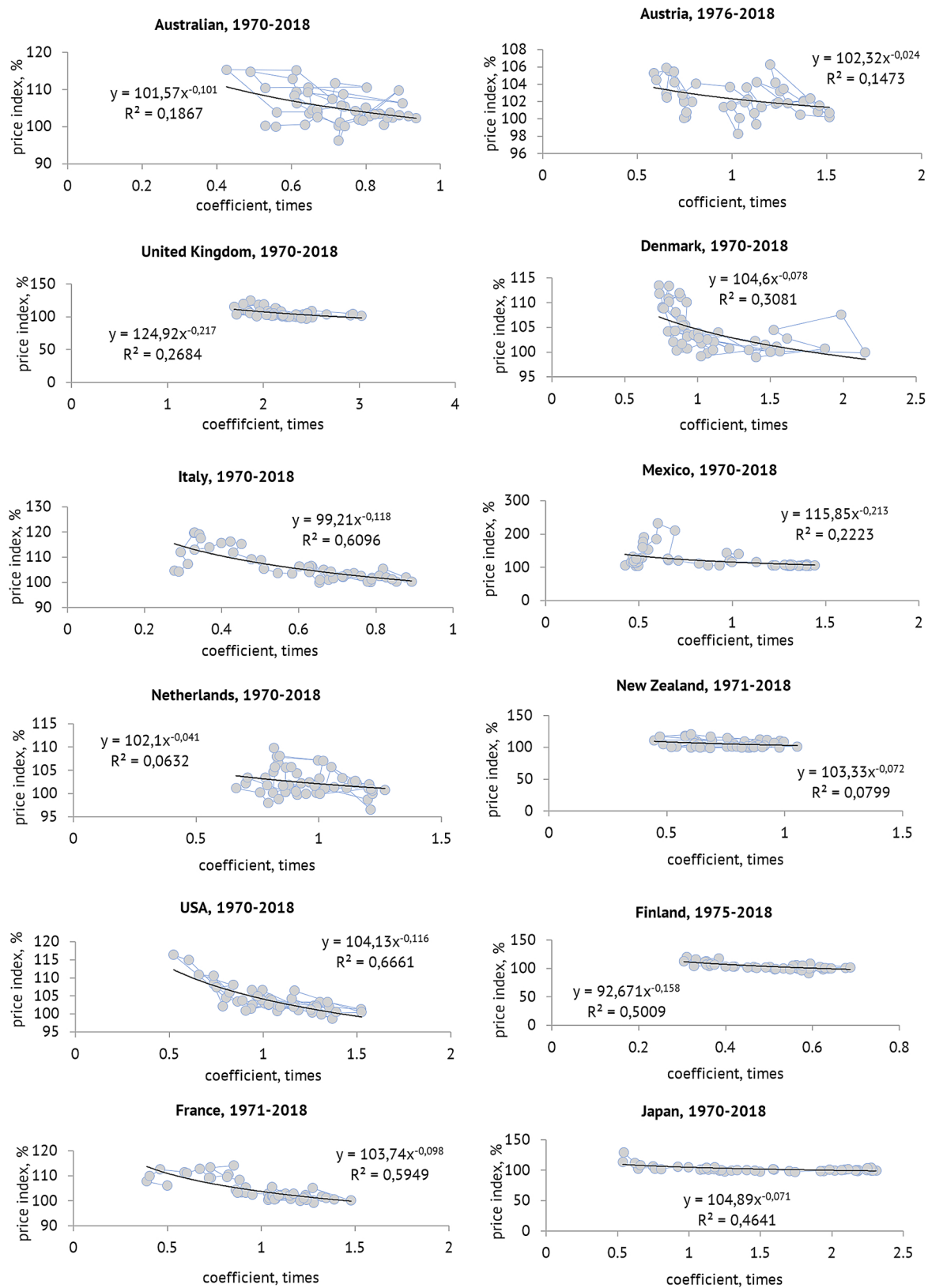


Figure 1. Correlation analysis of the relationship between the functional feature “CPI of food and soft drinks, %” and the factor feature “ratio of food industry GVA to agriculture GVA” according to long-term statistics of individual OECD countries

Source: compiled by the authors based the data from OECD (2022)

The results of this study confirm the hypothesis about a connection between the industry structure of agri-food production and the CPI. Its effect is manifested in the long term. According to the authors, it is significant that the average and high density of the relationship under study takes place in developed economies. This is probably due to the long period of formation of highly organised competitive agricultural production and national industrial capital, the development of a complex multichannel supply and sales logistics system, the achievement of a prominent level of purchasing power of the population, which eventually ensures the stable functioning of a closed value chain in the field of agri-food production.

CONCLUSIONS

In the conditions of unhindered export of products of domestic producers to the foreign market, sufficient volumes of agricultural production for food self-supply are no longer a guarantee of a deficit-free national food balance and stability of internal food prices. The latter should be provided with sufficient volumes of production

of finished products by enterprises of the national food industry. This means that prices for food products depend on the industry structure of agri-food production. The nature of this relationship is as follows: if other factors of influence stay unchanged, an increase in the ratio of GVA created in the food industry to GVA created in agriculture causes a decrease in the consumer food price Index, and vice versa. An essential condition for the stability of national food prices is sufficient production volumes by the food industry – the ratio of the gross added value created in the food industry to the gross added value created in agriculture should not be less than 1.

The clear conclusion for the Ukrainian economy is the recognition of the fact that the national agrarian policy, which is based solely on the problem of increasing budget support to agricultural producers, requires qualitative changes. Presently, its relevant task should be to create organisational and economic mechanisms for stimulating the demand of national food industry enterprises for agricultural raw materials and the final demand of households for food products.

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Галузева структура агропродовольчого виробництва та індекс споживчих продовольчих цін

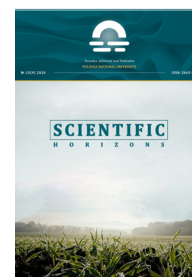
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Анотація. Вважається, що однією із головних умов відсутності дефіциту та стабільності продовольчих цін на внутрішньому ринку є достатній рівень продовольчого самозабезпечення, що розраховується, як відношення обсягів виробництва даного виду продовольства до обсягів його використання на території даної країни. Однак, цей методичний підхід має слабе місце: обсяги виробництва в чисельнику – це сільськогосподарська сировина, а не готова до споживання промислова продукція. Беручи до уваги експортний канал вилучення продовольчої сировини, достатні для продовольчого самозабезпечення обсяги виробництва сільськогосподарської продукції не є автоматичною гарантією їх надходження на національні підприємства харчової промисловості для виробництва продовольчих напівфабрикатів та готової їжі в кількості достатній для бездефіцитного функціонування продовольчого ринку. Тому, метою дослідження є перевірка гіпотези про те, що порушення галузевих пропорцій агропродовольчого виробництва є однією із причин зростання індексу споживчих цін на продовольчому ринку України. В якості показника, що характеризує галузеву структуру агропродовольчого виробництва, пропонується «коефіцієнт відношення валової доданої вартості, створеної в харчовій промисловості, до валової доданої вартості, створеної в сільському господарстві». Встановлено, що за незмінності інших факторів впливу, підвищення коефіцієнта «відношення валової доданої вартості, створеної в харчовій промисловості, до валової доданої вартості, створеної в сільському господарстві» на 1 % зумовлює зниження індексу споживчих цін продовольчих товарів і безалкогольних напоїв на 0,317 %. Робиться висновок, що для забезпечення стабільності національних продовольчих цін такий коефіцієнт не повинен бути меншим 1. Перспективою подальших досліджень є розробка організаційно-економічного механізму формування замкнутого ланцюга вартості в системі національного агропродовольчого виробництва

Ключові слова: сільське господарство, харчова промисловість, продовольчі товари, дефіцит, інфляція, додана вартість, коефіцієнт



UDC 631.1

DOI: 10.48077/scihor.25(7).2022.101-114

Marketing Support of Corporate Social Responsibility of Agri-Food Enterprises

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Article's History:

Received: 22.08.2022

Revised: 21.09.2022

Accepted: 22.10.2022

Suggested Citation:

Trusova, N., Vasyl'yeva, O., Kolokolchukova, I., Konovalenko, A., & Herasymenko, I. (2022). Marketing support of corporate social responsibility of agri-food enterprises. *Scientific Horizons*, 25(7), 101-114.

Abstract. The article considers the peculiarities of marketing support of corporate social responsibility of agri-food enterprises of Ukraine. The purpose of this study is to develop scientific positions to carry out the marketing support concept of corporate social responsibility of agri-food enterprises. Created positions will be directed toward building reliable partnerships with stakeholders. The logical architecture of realization of the concept of marketing support of corporate social responsibility of agri-food enterprises is formalized. The directions of harmonization of interests of business structures (stakeholders) and the state in the marketing support of corporate social responsibility of agri-food enterprises are presented. The graph-model of rational architecture of probabilistic time lag of profitability and competitiveness in the current business process of agri-food enterprises is structured. The three-level vector of realization of marketing programs of corporate social responsibility of the enterprises of agri-food production is defined. Economic indicators and the volume of expenditures on environmental and social aspects of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine are analysed. Factors influencing the sustainable level of marketing support of corporate social responsibility, which increases the motivation and productivity of employees, business, and public reputation of enterprises in the agri-food sector of the economy and reduces the risk of market losses, are substantiated. It is proved that socio-economic development of ethnic communities in the Steppe, Forest-Steppe, Polissia and Western zones of Ukraine in the context of the concept of marketing support of corporate social responsibility is carried out through the implementation of environmental, motivational levers for health protection, education, cultural values, infrastructure and other social projects, that is, by increasing the flow of social investment

Keywords: environmental and social aspects, business reputation, resource component, labour potential, social expenses, business processes



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INTRODUCTION

In present-day global competitive environment, the strategic vector of the agri-food sector of the world economy is the full reproduction of public life based on corporate social responsibility of economic entities, which gain several marketing advantages and occupy important places on the world stage. However, the lack of agri-food enterprises with proper incentives to implement the principles of the concept of marketing support of corporate social responsibility, leads to complete or partial loss of their social activity, lowering the level of business reputation and competitiveness. At the same time, the implementation of the concept of marketing support of corporate social responsibility can be the key to the prosperity of business structures in the economic environment and the effective functioning of the economy in general. In addition, awareness of the need to support a social balance between small, medium, and large businesses in agri-food production requires the development of promising marketing tools that can affect the viability of society not only at the micro level but also globally to provide a multifunctional model of socialization, integration and innovation of subjects the agri-food complex.

The importance of the formation of marketing support for corporate social responsibility was studied by many scientists around the world. For instance, C. Sun *et al.* (2021) found a straight link between core competence and an elevated level of corporate social responsibility. Scientists R. McMurray and A. Pullen (2020) considered corporate governance in the context of such spread social flows as feminism, ecology, and radical politics. S.D. Dmytriiev *et al.* (2021) state that stakeholder theory and CSR ensure separate but complementary theoretical basis with some duplication. V.S. Harrison (2021) studied the ethics of corporate CSR, especially, for non-profit organizations. According to J. Cook *et al.* (2021), specific problems which appear during the marketing model building are the most common reason for the further failure of the practice. In the work written by A.-M. Kennedy and N. Santos (2019) normative recommendations to develop the social fairness of social marketing are presented. X.L. Wang (2022) analysed strategic human resource management, while S.F. Kingma (2018) concentrated attention on the overview of risk, crisis, and emergency management. L. Wu and G.C. Kane (2021), in turn, considered the impact of the implementation of digital management tools on staff productivity. Scientist B.J. Calder (2022) shifted the focus from employees and employers to customers, and deal usage of customer interactions for building a strong brand.

The purpose of this study is the development of innovative provisions for further implementation of the marketing support concept to provide corporate social responsibility for enterprises in an agricultural business area. The mentioned concept has extreme importance for agri-food businesses due to its function of harmonization

long-term partnerships with business structures that are directed at meeting consumer needs. Implementation of corporate social responsibility will help to exert a positive socio-economic influence on the economic environment.

MATERIALS AND METHODS

In the research framework, the following scientific methods were used: a modified method of hierarchy analysis (MAI), method of formalization, and methods of analysis and synthesis. A modified method of hierarchy analysis (MAI) helped to find multi-criteria parameters of the optimization graph model of the probabilistic time lag of profitability and competitiveness of agri-food enterprises. Method of formalization was used to express technical and mathematical thoughts within the topic. Methods of analysis and synthesis helped to gather, consider in detail, and interpret necessary data in the study. The main part of the statistical data in presented figures was generated on the materials from Socio and economic situation of Ukraine (2021) and Competitiveness rating of Ukraine (2021) governmental documents.

Multi-criteria parameters of the optimization graph-model of the probabilistic time lag of profitability and competitiveness of agri-food enterprises are found using a modified method of hierarchy analysis (MAI). To obtain the values of indicative stimulators and disincentives for marketing support of corporate social responsibility of stakeholders, a matrix of pairwise comparisons of components of the resulting value is formed. According to the nonlinear equation, incompatible components are removed from the resulting value and a high-quality architectural model of an alternative time lag of profitability and competitiveness is built in several scenarios. The value of model architecture is reduced to the selection of information, which is structured based on expert assessments and allows figuring out its reliability.

The multi-criteria goal with the resulting set of optimal alternative components that simulates the architecture of stimulators and disincentives for marketing support of corporate social responsibility of business structures is $x^* \in X$, for which the equation is calculated (formula (1)):

$$x^* = \arg \max_{x \in X} \left(-1 + \prod_{j=1}^m (1 + w_{f_j}(x_i)^{w_p(f_j)}) \right), \\ w_p(f_j) \geq 0, \sum_{j=1}^m w_p(f_j) = 1, \quad (1)$$

where $w_{f_j}(x_i)$ is the priority of resource components x_i in relation to each criteria parameter; x_i is the optimal alternative to the architecture of the probabilistic time lag of profitability and competitiveness in the business process, $i = \overline{1, n}$; n is the total set of optimal alternatives; f_j are the criteria parameter of the model business process, $i = \overline{1, m}$; m is the general set of criteria parameters; $w_p(f_j)$ is the priority of the j^{th} criteria parameter relative to the target problem p ; p is the goal of the model architecture.

Based on corporate social responsibility, to find the probability of time lag profitability and competitiveness of agri-food enterprises and their

social needs to ethnic communities in a given area, the econometric regression equation is presented (formula (2)):

$$P_i = \left\{ Y_i = 0 \mid Q_{ik} \right\} = 1 - PW_i = 1 - \frac{e^{W_i}}{1 + e^{W_i}},$$

$$W_i = \theta_{i0} + \theta_{i1}Q_{i1} + \dots + \theta_{ik}Q_{ik}$$

$$Y_i = \begin{cases} 1, & \text{if in the study period the social needs of ethnic communities have not been met} \\ 0, & \text{if in the study period the social needs of ethnic communities have been met} \end{cases} \quad (2)$$

where P_i is the probability of a time lag of profitability and competitiveness of the i^{th} agri-food enterprise to meet social needs, $i = \overline{1, N}$; N is a set of social needs of ethnic communities of a certain area; Y_i is the binary (dichotomous) variable, which determines the probability of time lag of profitability and competitiveness of the i^{th} agri-food enterprise; Q_{ik} is a set of evaluative indicative stimulators and disincentives for profitability and competitiveness of agri-food enterprises, $k = \overline{1, m}$; m is the total number of evaluative indicative stimulators and disincentives; PW_i is the probability of time lag, which forms the loss and low competitiveness of the i^{th} enterprise of agri-food production, $PW_i \in [0; 1]$; e is the basis of natural logarithm; W_i is the amount of profit, thousand USD; θ_{ik} are the parameters of linear regression W .

The amount of cash income from meeting the social needs of ethnic communities in each area is found by formula (3):

$$CF^t = \sum_{i=1}^N P_i^t dz_i^{t-1} + \sum_{g=1}^G D_g^t \quad (3)$$

where CF^t is the probability of a time lag of cash flow at the end of the period t , EUR; t is the time lag, month; dz_i^{t-1} is the amount of cash receipts at the beginning of the estimated time lag t , EUR; D_g^t is the probability of a time lag of receipt of funds from the g^{th} ethnic community at the end of the time lag t , EUR, $g = \overline{1, G}$; G is a set of optimization alternatives.

RESULTS AND DISCUSSION

An overview of marketing support of corporate social responsibility of agri-food enterprises in Ukraine.

The current state of marketing support of corporate social responsibility of agri-food enterprises of Ukraine is characterized by significant imbalances in the globalization space, which with the rapid development of business environment and increased competition in Ukrainian and foreign markets is accompanied by modernization of marketing technologies and marketing processes. Directing goods to consumers and meeting all their needs activates the value of the global form of marketing support, which transforms the locally limited form of corporate social responsibility of agri-food enterprises and with the help of marketing technologies saturates the market with alternative goods and services

for ethnic communities (Alavion *et al.*, 2017). That is, marketing support for corporate social responsibility is an integral part of achieving tactical business in the market of marketing technologies, as well as targeted product policy (Serio, 2022; Abdulkader *et al.*, 2021).

Due to the tactical focus of development, corporate social responsibility gives an opportunity to agri-food businesses to resolve some of the professional tasks and problems. For example, to identify directions and ways for upgrading the socially responsible regulation state nowadays; to identify and assess the issues in labour and social area; to implement the set perspective steps, using the external and internal control systems; to predict the consequences of determining problems for all social partners; to create the ways to implement identified innovations; to choose and assess the most efficient ones. Among the main functions of corporate social responsibility also are the adoption of the social principles in the framework of the corporate governance system to make the regulation of labour relations more successful; building a positive image that is oriented toward providing care for the health and lives of staff and decent labour; implementation of the modern management methods. Corporate social responsibility could help to ensure an essential resource; to provide transparency of information; to provide information accessibility in the way of its proper exchange and building reliable communication with partners; to ensure the active straight link with stakeholders. It should not be forgotten that the agricultural area functions in the conditions of business processes operation (Krishnamurthy *et al.*, 2022; Ma & Sexton, 2021).

Marketing technological approaches of corporate social responsibility distinguish programs for their providing. It is possible through the solving of socially substantial issues by formulation of circumstances for an elevated level of social security and contributing to social unity. In this case, authors are not talking about mandatory compliance with the law, but about the voluntary desire of agri-food enterprises to find a balance between increasing production and ensuring social and environmental development of the agricultural economy. According to this, there is a three-level vector of implementation of marketing programs of corporate social responsibility - social commitment, social response, and social sensitivity (Fig. 1).

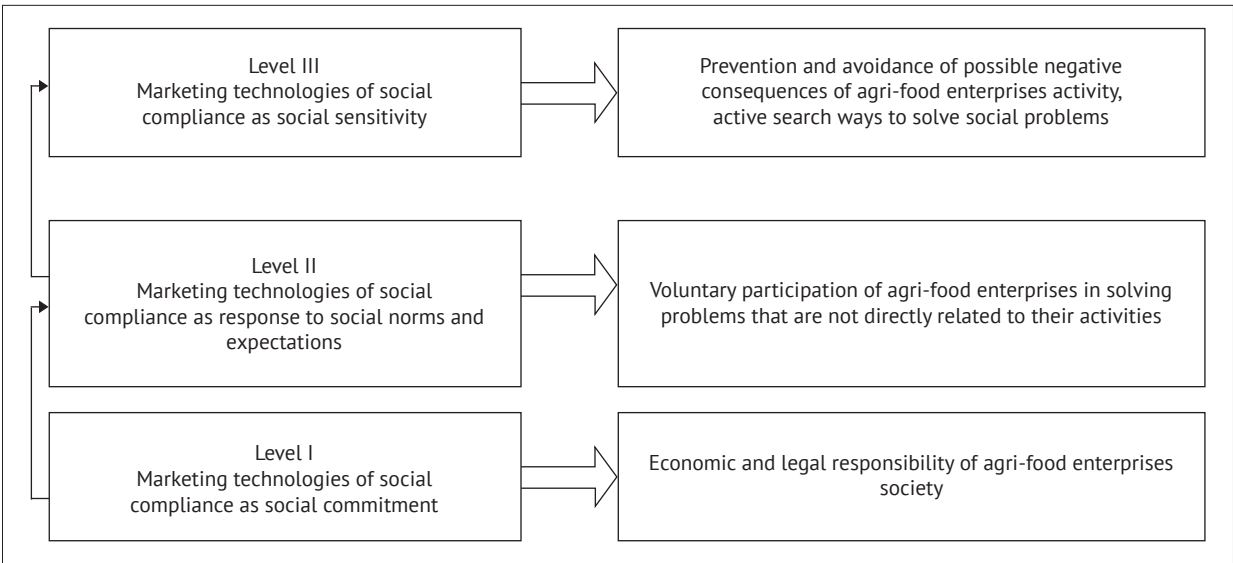


Figure 1. Three-level vector of realization of marketing programs of corporate social responsibility of agri-food enterprises
Source: improved by the authors according to data (Lungeanu & Weber, 2021; Lim et al., 2022)

Implementation of marketing programs of corporate social responsibility of agri-food enterprises is based on incentive components that take into account the basic, ethical and discretionary level of operational and production activities and ensure loyalty of major stakeholder groups (consumers, government, society, workers, etc.) to achieve quality of work and alignment of social imbalances to improve profitability in the long run, creating a trusting relationship between business, society and the state, which are important components of social relations. Social responsibility of agri-food enterprises as a socio-economic institution and as an open system within which the process of interaction between economic entities and its stakeholders is built, reduces transaction costs, suspends conflicts of interest, and provides sustainable competitive advantages through social investment, social partnership, social reporting (Lomovsky, 2016; Creane & Manduchi, 2022).

To continue thoughts of the essential formulas in the Material and methods section, the following expressions were used as well. It is necessary to combine in an integrated indicator R, stimulants and disincentives for profitability and competitiveness of marketing activities of agri-food enterprises, which dictate the effectiveness of corporate social responsibility, considering the needs of ethnic communities in certain areas by individual criteria (formula (4)):

$$R = \begin{cases} 1/D_E, & \text{if } D_E \in (0.01; 1], \\ 100, & \text{if } D_E \in (0; 0.01]. \end{cases};$$
$$D_E = \sqrt{\sum_j^m (1 - P_j^*)^2}; \quad P_j^* = \begin{cases} P_j/P_j^n, & \text{if } P_j \leq P_j^n, \\ P_j^n/P_j, & \text{if } P_j \geq P_j^n. \end{cases} \quad (4)$$

where D_E is the Euclidean distance of the standardized indicator of the effectiveness of corporate social responsibility of agri-food enterprises, considering the social needs of ethnic communities in a given area; P_j^* is the standardized value of the performance indicator, $P_j^* \in [0; 1]$; j is the number of the performance indicator, $j = 1, m$; m is the number of indicators of the effectiveness, considering the needs of ethnic communities in a given area; P_j is the actual value of the performance indicator; P_j^n is the planned value of the j^{th} performance indicator.

Analysis of the variable indicators of corporate social responsibility development in Ukraine.

One of the indisputable tendencies of intensification of social responsibility of Ukrainian agri-food enterprises is that for most of them the implementation of social protection marketing programs and social responsibility projects is an urgent task. However, due to the lack of funding for such programs, every tenth agri-food enterprise that is not a large-scale producer of agricultural food products imposes these responsibilities on the state, as it considers them an added burden in its operational, production and marketing activities (Grazhevskaya & Mostepaniuk, 2020).

The authors studied the enterprises of agri-food production in Ukraine from 2017 to 2021 because namely this period shows the most fully and meaningful information about different socio-economic indicators that influence the agri-food business. The material for analysis was selected due to the elevated level of economic development and the presence of a wide range of components of corporate culture and social responsibility. They are included in the map of the product range of the Steppe, Forest-Steppe, Polissia, and Western zones of Ukraine (Fig. 2).

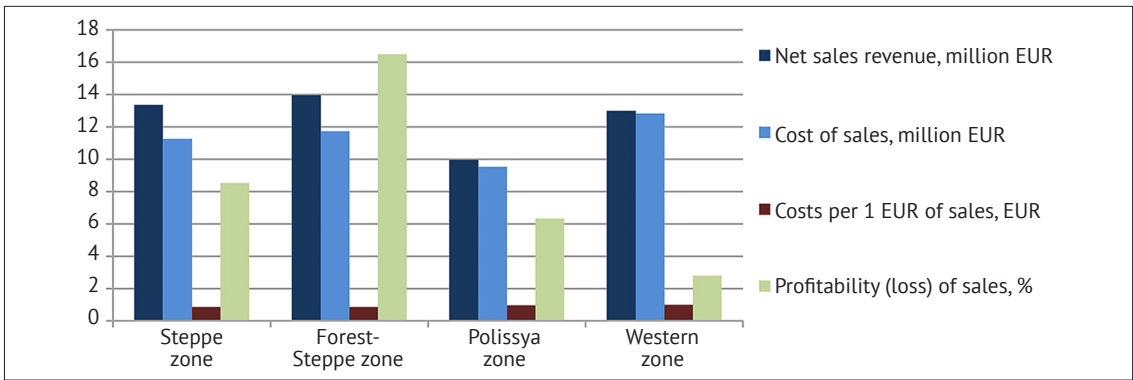


Figure 2. Economic indicators of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissya and Western zones of Ukraine for 2017-2021

Source: built by the authors according to data (Socio and economic situation..., 2021; Competitiveness rating of Ukraine..., 2021)

In 2017-2021, only 83% agri-food enterprises of Ukraine implemented the concept of marketing support of corporate social responsibility, but only half of them have tactical areas of social responsibility and twice as many of them (24%) have a budget for its implementation. It should be emphasized that stakeholders for the development of agri-food enterprises in the Steppe, Forest-Steppe, Polissya and Western zones of Ukraine, as active socially responsible entities, are becoming interested agents in the understanding of society.

Thus, if the marketing programs of stakeholders promote the corporate values of agri-food enterprises or allow sharing emotional mood with customers, they help increase consumer loyalty. Such tactics of Ukrainian agri-food producers can be characterized as effective and

efficient, especially in mass consumer markets. The social environment of enterprises (enterprise personnel, social infrastructure, components of quality of life of employees) are those material, social and spiritual conditions in which employees live and work, in which there is distribution and consumption, real connections are formed between entities, their moral and ethical values are expressed. The indirect economic effect of marketing social investment is manifested in lower production costs, increased productivity, reduced temporary disability, staffing, qualified specialists, changes in the organizational structure of production, improving social protection of workers and more. The social activity of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissya and Western zones of Ukraine is presented in Figure 3.

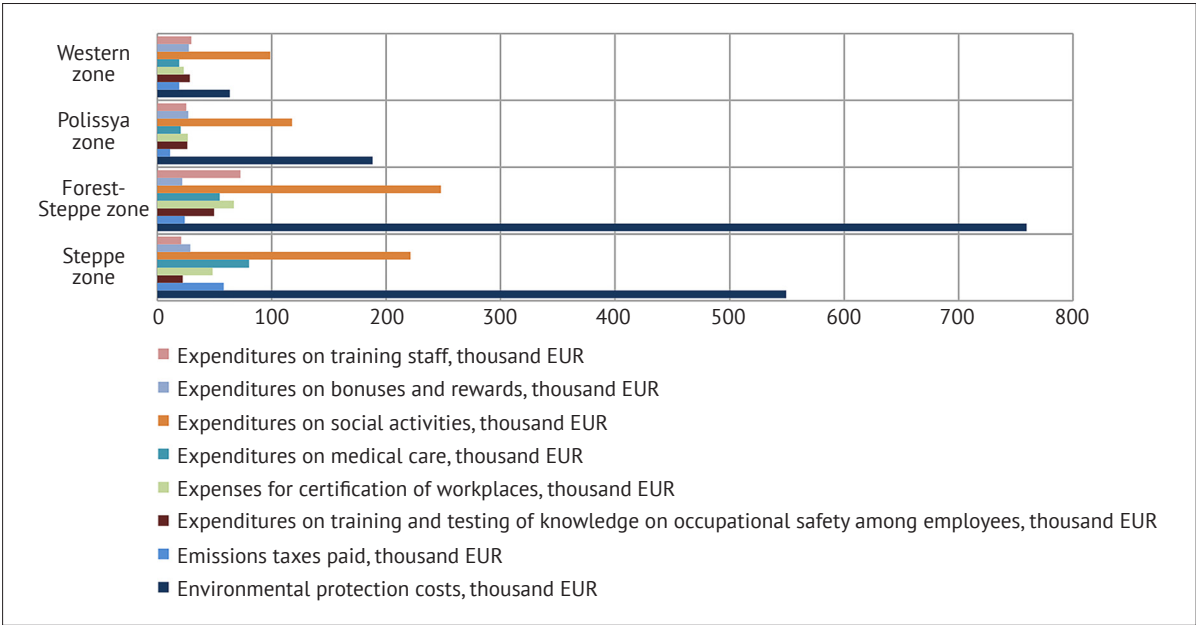


Figure 3. The amount of costs for environmental and social aspects of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissya and Western zones of Ukraine for 2017-2021, thousand EUR

Source: built by the authors according to data (Grazhevska & Mostepaniuk, 2020; Competitiveness rating of Ukraine..., 2021)

Strengthening the socio-economic position of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine allows achieving such tactical goals as increasing competitiveness, increasing investment attractiveness and market value overall. Theoretically, social investment should not include forced (i.e., legally regulated) costs of marketing programs that reduce their volume and, consequently, reduce corporate social responsibility. Social investments create a stable business environment, reduce operational risks, increase sales, increase productivity, expand markets, and increase financial performance and market value of enterprises overall.

The primary direction of the formation of marketing programs in the context of intensifying the marketing support of corporate social responsibility is the development of human capital, which includes improving the efficiency of human resources and the formation of intellectual potential of the enterprise. In addition, the intensification of marketing support for corporate social responsibility of Ukrainian agri-food producers in the context of increasing their competitiveness in national and global markets allows increasing the capital of intangible assets in the form of trademarks, brands, greater customer loyalty, business reputation and image among counterparties and increase investment attractiveness.

Socio-economic development of ethnic communities in the Steppe, Forest-Steppe, Polissia and Western zones of Ukraine in the context of the concept of marketing support of corporate social responsibility is carried out through the implementation of environmental, motivational levers for health protection, education, cultural values, infrastructure and other social projects, that is, by increasing the flow of social investment.

In Ukraine, the implementation of social investments is carried out in the form of financing social marketing programs, providing machinery and equipment for socially significant work by staff of enterprises with the involvement of volunteers (Wu & Kane, 2021). In authors' opinion, it is necessary to emphasize the socio-economic part of investment, as the social measures generate added income by increasing sales

and increasing the competitiveness of agri-food enterprises. The analysis of the principles of the concept of marketing support of corporate social responsibility of agri-food enterprises allowed figuring out the factors that affect their effective functioning:

1) the introduction of business approach within the communication with stakeholders. Such a step promotes the progressive reduction of the address of the budget deficit, the shadow economy in the state, and prompt tax obligation execution that relies on the budgeting and financing of government programs in the social marketing area. In addition, this implementation ensures business transparency, verification of actual reports by unbiased audit organizations, and provides information publicity on social and finance questions.

2) the introduction of the latest marketing technologies and modernization of production facilities to provide enterprises with innovation-oriented development. Finding ways to harmonize the interests of owners in terms of price, quality, safety, and environmental friendliness is a direct catalyst for innovation, including the modernization of production facilities. Implementation of marketing programs of corporate social responsibility of agri-food enterprises is considered as an added lever to stimulate their innovative development.

Using the method of assessing the comparative importance of certain parameters of marketing support of corporate social responsibility (financial, social and labour, social, environmental and relations with stakeholders) the expert assessment of the importance of the impact of selected components in agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine according to the 100-point system is made (Tables 1-6).

Expert assessment of the relative importance of the parameters of marketing support of corporate social responsibility is determined on the basis of a matrix of relative importance of factors (coefficients of the financial component of corporate social responsibility (CSR)) on current liquidity factors (1), quick liquidity (2), absolute liquidity (3), profitability (4), return on equity (5), return on business (6), turnover of fixed assets (7), turnover of equity (8), presented in Table 1.

Table 1. Matrix of relative importance of factors of marketing support of corporate social responsibility (coefficients of financial part of CSR) in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine

Factors	Steppe zone	Forest-Steppe zone	Polissia zone	Western zone	Average value (W_{ij})
1	1.124	0.119	0.114	0.116	0.368
2	0.109	0.104	0.114	0.101	0.107
3	0.109	0.119	0.128	0.116	0.118
4	0.137	0.149	0.128	0.130	0.136
5	0.137	0.134	0.128	0.144	0.136
6	0.123	0.119	0.114	0.130	0.122
7	0.123	0.119	0.128	0.130	0.125
8	0.137	0.134	0.142	0.130	0.136

Source: calculated by the authors

The level of the financial system of marketing support of CSR of agri-food enterprises of Ukraine with the help of an integrated indicator is calculated by formula (5) (Lomovsky, 2016):

$$K_{fs}=0.368K_1+0.107K_2+0.118K_3+0.136K_4+0.136K_5+0.122K_6+0.125K_7+0.136K_8, \tag{5}$$

Expert assessment of the parameters of the impact of social elements according to the factors of

influence (payment of bonuses and social benefits on social activities) (1), real estate efficiency (2), providing housing for workers (3), social staff costs (4), provision of healthcare facilities (5), providing medical care to employees (6), providing social protection for staff (7), providing socio-cultural facilities (8), providing social benefits to workers (9)) to the level of corporate social responsibility of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine, is presented in Table 2.

Table 2. Matrix of relative importance of factors of marketing support of corporate social responsibility (coefficients of social part of CSR) in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine

Factors	Steppe zone	Forest-Steppe zone	Polissia zone	Western zone	Average value (W_{ij})
1	0.114	0.121	0.111	0.114	0.115
2	0.102	0.107	0.105	0.107	0.105
3	0.108	0.121	0.117	0.121	0.117
4	0.102	0.107	0.105	0.100	0.104
5	0.108	0.100	0.111	0.094	0.103
6	0.120	0.121	0.117	0.114	0.118
7	0.120	0.114	0.117	0.121	0.118
8	0.114	0.107	0.105	0.127	0.113
9	0.122	0.100	0.111	0.100	0.108

Source: calculated by the authors

The level of the social part in the marketing support of CSR of agri-food enterprises of Ukraine using an integrated indicator is calculated by formula (6) (Cezarino et al., 2022; Lomovsky, 2016):

$$K_{ss}=0.115K_1+0.105K_2+0.117K_3+0.104K_4+0.103K_5+0.118K_6+0.118K_7+0.113K_8+0.108K_9, \tag{6}$$

Expert assessment of the importance of the impact of stakeholder relations development according to the factors of impact (economic losses (1), tax burden (2), costs of working with clients in total costs of the enterprise (3), receivables (4), providing enterprises with social infrastructure (5), financing of social infrastructure institutions (6)) at the level of corporate social responsibility of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine is presented in Table 3.

Table 3. Matrix of relative importance of factors of marketing support of corporate social responsibility (coefficient of the development of relations with stakeholders) in the range of Steppe, Forest-Steppe, Polissia and Western zone of Ukraine

Factors	Steppe zone	Forest-Steppe zone	Polissia zone	Western zone	Average value (W_{ij})
1	0.182	0.159	0.178	0.127	0.162
2	0.182	0.182	0.178	0.191	0.183
3	0.145	0.136	0.143	0.170	0.149
4	0.164	0.159	0.143	0.170	0.159
5	0.164	0.159	0.178	0.170	0.168
6	0.164	0.204	0.178	0.170	0.179

Source: calculated by the authors

The level of the development of relations with stakeholders in the marketing support of CSR of agri-food enterprises of Ukraine using an integrated indicator is calculated by formula (7) (Cezarino et al., 2022; Lungeanu & Weber, 2021; Lomovsky, 2016):

$$K_{ss}=0.162K_1+0.183K_2+0.149K_3+0.159K_4+0.168K_5+0.179K_6, \tag{7}$$

Expert assessment of the importance of the impact of social and labour component according to the factors of impact (employee skills (1), staff turnover (2), loss of working time (3), turnover from hiring staff (4), turnover from dismissal of staff (5), providing workers with proper working and leisure conditions (6), the cost of professional development (7), wage arrears (8), compliance with the level of wages at the enterprise to

the average level of wages in Ukraine (9) on the level of corporate social responsibility of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine is presented in Table 4.

Table 4. Matrix of relative importance of the factors of marketing support of corporate social responsibility (coefficient of social and labour part of CSR) in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine

Factors	Steppe zone	Forest-Steppe zone	Polissia zone	Western zone	Average value (W_{ij})
1	0.114	0.136	0.116	0.111	0.119
2	0.100	0.106	0.116	0.111	0.108
3	0.086	0.106	0.101	0.079	0.093
4	0.143	0.152	0.130	0.143	0.142
5	0.128	0.136	0.116	0.159	0.135
6	0.100	0.076	0.087	0.079	0.086
7	0.114	0.091	0.101	0.095	0.100
8	0.128	0.121	0.145	0.159	0.138
9	0.086	0.076	0.087	0.063	0.078

Source: calculated by the authors

The level of social and labour part in the marketing support of CSR of agri-food enterprises of Ukraine using an integrated indicator is calculated by formula (8) (Cezarino *et al.*, 2022; Lungeanu & Weber, 2021; Lomovsky, 2016):

$$K_{ss}=0.119K_1+0.108K_2+0.093K_3+0.142K_4+0.135K_5+0.086K_6+0.100K_7+0.138K_8+0.178K_9,$$

(8)

Expert assessment of the importance of impact of the environmental component according to the

impact factors (payment of environmental fees (1), losses of enterprises from irrational use of nature (2), adequacy of environmental costs (3), cost-effectiveness of environmental measures (4), environmental friendliness of products (5), compliance of the volume of emissions of harmful substances to their limit norm (6) to the level of corporate social responsibility of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine is presented in Table 5.

Table 5. Matrix of relative importance of factors of marketing support of corporate social responsibility (coefficient of ecological part of CSR) in the range of Steppe, Forest-Steppe, Polissia and Western zone of Ukraine

Factors	Steppe zone	Forest-Steppe zone	Polissia zone	Western zone	Average value (W_{ij})
1	0.196	0.178	0.167	0.170	0.178
2	0.157	0.200	0.148	0.170	0.169
3	0.176	0.156	0.167	0.149	0.162
4	0.157	0.133	0.185	0.128	0.151
5	0.137	0.156	0.167	0.170	0.157
6	0.176	0.178	0.167	0.213	0.183

Source: calculated by the authors

The level of the environmental component in the marketing support of CSR of agri-food enterprises of Ukraine using an integrated indicator is calculated by formula (9) (Cezarino *et al.*, 2022; Lungeanu & Weber, 2021; Lomovsky, 2016):

$$K_{ss}=0.178K_1+0.169K_2+0.162K_3+0.151K_4+0.157K_5+0.183K_6,$$

(9)

The indicators of the components of marketing support of corporate social responsibility of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia

and Western zones of Ukraine for 2017-2021 are analysed (Table 6).

Theoretical basis and argumentation of marketing support of corporate social responsibility of Ukrainian agri-food enterprises.

The level of marketing support of corporate social responsibility of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine has heterogeneity of parameters of socially responsible business processes, which radically change the value of the integrated indicator, which has an average position of the competitive status of enterprises in the market (Fig. 4).

Table 6. The level of marketing support of corporate social responsibility of agri-food enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine on average for 2017-2021

Economic zones of Ukraine	Components of marketing support of corporate social responsibility					The level of corporate social responsibility
	Financial	Social	Development of relations with stakeholders	Social and labour	Ecological	
Steppe zone	1.486	0.726	0.195	0.302	0.643	0.675
Forest-Steppe zone	0.389	0.690	0.217	0.336	0.609	0.452
Polissia zone	1.599	0.706	0.193	0.258	0.583	0.673
Western zone	1.008	0.696	0.164	0.323	0.600	0.563

Source: calculated by the authors



Figure 4. Signs of the level of marketing support of corporate social responsibility of enterprises in the range of Steppe, Forest-Steppe, Polissia and Western zones of Ukraine

Source: developed by the authors

Thus, social responsibility for agri-food enterprises allows increasing the efficiency of business processes, which create the need to adapt the production cycle to environmental standards, the emergence of psychological motivating factors, increasing motivation and productivity, business, and public reputation of agri-food risks of loss of markets. The last of these advantages has a purely external pragmatic orientation for stakeholders in assessing the corporate social responsibility of agri-food enterprises, thus trying to get direct positive effects from its introduction.

Reproduction of the resource component in society, which is depleted every year and affects the environment, which is extremely vulnerable to the negative impact of human activities, requires the implementation of the concept of marketing support for corporate social responsibility (Haryanto *et al.*, 2021). This concept extends the boundaries from the economic-managerial system of relations “producer – consumer”, considering such elements as intermediaries, competitors, distributors and contact audiences, to the social process influenced by the social values of its participants and society (Cook *et al.*, 2021). Combining corporate and

social intentions of agri-food enterprises with ethical characteristics of consumers affects the development of business, which is based on marketing tools with a two-vector direction, namely: first, such an association reflects the proposal to expand marketing technologies in business and to introduce in the circulation the resource elements of marketing support exclusively as a social responsibility, secondly, a radical revision of resource elements and their expansion within the framework of marketing support allows to form the latest technologies of business development with awareness of the in-depth development of corporate social responsibility (Wang, 2022; Borchers & Enke, 2022).

In this context, the implementation of the concept of marketing support of corporate social responsibility does not deny the purposeful action of agri-food enterprises – eventual commercialization and justification of profitability criteria as a social subsystem, where each element affects the economic environment and each element, in turn, affects the business (Grazhevskaya & Mostepaniuk, 2020). Thus, the long-term and profitability of agri-food enterprises in business has a social and economic connotation. At the same time, their

business task is to form such marketing behavior, under which the needs of consumers and society are met; self-employment, as an expansion of the resource elements of marketing support on the basis of corporate social responsibility, the formation of the material basis of production and its profitability (Calder, 2022; Borchers & Enke, 2022).

In addition, the marketing of corporate social responsibility creates competitive privileges to strengthen the corporate image for the benefit of consumers and creates conditions different from competitors, by creating emotional and spiritual connections with their customers (Cook *et al.*, 2021; Cezarino *et al.*, 2022).

Meanwhile, the implementation of the concept of marketing support for corporate social responsibility of agri-food enterprises determines profit as the main motive for doing business, which is acceptable if the market offers goods and services that satisfy customers in a fair way and allows them to make informed decisions regarding the purchase, as well as in the case of refusal of subjects from marketing practices that may have devastating consequences for society.

Therefore, a conceptual approach to the implementation of marketing support for corporate social responsibility, with signs of conflicting expectations of a positive social and economic effect of interested stakeholders, is aimed at sustainable development. It is the basis of corporate social responsibility of those business structures that make business decisions to those to whom these actions are directed, namely agri-food enterprises. Corporate social responsibility is the implementation of corporate governance of social obligations of interested business structures (mostly voluntary) to employees, partners, the state, civil society institutions and society itself (Wang, 2022; Alavion *et al.*, 2017).

The social component of the concept of marketing support of corporate social responsibility is a priority in harmonizing the interests of business structures and the state, and, above all, aimed at marketing activities of agri-food enterprises:

- 1) creating economic conditions for profitability and competitiveness of production not lower than the average level in the economy (Lungeanu & Weber, 2021);
- 2) ensuring comprehensive development of corporate social responsibility in the territory of ethnic communities on the basis of integration of business processes of marketing support of agri-food production and implementation of state development programs with simultaneous improvement of marketing tools of corporate capacity of enterprises (Calder, 2022);
- 3) introduction of modern marketing technologies and methods of forming a transparent market of competitive products and food (Hernández González, 2022);
- 4) formation of favourable pricing, marketing policy in order to stimulate marketing activities and corporate social responsibility in the agri-food sector of the economy (Krasnostavskaja *et al.*, 2021).

The state should define clear directions for balancing the business process of marketing support of corporate social responsibility of stakeholders for the development of agri-food enterprises, which should accumulate significant volumes of marketing innovations through marketing tools to manage corporate capacity of capital investment entities with limited involvement of external resources by stakeholders.

The concept of marketing support of corporate social responsibility of agri-food enterprises should be formed in the areas of "priority of selective amplitude of growth of economic interests" of stakeholders, to direct state influence on the level of investment in marketing activities (Pazienza *et al.*, 2022).

At the same time, stimulating the marketing activities of small and medium-sized businesses in the agri-food sector of the economy, which should be managed by stakeholders will influence GDP growth, private investment, capital accumulation in business processes of marketing socialization to make a profit and (or) achieve positive social and economic effect, through the use of the latest marketing tools in organic production.

Modelling of marketing support of corporate social responsibility of agri-food enterprises

At the same time, time constraints on increasing the relocation of marketing tools in the economic environment of agri-food enterprises based on marketing policy of economic entities will smooth the interregional asymmetry of the information field for interaction of business structures with local authorities (Borchers & Enke, 2022; Lomovsky, 2016).

Modelling could be defined as a reflexive technology aimed to be the methodological foundation of the main model in the initial stages. Using this technological approach, the vibrant economic reality of agri-food companies links with the modern analytical process (Harrison, 2021; Calder, 2022).

Among the main functions of modelling, the following should be emphasized: evaluation function (identification of the condition of the study's object functioning), diagnostic function (determination of the possible modification of its state), and search function (prediction of potential actions to develop or repair the condition of the object of study) (Yadav & Samuel, 2022).

The main factor in the formation of the theory of process modelling is the business process, which embodies a set of interdependent functional, both input and output flows, which in time are transformed by a certain synchronicity and rhythm of resources, and thus form the resulting output of products and services at the request of consumers.

Characteristic features of the business process of marketing support of corporate social responsibility of agri-food enterprises are the focus on the modern consumer and going beyond the formal organizational structures of marketing socialization of ethnic communities in each area (Miklovda *et al.*, 2012). At the same time,

based on the application of the architecture of reference models, business process modelling covers a significant set of actions aimed at differentiating the parameters of increasing current resource flows in marketing activities (Beard, 2018; Grazhevskaya & Mostepaniuk, 2020).

In the general case, the “flow” from the standpoint of mathematics, economics, logistics and computer science is defined as a set of homogeneous elements that are perceived as a whole and exist in a certain time interval. From the point of view of the current business process, the flow as a dynamic series of financial, material and information indicators reflect the transition of the enterprise from one state to another during a certain time interval. Figuring out the change in the

qualitative or quantitative structure of modelling the current business process of marketing support of corporate social responsibility of agri-food enterprises, it becomes possible to simultaneously assess the unit of time, volume and quality of product promotion and meet consumer needs (Socio and economic situation..., 2021; Beliaeva et al., 2022).

The structure of the business process of marketing support of corporate social responsibility of agri-food enterprises is considered as a multicriteria task based on the advantages of the hierarchical scenario model of the rational reference model of probabilistic time lag of profitability and competitiveness, as graphically structured by the relations “criteria parameter-alternative” (Fig. 5).

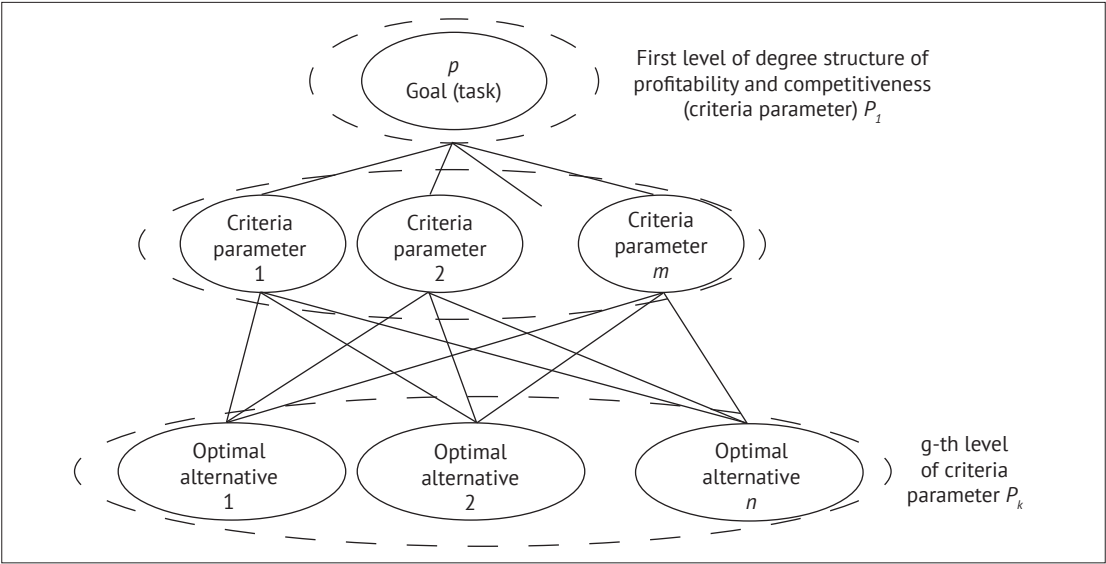


Figure 5. Structural graph-model of rational architecture of probabilistic time lag of profitability and competitiveness in the current business process of agri-food enterprises
Source: improved by the authors according to data (Kennedy & Santos, 2019; Lee & Jin, 2019; Miklovda et al., 2012)

To achieve effective modelling of the business process of marketing support of corporate social responsibility of agri-food enterprises, one of the priority areas is to maximize the quality of sold products through optimal movement of resources with a probable time lag of profitability and competitiveness (Petr et al., 2021). This allows perfecting the multi-criteria variation of the business process by using indicative stimulators and disincentives to realize the interests of business structures based on tools of economic and mathematical modelling. In addition, there are causal links in the dysfunctions of marketing activities of agri-food enterprises to synchronize resource flows into the latest marketing technologies to obtain a positive social and economic effect.

CONCLUSIONS

Thus, the main direct effect of marketing support for corporate social responsibility is to form a positive image of agri-food enterprises, to increase their business

reputation, which can be converted into revenue growth through the relevant advertising company. At the same time, it is necessary to emphasize the types of effectiveness of corporate social responsibility in reducing individual and social risks for enterprises. That is, when implementing corporate social responsibility policy, agri-food enterprises must overcome the risks of socio-cultural organization, which weaken the implementation of the principles of the concept of marketing support of CSR and safe level of investment attractiveness of agri-food sector of economy.

During the analysis carried out within the framework of this study, it was found that between 2017 and 2021, only 83% of Ukrainian agri-food enterprises used corporate social responsibility marketing practices. Half of the organizations mentioned above have embarked on this practice, and 24% have even received the material base to implement it. A more stable position of the socio-economic state of agro-industrial enterprises in the in the Steppe, Forest-Steppe, Polissia and Western

zones of the country will allow attracting investments to the regions, form the competitiveness of the population, and increase the market value. Socio-economic development in these areas of Ukraine occurs by increasing the number of relevant social investments in various areas, including ecology, health protection, culture, and others.

The transformation of tactical business processes of agri-food entities in a competitive environment of corporate social responsibility significantly changes economic relations and requires new model designs for planning, evaluating, and forecasting the resource component of marketing activities. The model design of socially relevant business processes is a vector for levelling some uncertainty in the movement of resource

flows. Therefore, the model-forming components of marketing support of socially responsible business processes in agri-food enterprises must withstand the time lag of the trajectory of resource flow, form a balance of financial, social, environmental, and socio-labour components, as well as combine them with the development of relations between stakeholders. This will allow managing the level of corporate social responsibility in view of its purpose, modelling socially responsible business processes, forming a state of stable balance of resource flows and according to target parameters, adhering to the constant value of indicators that affect the performance of agri-food enterprises, under the best development scenario.

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Маркетингове забезпечення корпоративної соціальної відповідальності агропродовольчих підприємств

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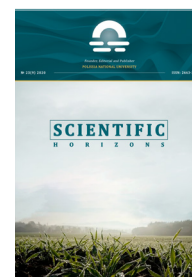
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Анотація. У статті розглянуто особливості маркетингового забезпечення корпоративної соціальної відповідальності агропродовольчих підприємств України. Метою даного дослідження є розробка наукових положень щодо реалізації концепції маркетингового забезпечення корпоративної соціальної відповідальності агропродовольчих підприємств. Сформовані положення будуть спрямовані на побудову надійних партнерських відносин зі стейкхолдерами. Формалізовано логічну архітектуру реалізації концепції маркетингового забезпечення корпоративної соціальної відповідальності агропродовольчих підприємств. Представлено напрями гармонізації інтересів бізнес-структур (стейкхолдерів) і держави в маркетинговому забезпеченні корпоративної соціальної відповідальності агропродовольчих підприємств. Структуровано граф-модель раціональної архітектури

імовірного часового лагу прибутковості та конкурентоспроможності в поточному бізнес-процесі агропродовольчих підприємств. Визначено трирівневий вектор реалізації маркетингових програм корпоративної соціальної відповідальності підприємств агропродовольчого виробництва. Проаналізовано економічні показники та обсяги витрат на екологічні та соціальні аспекти діяльності агропродовольчих підприємств у діапазоні Степової, Лісостепоної, Поліської та Західної зон України. Обґрунтовано чинники впливу на стійкий рівень маркетингового забезпечення корпоративної соціальної відповідальності, що підвищує мотивацію та продуктивність праці працівників, ділову та суспільну репутацію підприємств агропродовольчого сектору економіки та знижує ризик ринкових втрат. Доведено, що соціально-економічний розвиток етнічних громад Степової, Лісостепоної, Поліської та Західної зон України в контексті концепції маркетингового забезпечення корпоративної соціальної відповідальності здійснюється через реалізацію екологічних, мотиваційних важелів охорони здоров'я, освіти, культурних цінностей, інфраструктурних та інших соціальних проектів, тобто шляхом збільшення потоку соціальних інвестицій

Ключові слова: екологічні та соціальні аспекти, ділова репутація, ресурсна складова, трудовий потенціал, соціальні витрати, бізнес-процеси



UDC 621.0

DOI: 10.48077/scihor.25(7).2022.115-122

State and Problems of the Machine-Building Complex of the Republic of Kazakhstan

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Article's History:

Received: 16.08.2022

Revised: 15.09.2022

Accepted: 14.10.2022

Suggested Citation:

Nurmukhametov, N. (2022). State and problems of the machine-building complex of the republic of Kazakhstan. *Scientific Horizons*, 25(6), 115-122.

Abstract. The challenge of supporting a competitive position in the global market is acute for many countries, including Kazakhstan. In the current environment, the factors that could ensure greater competitiveness in the future are absent. The purpose of this study is to take an in-depth look at the state and issues of mechanical engineering in the Republic of Kazakhstan. The study employs the practices of advanced Western economies on resource, industry, and national economic competitiveness, and statistical data on Kazakhstan's mechanical engineering sector. The methods used included special theoretical approaches, such as comparing the mechanical engineering sector in Kazakhstan and other countries, analysing their current economic status, and naming the characteristics and shortcomings of the mechanical engineering sector of the countries in question. Factors that contribute to the rate of growth of mechanical engineering products were considered. Distinctive features and shortcomings of machine-building products of Kazakhstan were found. The influence of machine-building enterprises on the macroeconomic indicators of the region was studied. The main limitations for the further successful development of the mechanical engineering industries were also defined. The progressivity of structural transformations in the machine-building industry was assessed based on data on the production of the main types of equipment and machines for industry. The resulting conclusions are drawn as suggested measures to resuscitate Kazakhstan's present competitive capability in mechanical engineering. The findings include an assessment of the current economic situation and a forecast of potential future developments

Keywords: economy of Kazakhstan, mechanical engineering, competitiveness, development experience



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INTRODUCTION

The experience of developed Western countries in terms of resource, industry, and national economic competitiveness is particularly valuable since the creation of new competitive industries is closely tied to the national development strategy (Madiyev *et al.*, 2018; Makarenko, & Kazanskaya, 2018; Chashkov *et al.*, 2019). For Kazakhstan, the question of supporting a competitive position on the world market is particularly acute, as the factors that could have ensured an increase in competitiveness in the future are neglected in the current environment. Therefore, the state policy on the support and development of priority sectors of the economy, aimed at developing an adequate mechanism to provide a competitive advantage for Kazakhstan's economy, gains considerable importance (Vishnyakova & Tatarskih, 2019; NPP "Atameken" ..., 2019; Szczepaniak & Trojanowska, 2019). To develop the mechanical engineering industry of Kazakhstan and bring it to a new engineering and technical level, the government of the country has developed and approved a Roadmap for the Development of Mechanical Engineering of the Republic of Kazakhstan for 2019-2024 (Vishnyakova & Tatarskih, 2019).

The roadmap assumes a reboot of mechanical engineering by introducing innovative technologies and orienting enterprises towards exports. This will generate more jobs in the industry, increase salaries and ensure that a new pool of engineers is in demand (Suwarno *et al.*, 2018). The government foresees the provision of raw materials to enterprises, increasing the share of local content in procurement, improving technical regulation measures, and introducing economic incentive mechanisms. The desired results of the implementation of the Roadmap principles are as follows: The volume of production will double and amount to \$4.2 million, with a target of \$7.4 million by 2030. Labour productivity will double by 2024 to \$25,000 per person, and by 2030 to \$40,000. Export volume: current figure: \$720 million, 2024: \$864 million, 2030: \$1.08 billion (NPP "Atameken" ..., 2019).

In recent years, Kazakhstan's machine building sector has been running under conditions of forced economic growth and the formation of an active industrial policy at the state level (Statistical Yearbook of Kazakhstan, 2017). In the period between 2016 and 2019, political, economic, social, and macroeconomic sustainability was ensured, because of which the state became more active in supporting the country's core scientific and educational potential, and the elements of an innovation system were formed and began to appear (Szczepaniak & Trojanowska, 2019). However, an analysis of the capacity of the current state of mechanical engineering enterprises showed an increase in production, so according to the Kazakhstan Statistics Agency, for 2019 mechanical engineering enterprises generated output worth \$365,246 or 29.0% more than

in the corresponding period of 2018, with the entire industry increasing by only 5.8% (Chichkin, 2014; Mechanical engineering of Kazakhstan..., 2017). The current change in behaviour strategy between economic entities, the expansion of their organisational capacity in the process of forming partnerships and building integrated corporate structures, which allows partially solving the problem of restoring the cooperative ties that were destroyed with the transition to market relations (Kaur *et al.*, 2017; Park, 2017; Liu, 2019). Changes in the external and internal operating environment of mechanical engineering enterprises have led to structural changes in the mechanical engineering industry (Waibel *et al.*, 2018).

With the creation of a new economic zone within the Eurasian Economic Union (EAEU), Kazakhstan's machine building industry has received a new impetus for its development, which is characterised by the interactions of EAEU member states having reached a new stage of integration (Alekseieva *et al.*, 2018; Ermakova, 2021; Makoveev & Mukhametova, 2020). As noted, "One of the most important and promising mechanisms of the new stage of integration of the EAEU member states is industrial cooperation aimed at implementing a coordinated industrial policy in the Union to accelerate and improve the sustainability of industrial development, enhance the competitiveness of industrial complexes of the member states and their innovative activity" (Order of the Prime Minister No. 115-r, 2019). At the same time, several industry segments of the total market are dominated by imports from third countries: machinery and equipment (54.1%), electrical, electronic, and optical equipment (55.2%) and textile and clothing products (58.9%). This necessitates the creation of new innovative sectors of the mechanical engineering industry and the modernisation (technical re-equipment) of existing production facilities in the EAEU – the main condition for increasing the technical level of the mechanical engineering complex and its transition to the fourth technological mode (Suwarno *et al.*, 2018).

The purpose of this study is to investigate the state and issues of mechanical engineering in the Republic of Kazakhstan.

CHARACTERISTICS OF KAZAKHSTAN'S MECHANICAL ENGINEERING INDUSTRY

The East Kazakhstan region is one of the most developed centres of manufacturing industry in the Republic of Kazakhstan: the share of mechanical engineering and metalworking in the region's industrial output was 31.8% in 2019, so it should be given particular attention when carrying out structural and institutional reforms in the region (Bayomy *et al.*, 2021; Blazhchuk *et al.*, 2021). It is the leader in terms of its share in the structure of mechanical engineering output and its growth rate. At the beginning of the 21st century, mechanical

engineering accounted for 26-28% of Kazakhstan's industrial output (Karpuzov *et al.*, 2020). In the Republic

of Kazakhstan, steady growth in the mechanical engineering sector has been supported since 2013 (Table 1).

Table 1. *The position of the mechanical engineering sector in the region's industry*

Indicators	2013	2014	2015	2016	2017	2018	2019
1. Share of mechanical engineering and metalworking in industrial production	31.9	25.9	27.3	23.1	23.8	23.7	27.3
2. The share of the mechanical engineering sector in total employment in the industry	24.6	21.1	29.9	27.8	27.1	28.3	28.3
3. Physical output index (as % of the previous year): The industry as a whole mechanical engineering and metalworking industries	108.6 118.3	108.6 108.6	107.6 121.5	105.6 96.8	110.2 112.5	109.2 111.2	107.2 108.3
4. Ratio of nominal wages of the mechanical engineering sector to industry	89.6	85.5	84.8	90.6	97.6	96.3	91.2
5. Growth rate of nominal wages, % of the previous year, adjusted for consumer price growth: the industry as a whole mechanical engineering and metalworking industries	85.1 85.8	120.3 114.8	122.2 121.2	109.7 117.1	109.9 118.5	109.8 117.2	110.1 111.3
6. The ratio of labour productivity of the mechanical engineering sector to industry	0.71	0.63	0.68	0.61	0.64	0.65	0.67
7. Producer price indices (% of the previous year): the industry as a whole mechanical engineering and metalworking industries	140.5 128.0	136.7 161.8	128.5 127.1	112.3 113.4	114.5 111.0	116.8 112.0	118.9 114.3
8. The efficiency of using the labour potential of the mechanical engineering sector. Labour productivity growth rates	129.0	112.3	122.4	101.8	116.5	117.2	118.3
Labour productivity growth rates	145.3	138.7	146.2	133.9	134.9	145.3	146.8

Source: (Statistical Yearbook of Kazakhstan, 2017)

The growth rates of mechanical engineering industry products are explained by the following factors:

1. Structural adjustment. In the engineering sector, the processes of liquidation and withdrawal from the market of struggling and failing enterprises as well as capacity optimisation and restructuring of the assets of existing enterprises have been completed. Many mechanical engineering industries have found their niche in the market and have started to develop effectively.

2. High solvent demand of the fund-consuming sectors based on improved financial conditions. A fair number of engineering companies have resuscitated their production and have concluded enough contracts for the supply of their products. However, the process is still ongoing and there are a lot of reserves for concluding mutually beneficial contracts.

3. Strengthening of import substitution processes, which predetermines the positive dynamics of production of most types of equipment and the development of new types of equipment.

4. Expansion of the market for engineering products, including through improved customs and tariff policies. Developing rapidly, driven by government support for the industry and a significant increase in import duty rates on imported cars under the Customs Union (CU). The development of automobile assembly plants in

Kazakhstan is being carried out through cooperation with Russian and other foreign automakers (Çakırgil *et al.*, 2020).

5. Formation of legislation to create favourable conditions for business as part of an active industrial policy. Support is given to promising industries: they are distributed funds from the budget to subsidise the interest rate on loans to adapt older facilities to the needs of the modern market.

6. A systematic, targeted effort by the authorities to contract out the supply of engineering products within the framework of the development policy.

The distinguishing features and disadvantages of Kazakhstan's engineering products include a strong focus on the domestic market, low quality compared to the best foreign products, and high production costs, explained by insufficient labour productivity in the industry. In 2018, domestic mechanical engineering production totalled \$3.1 billion. The oil and gas engineering sector accounts for 5% or \$112,5 million in the sector's structure (Kato, 2020). However, from 2010 to 2018, the Republic produced \$32.6 billion and imported \$123.7 billion worth of goods (Esmaeili-Najafabadi *et al.*, 2021).

The volume of production in the mechanical engineering industry in value terms for 2018 amounted to more than \$2.1 billion – 17.5% more than in 2017. The

index of industrial production by 2017 amounted to 114.1%. In January-April 2019, output in mechanical engineering was \$763,3 million, a 17.6% increase compared to January-April 2018. The industrial production index was 119.8% compared to the previous year (Saghiri & Wilding, 2021). A noticeable increase in production volumes in mechanical engineering was observed in the production of motor vehicles, trailers and semi-trailers (by 58.9%, up to \$178.1 million) and the production of other vehicles and equipment (by 62.9%, up to \$49.2 million). The highest index of industrial production against the reporting period of last year was recorded in the production of motor vehicles, trailers, and semi-trailers – 145.8% (Tahmasian, 2021).

Production of computers, electronic and optical products decreased significantly: by 39.1% to \$17.6 million. More than half of the production volumes in the engineering sector account for 4 regions: East Kazakhstan, Kostanay and Karaganda regions and the city of Almaty. The leading region is the East Kazakhstan Region (hereinafter EKR) with a production volume of \$134.8 million, with a 33.8% year-on-year increase, followed by Kostanay Region: \$106.8 million – 2.1 times

more than in the same period of 2018. It is noteworthy that in the East Kazakhstan region and Kostanay region, the production of motor vehicles, trailers and semi-trailers prevails in the field of mechanical engineering: \$86.6 million and \$81.3 million, respectively. Such major plants as AsiaAvto, SemAZ and Daewoo Bus operate EKR, while SaryarkaAvtoProm operates in the Kostanay region. Absolute wages for employees in the mechanical engineering sector have a steady upward trend but have not reached an elevated level. So far, the forefront of technological progress has fallen behind in the social process (Ren *et al.*, 2018).

Unfortunately, in the engineering sector, wage growth has outpaced productivity growth rates by five years. The influence of engineering enterprises on the region's macroeconomic performance is weakening, as showed by the ratio of labour productivity in the engineering to industry: it declined from 0.71 in 1999 to 0.56% in 2017, i.e., the output per worker in engineering enterprises grew at a slower rate than in industry in general. Many engineering industries are now facing severe constraints on their further successful development (Table 2).

Table 2. Constraints to further development of the mechanical engineering sector

Growth rate limitations	Efficiency growth limitations
1. Underdevelopment of the domestic market for many engineering products. 2. Outstripping price growth for products and services of the natural monopolies. 3. Low product competitiveness: – due to the non-compliance of the technological level with modern requirements; – on terms and conditions of delivery: timing, settlement procedures, service, training of staff, etc.	1. Great wear and obsolescence of the active part of the fleet of operated equipment. 2. Insufficient structuring and lack of a unified technical policy. 3. Lack of working capital and investments. 4. Weak interaction with financial and credit institutions. 5. Personnel shortage.

Source: (Ren *et al.*, 2018)

The progressiveness of structural change in the mechanical engineering industry can now be assessed based on data on the production of major types of equipment and machinery for industry. The period between 2001-2006 finally clarified the situation by separating the successful mechanical engineering industries from those that failed during the 29 years of the market economy. The highest growth was in production of instruments and automation equipment and spare parts (2.9 times), machinery and equipment for livestock, poultry, and feed production (187%), electrical heating equipment (183.6), high voltage equipment (181.7) and electric welding equipment (163.9), oilfield, drilling and exploration equipment (161.5%) (Yan *et al.*, 2022).

The reorientation of consumers towards Kazakh food products has given a significant boost to the production of equipment for livestock, poultry, and feed production. The relative prosperity of oil and gas equipment

manufacturers has its roots in the favourable oil and gas price environment of recent years. The competitive advantage of certain types of Kazakh electrical equipment in the global domestic market and the growing demand from consumers have stimulated high rates of production at Kazakh enterprises (Yan *et al.*, 2022).

In other mechanical engineering industries, the picture was far from perfect. The production of generators for steam, gas and hydraulic turbines decreased from 5 to 3 units, mobile power plants from 135 to 83 units, and large electric machines from 270 to 250 units. When the output of technological equipment for light industry fell by 27%, there was a sharp reduction in the output of household appliances: the production of washing machines and televisions stopped, the production of radio receivers decreased by 50.3%, electric irons – by 32%, electric shavers – by 9.0%. The products of Novosibirsk enterprises producing household appliances have become uncompetitive (Yan *et al.*, 2022).

FEATURES OF THE IMPACT OF ECONOMIC DECLINE ON MACHINE OUTPUT

Kazakhstan has recently developed the production of vehicles (railways, motor vehicles), including in joint ventures with Belarusian and Russian companies supplying products to the common market. Manufacturers in the mechanical engineering sector generate 0.6% of the gross value added (GVA), for comparison, this indicator in Russia is 2.9%. However, this is insignificant compared to the leading countries in the production of engineering products. Thus, in Germany, it accounts for 8.1% of the GVA, and in Japan – 7.2%, in Belarus – 7.1% (Dong *et al.*, 2020). Currently, support for light industry enterprises is provided within the framework of systemic measures aimed at the manufacturing industry.

In 2018, the volume of textile products amounted to \$111.7 million, which in nominal terms is 21% higher than in 2017. Production in the textile industry in Kazakhstan in 2019 was \$67.3 million, up 25% in nominal terms from the same period in 2018. At the same time, production of domestic processing equipment (weaving machines) for the textile industry has declined sharply. One of the reasons for this is that domestic textile and knitwear manufacturers are not competitive with foreign companies. This is confirmed by data on exports and imports of such types of products. Thus, the import of knitted clothing in 2018 amounted to \$ 274 million, while its export is only \$ 67.8 million, and textile clothing – 345 against \$ 195 million, respectively. Especially alarming is the fact that, between 2000 and 2003, there was a significant drop in the production of machine tools and forging presses. The machine tool industry in the Republic of Kazakhstan has had no demand for new types of metal machining equipment, thus sharply narrowing the domestic base for technical re-equipment of the machine tool industry itself. The primary cause is the insufficient technical level of the metalworking equipment (Dong *et al.*, 2020).

The role of the investment part in the rise of the domestic engineering sector has been negligible. Low level of investment in mechanical engineering and metalworking in the republic does not leave much room for improvement in the competitiveness of its products and for overcoming the trend of degradation of the production-technological apparatus. On the other hand, the degree of investment attractiveness of enterprises decreases as the depreciation of fixed assets rises. The reluctance of investors to invest in capital-eating companies is more than understandable. By the end of 2017, the following serious issues had become dramatically clear in the mechanical engineering sector:

1. The need for urgent renewal of production assets, the introduction of innovative technologies. Mechanical engineering companies are trying to introduce innovative technologies, but not on the same scale as the time requires. In the past almost 17 years, there has been no renewal of the equipment fleet. Kazakh manufacturers

have lagged far behind their Western counterparts. The quality of the products is affected by wear and tear – it is obviously challenging to produce high-precision parts and modern machinery products on old equipment. The production capacity of most engineering companies is in a critical state and cannot be used to produce quality machinery. Moreover, their condition can no longer be a motive to upgrade and overhaul them. In terms of costs to be incurred and costs to be minimised, it is more profitable to completely dismantle old workshops and build new ones.

2. Lack of qualified personnel and low labour productivity. To date, universities are more oriented towards training specialists in the humanities. Over the past few years, young people's priorities have been directed away from heavy engineering in favour of other areas of the economy. Hence the ageing of the workforce, the lack of specialists, especially skilled workers. There are no lathe operators, milling operators, other machine operators, or toolmakers under the age of 30 at engineering enterprises in Kazakhstan. Many graduates of technical schools do not want to work in this industry due to low wages.

3. The need for financial restructuring of mechanical engineering enterprises, which is caused by certain financial problems:

- low level of investment in mechanical engineering, due to high macroeconomic risks;
- high lending rates;
- lack of “long and cheap money”;
- outstripping cost increases due to higher raw material and energy prices;
- the virtual absence of instruments to stimulate demand;
- shortage of working capital of commodity producers, as customers demand pre-payment of orders for the supply of raw materials and components for an extended period in advance (Order of the Prime Minister No. 115-r, 2019).

4. Lack of investment resources in mechanical engineering enterprises. The enterprises' own funds are clearly insufficient for the renewal of fixed assets and the implementation of new investment projects. Two-thirds of the fixed assets of mechanical engineering and metalworking have been in operation for 15-20 years, and new, with a period of use of up to 5 years, accounts for about 5%.

5. Insufficiently sustained protectionist policy of the state. Many countries are taking measures to support engineering companies: increasing import duties on equipment, organising tied loans for the sale of equipment, direct investment, and supporting research and development. In Kazakhstan, such measures are clearly insufficiently developed. Additionally, mechanical engineering products now must fight another competitor – used equipment and machinery from abroad. Many companies supplement and complete used imported equipment with automated control systems, and such upgraded equipment becomes cheaper than new Russian equipment (Kong *et al.*, 2020; Hernandez-de-Mendoza & Morales-Menendez, 2019; Wang *et al.*, 2018).

To keep the positive trends in the machine-building complex going, these must be strongly supported not only by proper investment and innovation activities of the enterprises themselves, but also by an active industrial policy, whose key variables must consider short- and long-term goals (Table 3).

Table 3. Economic policy alternatives for the development of the mechanical engineering sector		
Key variables	Choice based on current goals	Possibility dictated by strategic objectives
1. Market for implementation 2. Product Description	1. Development of domestic demand 2. High value-added products output	1. Export growth 2. Highly marketable knowledge-intensive products

Source: (Wang et al., 2018)

According to T.E.T. Dantas *et al.* (2021), Kazakhstan’s engineering sector is extremely heterogeneous in its structure. It has both developing industries, which have access to foreign markets, but also depressed ones. Y. Huan *et al.* (2021) consider that over the past one and a half decades of transition to market principles of management and state-directed conversion, most of the scientific and production structures of the engineering industry have been forced to assimilate non-core products. The results of the presented study coincide with this statement because the reasons for the differences in the economic status of individual industries are due to the different state and dynamics of the markets to which engineering products enter.

A.P.M. Velenturf and P. Purnell (2021) convinced that the engineering industry employs more than a third of Kazakhstan’s industrial and manufacturing workforce. At the same time, statistics show a significant reduction in the share of the engineering industry in the industrial workforce in Kazakhstan. The labour potential of the complex has decreased by 7.5% over the past five years (2015-2019) (Afshari *et al.*, 2020). According to S. Liu *et al.* (2018), to assess the quality of performance of engineering companies, indicators of the growth rate of labour productivity (output) and wages are important. In methodological terms, the growth rate of labour productivity should outpace the growth rate of the wage bill. M.A. Fauzi & N. Paiman (2019) believed that intensification, and hence the competitiveness of the business entity, is otherwise not achieved. However, the reproduction strategies cannot ensure expanded production in either qualitative or quantitative terms.

The author of the presented study agrees with P. Saini & P. Chitrao (2021), as these scientists assert that today, the most promising sectors for Kazakhstan’s machine building industry are car manufacturing, production of energy equipment for those in the fuel and energy sector, production of transport machinery, and means for the oil industry and agricultural machinery.

The growth of mechanical engineering in Kazakhstan in 2004 (Zemigala, 2019), as in previous years, was largely “compensatory” in nature and was caused by non-investment factors: idle capacity, “eating up” the resource of fixed assets. At the same time, these non-investment factors are interpreted in the economic literature as transitory or unsustainable growth factors. From 2018, economic growth in the mechanical engineering sector is characterised by the fact that although production is now gradually moving back from emerging markets, particularly China, back to developed countries, a greater role is likely to be played by emerging markets.

CONCLUSIONS

It is proved that despite ongoing economic growth, the overall situation in the domestic mechanical engineering industry, particularly in the agricultural sector, is still difficult. This is especially clear in the unequal conditions of competition between Kazakh and foreign manufacturers of agricultural machinery for farms. For example, the governments of Belarus and Ukraine seek to create various preferences for the companies engaged in the production of machinery and equipment for agricultural producers, and budgetary subsidies are allocated to these companies every year. This allows foreign producers to supply products at dumping prices to Kazakhstan’s markets as well. Moreover, there are no customs barriers for imported foreign agricultural machinery at Kazakh borders, unlike, for example, Belarus, which is reluctant to allow foreign machinery into its market.

In addition, it was found that mechanisms and instruments of active industrial policy in Kazakhstan should be used to solve the fundamental issues of the development of regional mechanical engineering. To support positive trends in the machine-building complex, enterprises must be supported by an active industrial policy, the key variables of which must consider short- and long-term tasks.

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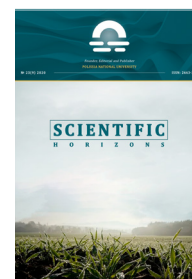
Стан та проблеми машинобудівного комплексу Республіки Казахстан

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Анотація. Проблема підтримки конкурентних позицій на світовому ринку гостро стоїть перед багатьма країнами, в тому числі і перед Казахстаном. У нинішніх умовах відсутні фактори, які могли б забезпечити підвищення конкурентоспроможності в майбутньому. Метою даного дослідження є поглиблений погляд на стан і проблеми машинобудування в Республіці Казахстан. У дослідженні використано практику розвинених західних країн з питань ресурсної, галузевої та національної економічної конкурентоспроможності, а також статистичні дані по машинобудівному сектору Казахстану. Використані спеціальні теоретичні підходи, такі як порівняння машинобудування Казахстану та інших країн, аналіз їх поточного економічного стану, виявлення особливостей і недоліків машинобудівного сектору країн, що розглядаються. Були розглянуті фактори, які впливають на темпи зростання продукції машинобудування. Виявлено відмінні риси та недоліки машинобудівної продукції Казахстану. Досліджено вплив машинобудівних підприємств на макроекономічні показники регіону. Визначено основні обмеження для подальшого успішного розвитку галузей машинобудування. Оцінено прогресивність структурних перетворень у машинобудівній галузі на основі даних щодо виробництва основних видів устаткування та машин для промисловості. Отримані висновки сформульовані у вигляді запропонованих заходів щодо реанімації нинішнього конкурентного потенціалу Казахстану в машинобудуванні. Висновки включають оцінку поточної економічної ситуації та прогноз можливого розвитку подій у майбутньому

Ключові слова: економіка Казахстану, машинобудування, конкурентоспроможність, досвід розвитку



UDC 338.1

DOI: 10.48077/scihor.25(7).2022.123-132

Economic Forecast of Further Development for Oil Suppliers to World Markets Against the Background of the Development of Renewable Energy Sources

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Article's History:

Received: 07.08.2022

Revised: 08.09.2022

Accepted: 07.10.2022

Suggested Citation:

Aliyev, T., & Aliyeva, Sh. (2022). Economic forecast of further development for oil suppliers to world markets against the background of the development of renewable energy sources. *Scientific Horizons*, 25(7), 123-132.

Abstract. The energy problem in the conditions of modern economic development has acquired a particularly large scale: this is due to the elevated level of environmental pollution from conventional energy sources and their limited amount in the Earth's interior. This has forced countries to develop new, renewable energy sources. However, it is relevant to consider the prospects for the development of energy exporting countries, namely oil supplier states. Thus, the purpose of this study is to forecast the development trends of these countries, considering the current pace of introduction of renewable energy sources in the world. Main methods for authoring the paper were modelling and forecasting, considering the model of the future development of the oil market designed in this paper. The authors conclude that the demand for oil, at least in the short and medium term, will increase. This is due to a considerable projected increase in global energy demand, which cannot be met only through the development of renewable energy sources. In this case, most oil-exporting countries may experience an increase in cash receipts over the future. However, authors believe that it is better for these countries, especially the OPEC member states and Azerbaijan, to start pursuing a policy of export diversification to become less dependent in their economic well-being on trends in the energy market and have more sources of income in case of problems in this market. The paper allows taking a fresh look at current changes in the oil market and the role of renewable energy sources in its development

Keywords: international economy, green energy, sustainable development, world trade, oil exporting countries, diversification



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INTRODUCTION

Energy carriers play an essential part in the development of any country: for exporters, they are the main source of income, and for importers – the key factor for the functioning of the economy (Taghizadeh-Hesary *et al.*, 2019). Therefore, it is not surprising that scientists are constantly conducting new research on the price of oil, natural gas, coal, and other resources, as well as the impact of these resources on the economy (Kaufmann & Connelly, 2020). Usually, members of OPEC (The Organisation of the Petroleum Exporting Countries) are primarily associated with oil exporting countries, although they are not the only major players in the market (Ologunde *et al.*, 2020). The specific feature of OPEC is that it is a cartel (albeit with its specific features), i.e., its member states regulate the amount of oil produced and put on sale, thus regulating its price (Parnes, 2019). Notably, scientists have indeed proved that OPEC affects the price of oil on the world market: in 2020, restrictions on the sale of oil increased its price by 4 US dollars per barrel (Quint & Venditti, 2020), which is one of the reasons for the introduction of renewable energy sources among oil importing countries.

Since the end of the 20th century, there has been a rapid trend towards sustainable development in the world, which has become a new paradigm for the development of the world's countries based on overcoming hunger, poverty, problems with education, and, most importantly, environmental issues (Mensah & Casadevall, 2019). Since one of the key components of this paradigm is the use of renewable energy sources, this brings a certain danger to energy exporting countries. Therefore, it is still relevant to consider the possible danger for such countries from the later increasing implementation of green energy in the economic structure of the world's countries.

Many researchers have investigated the issue of renewable energy sources and the oil market. Thus, it is worth highlighting M. Jefferson (2020), who studied the trends in the development of the oil market during the COVID-19 crisis, proved changes in supply and demand for this resource, as well as its prices. Important at the time of writing were the studies of researchers engaged in forecasting the future demand and price of oil. Among them, it is worth highlighting M. Bradshaw, T.V.D. Graaf, and R. Connolly (2019), as well as S. Dale and B. Fattouh (2018). An essential role was played by studies that investigated the impact of the future development of renewable energy sources on individual energy exporting countries. Thus, it is worth highlighting A. O. Adeola *et al.* (2022), who investigated the features of the functioning of African countries and their dependence on the oil market. The researchers found that oil revenue in Africa should be used to create sustainable investments for long-term benefits, while addressing current challenges. In turn, B. Fattouh and A. Sen (2020) evaluated the exports of Arab countries. In the study,

they argue that the broader characteristics of the current energy transition matter more for economic diversification than when oil demand will peak. K. Mohaddes and M. Raissi (2019) studied the features of the United States as a player in the oil market. The researchers showed that oil price uncertainty shocks dampen real stock prices, with the effect found to be more persistent for countries with greater reliance on oil in their exports. E. Akhmedov (2019) assessed Azerbaijan's readiness for potential future changes in the world oil market. The results of his research show that oil price is a significant contribution of non-oil GDP as the oil price coefficient is positive and significant for Azerbaijan.

The role of Azerbaijan in the export of oil around the world is small. In 2021, only about 26 million tons of oil were exported (Bashir *et al.*, 2022). It is unlikely that this volume will increase in the future. But Azerbaijan is one of the countries with a high potential for the use of renewable energy sources. The potential of economically practical and technically suitable renewable energy sources in Azerbaijan is 27,000 MW, including 3,000 MW of wind energy, 23,000 MW of solar energy, 380 MW of bioenergy potential, 520 MW of mountain river potential (Akinsola & Odhiambo, 2020).

Thus, *the main purpose of this paper* was to forecast the development of the oil market, considering current trends in the spread of renewable energy sources, and draw conclusions on the impact of these changes on oil exporting countries. The main object of this study was the oil market as such, as well as current trends in its development. The originality of this study lies in the authors' prediction of the development of the oil market and its statistical justification.

MATERIALS AND METHODS

To author this article, the authors used a sufficient statistical database. The main source was the TradeMap (2022) statistical internet source, data from which primarily concerned information on oil exports and imports in various countries of the world. However, other internet sources also played an important part, namely the official website of the World Bank (2022), the Our World in Data statistical source (OurWorldInData Energy Production, 2022; OurWorldInData Renewable Energy, 2022), a versatile site with statistical (and not only) information about investments and everything related to them, Investing (2022), etc. Furthermore, a considerable number of scientific papers and reports were used for this study, including on sustainable development and the implementation of its principles in countries.

The study employed some statistical methods for analysing the obtained data. Finding the root mean square is widely used. It can be found using the following formula (1):

$$\sigma = \sqrt{\frac{\sum (x_n - x_{avg})^2}{n}} \quad (1)$$

where σ_x is the average square deviation of the feature x ; x_n is the value of the attribute x under the number n ; $\bar{x}$ is the arithmetic mean of the sum of all values of the feature x ; n is the number of values in the feature x .

Furthermore, a correlation model was used to find the interdependence between several variables. To find the correlation between two variables (x and y), the formula (2) was used:

$$r = \frac{(xy)_{avg} - \bar{x} \cdot \bar{y}}{\sigma_x \cdot \sigma_y} \quad (2)$$

where r is the correlation index, $\bar{x}$, $\bar{y}$ are the average values of variable features (factor and effective); $(xy)_{avg}$ is the average values of multiplied factor and effective features; σ_x , σ_y are the standard deviations of the effective and factor features.

Some forecasting methods were also used in this study. Trend lines were constructed using Excel, which allowed observing probable variants of the future course of events on the chart and the amount of possible future energy output from renewable sources. Other statistical research methods were used, namely graphical method, for a better visual representation of the selected information. Abstract-logical research methods were also widely used in this study, namely analysis (to process considerable amounts of data used in the study), abstraction (to assess the influence of only one

or more variable factors on the performance trait), the above-mentioned forecasting method, etc. In turn, the historical method allowed analysing the development of the oil market in dynamics, to see the causes and consequences of changes in oil demand and prices.

All the study can be divided into several stages. Thus, the first stage presents a detailed analysis of the main oil exporting countries, the level of their dependence on the export of this resource and considers the oil market. The second stage provides a model that allows calculating the future volume of demand for energy resources and drawing conclusions about the development trends of oil supplier states. The third and final stage of this study discusses the validity of the results obtained and the opinions of other researchers on the future role of oil in the global economy and proves the economic development of oil-exporting countries.

RESULTS AND DISCUSSION

Before considering the impact of the proliferation of renewable energy sources, it is worth considering the dynamics and structure of oil trade among the main exporting countries (they account for about 90% of all exports, thereby making their examination sufficient to observe the entire picture). Figure 1 shows the amount of exported oil in billions of dollars among the world's largest countries.

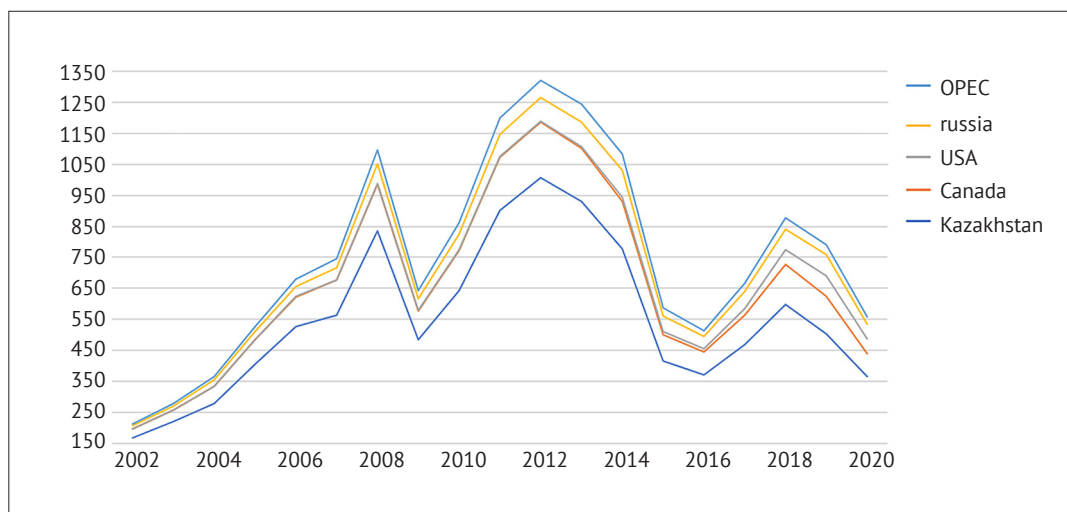


Figure 1. The amount of exported oil with the countries of the world from 2002 to 2020, billion dollars
Source: compiled by the authors based on TradeMap (2022) and OecWorld (2022) data

Figure 1 shows the dynamics of the amount of oil exported over the selected period. Oddly enough, its amount does not increase gradually, but changes in waves. Counting in 2002 prices, i.e., considering the dollar inflation, these waves have even lower values and become sharper in their movements (WorldBank, 2022). For greater clarity, one can estimate which of the countries occupies what share in total oil exports.

For this, the data presented below in Figure 2 should be considered.

The data in Figure 2 on OPEC relate to the left scale of the chart, and other countries – to the right. Figure 2 shows that the share of most countries in total exports is stable, which can be proved based on the standard deviation. The calculated standard deviation data is presented in Table 1 below.

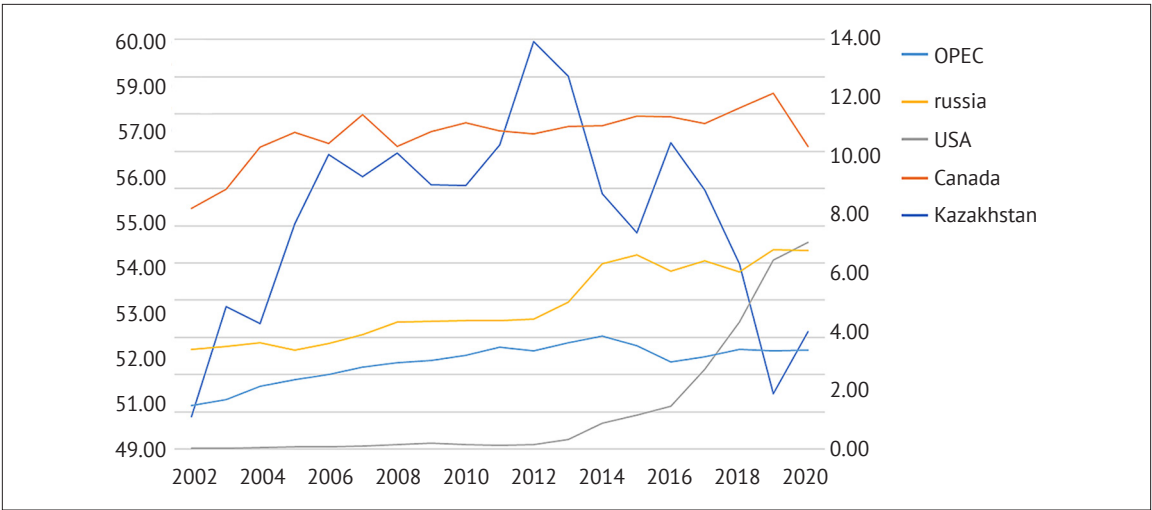


Figure 2. Share of countries in total oil exports in 2002-2020, %

Source: compiled by the author based on TradeMap (2022) and OecWorld (2022) data

Table 1. Some characteristics of the standard deviation of the share of exports of oil exporting countries

Country	Average share of oil exports from 2002 to 2020	Standard deviation of the share in the export structure, %	Ratio of the standard deviation to the average share in the export structure, %
OPEC	55.22	2.69	4.87
russia	10.75	0.91	8.50
USA	1.35	2.21	163.69
Canada	4.93	1.28	25.97
Kazakhstan	2.97	0.65	21.95

Source: compiled by the author based on TradeMap (2022) and OecWorld (2022) data

Table 1 proves that the highest level of standard deviation is observed in the United States (2.21%), which is associated with a considerable increase in the country's share in exports, as well as in Canada (0.25%) and Kazakhstan (0.22%). The standard deviation of OPEC member states is also significant (2.69%), but it is also worth considering the ratio of the standard deviation to the average share of the country in the total structure of oil exports

over these years. It is also the most stable for this group of countries, which suggests that the share of OPEC member states is the most stable among all other countries.

It is essential to estimate the volume of oil sold not only in monetary terms, but also in physical terms. This information was calculated based on the average oil price in the corresponding years. It is presented in Figure 3 as a filled-in area.

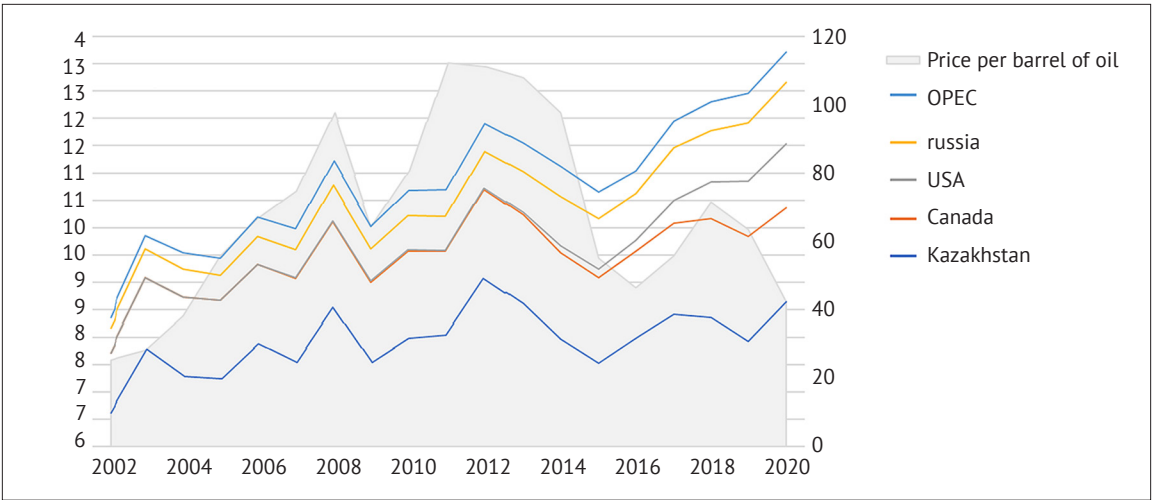


Figure 3. The amount of exported oil with the countries of the world from 2002 to 2020, billion barrels

Source: compiled by the author based on data from TradeMap (2022), OecWorld (2022), and Investing (2022)

As Figure 3 shows, the number of barrels of oil exported stays at a relatively stable level. However, it is gradually increasing, which is due to an increase in the number of US oil exports. This is also shown by the correlation between the average price per barrel and the number of sales: the higher the price, the more barrels are sold on the market. Thus, the correlation of world exports and the average price level is about 0.4, and OPEC exports and prices – about 0.6. These data clearly show the specific features of the functioning of this association as a cartel.

Thus, the most influential countries in the market are OPEC member states (which can be considered as the only subject of international trade in this market), as well as Russia, the United States, Canada, and Kazakhstan. However, this does not mean that their economies are dependent on oil exports: for this, it is worth considering the export structures of these countries in more detail. Table 2 below shows exactly the share of oil exports in the countries under study in some years.

Table 2. Share of oil exports in the total export structure in the largest oil exporting countries in some years, %

Year	2004	2007	2010	2013	2016	2019	2020	2021
OPEC*	88.75	82.19	88.88	73.23	57.10	59.79	64.80	74.17
Russia	54.85	61.46	66.16	70.56	47.18	52.24	42.10	43.15
USA	2.34	3.61	6.39	9.44	6.48	12.15	10.61	13.67
Canada	16.67	20.78	23.83	26.39	15.97	22.04	17.67	23.86
Kazakhstan	64.26	66.01	71.68	76.30	60.73	67.07	58.21	48.11

Note: * – in this case, the average value among all OPEC countries is calculated for OPEC countries; in Table 3, this share is calculated in more detail for each member state

Source: compiled by the author based on TradeMap (2022) and OecWorld (2022) data

Table 2 demonstrates that OPEC member states are the most dependent on oil exports. Russia and Kazakhstan are significant, which have obviously diversified their exports and reduced the share of oil exports in the total exports of the countries since the 2000s. However, in all the countries mentioned above, the share of

oil exports to total exports is gradually decreasing. Interestingly, the countries of North America, namely the United States and Canada, only continue to increase the amount of oil sold on the market. It is worth considering the share of oil exports of OPEC member states in more detail. This share is presented in Table 3 below.

Table 3. Share of oil in total OPEC member exports from 2016 to 2021, %

Years	2016	2017	2018	2019	2020	2021
Iraq	94.46	96.58	98.17	96.39	86.90	98.22
Libya	89.05	89.05	95.40	94.48	76.71	96.02
Angola	92.70	94.94	92.40	95.24	93.11	94.13
Kuwait	89.64	90.18	90.90	91.02	89.29	91.83
Equatorial Guinea	87.72	86.28	87.13	89.06	89.89	91.45
Nigeria	96.48	96.03	94.11	87.04	88.70	89.15
Algeria	95.31	96.11	94.10	93.07	89.78	88.42
Saudi Arabia	75.46	77.36	78.63	59.57	74.78	77.02
Gabon	75.39	65.05	65.32	67.60	58.54	63.83
United Arab Emirates	16.12	22.07	28.83	29.74	51.70	55.70
Iran	65.57	66.62	68.69	47.03	40.61	6.12
Democratic Republic of the Congo	4.17	2.65	0.72	1.12	0.49	5.14
Venezuela	83.07	88.29	86.63	87.14	67.65	2.49

Source: compiled by the author based on TradeMap (2022) and OecWorld (2022) data

Table 3 shows that most OPEC member states have a large share of oil in their exports. Only three countries are exceptional: Iran, the Democratic Republic of the Congo and Venezuela, which account for less than 10% of their

oil exports. For these countries, this is due to the sanctions imposed on them, which prohibit the import of their oil to most countries of the world. For Iran, this situation is related to the country's nuclear programme. To counter this,

some countries, including the United States, the United Kingdom, Germany, and China, have imposed sanctions to limit economic relations with Iran until it reduces its nuclear activities (Kokabisaghi *et al.*, 2019). Admittedly, the sanctions were effective, which led to a 96.5% decline in the country's oil exports since 2002 (TradeMap, 2022). For Venezuela, the reason was the policy of the Maduro government, which was aimed at leaving its ability to illegally extract gold, oil, and conduct some other operations that could contribute to the criminal activities of the regime; evidently, this policy was effective and led to a considerable decrease in exports in absolute units (by 99.5% compared to 2002) and a deterioration in the standard of living of the country's citizens (Weisbrot & Sachs, 2019). The Congo was also sanctioned in 2003 for acts of violence that were systematically committed against civilians, including violations of international humanitarian law and human rights (U.S. Department of the Treasury, 2022). Next, knowing the approximate dependence of each country on oil exports, one can estimate

the losses that they may suffer in the future from the development of renewable energy sources. For this, some initial data should be entered. First, scientists (Chi & Hongmei, 2018), considering the constant development of the global economy and the increase in the number of people, believe that an increase in demand for electricity in the world by 1.3% should be expected by 2040. It is probable that this demand will be met only through renewable energy and without the need for conventional sources. By calculating the projected amount of energy produced from renewable sources, one can calculate the amount that will remain on conventional sources. This way, one can only find an approximate increase in oil demand, since changes can also occur within conventional energy sources, i.e., oil may begin to occupy a smaller or larger share in this structure compared to years.

To assess this, it is worth considering the existing data on the spread of green energy in the world. Figure 4 below shows the amount of energy produced from renewable sources from 1965 to 2020.

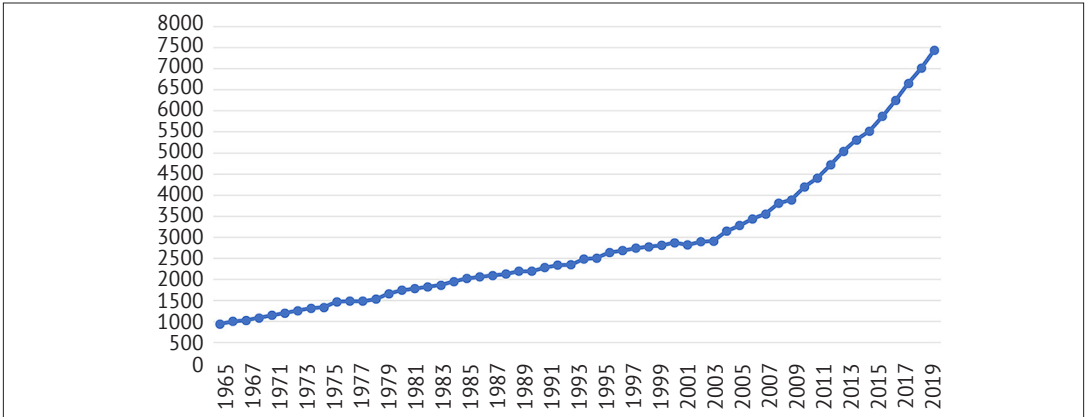


Figure 4. Growth rate of energy output from renewable sources in 1965-2019 in TWh (terawatt hours)
Source: compiled by the author based on OurWorldInData data (OurWorldInData Energy Production, 2022)

Data in Figure 4 allows calculating the average growth rate of renewable energy production: thus, it is about 3.83% per year. However, this is not the only way to calculate future renewable energy output values.

One can also use trend lines. Thus, the authors obtained three scenarios for the future growth of the amount of energy produced from renewable sources and presented them in Figure 5 below.

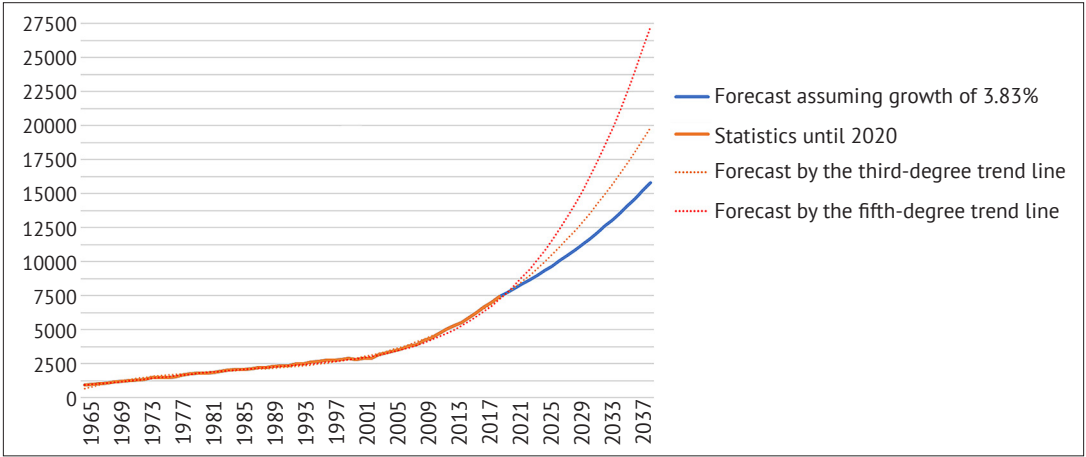


Figure 5. Some potential scenarios with the growing amount of renewable energy produced in the world, TWh
Source: compiled by the authors based on OurWorldInData data (OurWorldInData Energy Production, 2022)

Within the framework of this study, the three possible scenarios from Figure 5 were distinguished as follows: pessimistic (blue line; forecast with growth of 3.83% per year), normal (orange dashes; forecast with construction of a polynomial trend line of the third degree), and optimistic (red dashes; forecast with construction of a polynomial trend line of the fifth degree). Below are the formulas suggested by Excel that display trend line data to confirm later calculations. Thus, the third-degree trend line formula looks as follows (3):

$$y=0.0956x^3-5.9247x^2+152.22x+535.17 \quad (3)$$

It is also important that the value $R^2=0.994$ for this line. Next, the formula for the fourth-degree trend

line is drawn as follows (4):

$$y=0.0023x^4-0.1702x^3+3.8748x^2+25.493x+925.03 \quad (4)$$

Value $R^2=0.9985$ for this line.

According to the Our World in Data statistical website (2022), the amount of energy consumed in 2019 amounted to 173,340 TWh, and in 2020 it decreased by 5% (Statista, 2022). Thus, considering the data on the growth of electricity demand and the estimated growth rate of the amount of renewable energy produced, one can calculate the amount of energy that will be produced from all other energy sources in the following years until 2040. This data is presented in Figure 6.

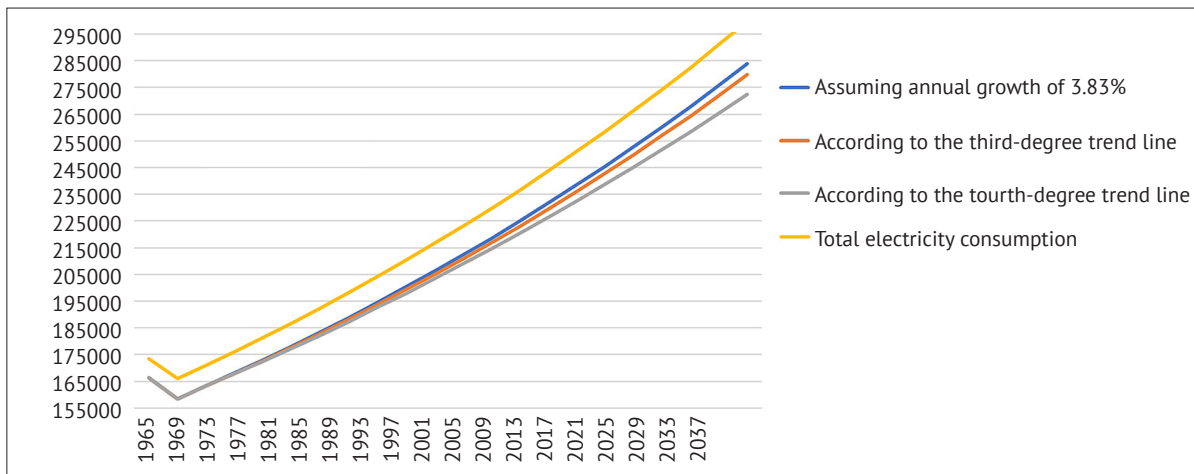


Figure 6. Forecast of the amount of energy produced by conventional sources from 2019 to 2040, TWh

Source: compiled by the authors based on OurWorldInData data (OurWorldInData Energy Production, 2022; OurWorldInData Renewable Energy, 2022)

As Figure 6 shows, the amount of energy produced from conventional sources for all models exceeds it in 2019 and 2020. This suggests that the current and recent pace of adoption of renewable energy sources in the world is still statistically insufficient to completely replace conventional sources in the near future. Next, the authors of this paper assumed that the demand for oil would grow at the same rate as for all conventional energy sources. Thus, under the pessimistic scenario, oil demand will grow by 70.69% compared to 2019; under the usual scenario – by 68.24%; under the optimistic scenario – by 63.79%. It is quite logical to assume that the profits of countries engaged in the export of this resource will increase by the same amount.

Thus, added theses to this study can be made as follows. First, according to the model developed by the authors, with the current growth rate of the amount of energy produced from renewable sources, the demand for conventional sources (including oil) will still grow. Secondly, there is still the possibility that the development of renewable technology production will follow a different scenario and oil demand will not develop as it was provided for in the models within the framework of this study; therefore, for oil exporting countries with a considerable share of exports of this resource in

foreign trade, export diversification and the economy as a whole remains relevant. The authors of this paper offer several ways to strengthen diversification. These include general economic methods (i.e., the establishment and increase of customs duties on certain products to increase opportunities for the development of domestic producers) and administrative methods (the creation of national programmes to support certain types of businesses).

After the study, it is important to discuss some of the controversial issues that its authors have encountered during their study, and their solutions. The most complicated issue was figuring out the amount of future oil demand for calculations. Researchers have defined it differently in their studies. Thus, the International Energy Agency (2021), upon developing sustainable development scenarios, predicted a decrease in oil demand by 25 MB (million barrels) the day before the beginning of 2040. In turn, in its 2018 studies, British Petroleum (2018) predicted an increase in oil demand until 2030, but with a gradual decline after that. Some researchers have similar opinions on the future dynamics of oil demand. Thus, M. Bradshaw, T.V.D. Graaf and R. Connolly (2019), upon analysing the development of Saudi Arabia and Russia in the context of current trends in oil

prices, and S. Dale and B. Fattouh (2018), who investigated long-term trends in oil demand, also discussed the upcoming decline in the price of the resource and explained its occurrence with the increase in the cost of the conventional method of oil production and the future drop in oil demand due to climate change mitigation lays the foundations for a new oil order.

Currently, the hypothesis of “peak demand for oil” is popular, which suggests that eventually the demand for this resource will reach its maximum value. It was highlighted in the study of H. Abdel-Latif & M. El-Gamal (2020), which examined the possible dangers to the oil market associated with a probable future decline in oil demand, and in the study of M. Jefferson (2020), which analysed changes in demand, supply, and oil prices in the context of the COVID-19 crisis, as well as the impact of these changes on the main oil exporting countries. It is impossible to confidently state whether the world has already observed “peak oil demand” (mostly singling out 2005 as a peak, although the price of oil was not the maximum then), or whether this is still to be expected (scientists suggest that this may happen in the 2030s or 2040s (Bradshaw *et al.*, 2019)). Subsequently, a substantial decrease in demand for this resource and its price should be expected.

There are several reasons why this hypothesis can be considered true. First, as E. Ansari & R.K. Kaufmann (2019) assure when analysing the study of the industrial development of India and China, the increase in oil demand has recently been strongly influenced by the development of China and India, which carried out large-scale industrialisation. Thus, after the beginning of the transition of these countries to more sustainable methods of development, oil demand should have fallen considerably. Notably, this concept has one significant drawback, which follows from the concept of moving industrial capacities. It can be seen especially vividly behind the waves of the so-called “Asian Tigers” (Feng *et al.*, 2020): thus, industrial capacities from highly developed countries moved to countries with low wages and easy business opportunities, due to which companies received super-profits, and states – rapid economic development due to industrialisation. However, this process is cyclical: that is why scientists distinguish several waves of “tigers”, which are accompanied by the movement of production facilities and the change of the main centres of world production. Thus, according to the authors of this study, in the future, the demand for oil will still increase due to the need for this resource from an increasing number of countries.

Secondly, T. Ahmad and D. Zhang (2020), in their study on the global history of changes in electricity supply and demand, note that oil demand should decrease due to the rapid recent spread of technologies that increase energy efficiency, i.e., energy-saving technologies. This trend leads to a decrease in demand for all energy resources, and first, countries will abandon conventional energy sources, including oil. However, one cannot be sure that the future growth rates of electricity demand will be lower than the trends in the spread of energy-saving technologies. That is why in this paper the author adhered to

the idea of increasing oil demand, albeit at a slight pace, which was described in the work of J. Chi and Y. Hongmei (2018), who concluded on the average annual growth in electricity demand by 1.3% until 2040.

Next, this study analysed the impact of future trends in oil demand on the main oil exporting countries. Thus, B. Fattouh and A. Sen (2020), who analysed the export structure of Arab countries, concluded that in any case, international oil trade will remain one of the key components of their exports. If export diversification occurs, at least such a transition will not be abrupt, since a rapid transition to renewable energy sources that could replace oil is unlikely. The export diversification strategy of such countries is likely to be implemented for decades, depending on changes in oil demand and other factors: their main purpose is to ensure a smooth transition for their economies to the future realities of the functioning of the energy sector in a globalised world.

I.A. Ologunde *et al* (2020), together with Adeola *et al.* (2022), considered the future components of African development in terms of the social, economic, and environmental impact of changes in oil prices and demand. They note the significant dependence of the African countries mentioned in the paper on oil exports. However, the specific feature of implementing reforms that could ensure economic diversification for them is the low standard of living of the population and the instability of their incomes. Thus, according to the authors of this paper, the authorities of these countries should first focus on providing the population with basic needs, including high-quality education and health-care, as well as start developing some strategically important industries for the countries, e.g., agriculture. The initial increase in people's living standards will lead to an increase in demand among the population, which will facilitate the subsequent diversification of the economy and the transition of countries to new paradigms of functioning.

The study of the further impact of changes in oil market characteristics on North American countries showed that the US entry into the global oil market strongly affected its conjuncture, as demonstrated in Figure 3. This is also stated by K. Mohaddes and M. Raissi (2019) in their study investigating the impact of the “American oil revolution” on the economies of countries around the world, wherein they note that the increase in oil supply due to the entry of the United States market has led to an increase in business activity in most countries of the world. As for the development prospects of North American countries, according to the authors of this paper, the future possible decline in oil demand will not cause considerable harm to them. This is due to the small share of oil in their total exports in these countries. It will be more difficult for Canada to survive this, due to its general orientation on the export of resources, but it should not bring significant losses to the countries. However, such diversification of these countries makes it impossible to obtain super-profits in case of the development of the oil market according to the scenario described in this paper in Figure 6.

CONCLUSIONS

In this paper, current trends in the development of the oil market were analysed. It was noted that the market behaves very cyclically, has clearly defined waves of growth and decline in oil sold and prices for it. Furthermore, there was an interdependence between the size of oil demand and its price, which once again proves the high influence of the cartel on the formation of the market price.

Upon analysing individual countries in terms of oil exports, the authors proved that the OPEC member states hold the largest share (which should be considered as one subject, since they pursue a single policy in the market), Russia, the United States, Canada, and Kazakhstan. All these countries, except the United States and Canada, have a considerable share of oil in their exports and issues with export diversification and the economy, i.e., they are highly dependent on changes in the price and demand for oil. Upon analysing practical options for the development of the oil market, considering the impact of the development of renewable energy sources, the authors

of this study concluded that the demand for conventional energy resources will still increase due to significant projected growth rates of electricity demand in the world and insufficient rates of introduction of renewable sources. Thus, exporting countries are likely to still be able to make super-profits from the sale of petroleum products in the near future, which may increase by 60%-70% in 20 years. However, given the predictions of other scientists about the inevitable decline in oil demand, they still could suffer losses. According to the authors, low export diversification is a dangerous component of the development of these countries in the long term. Countries such as the Democratic Republic of the Congo, Venezuela, and Iran are also exceptional, but similar trends for these states are related to sanctions imposed on the import of their resources. Future research should cover the development of practical recommendations on the diversification of the economies of oil-exporting countries in connection with potential future dangers to their economies.

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Економічний прогноз подальшого розвитку країн-постачальників нафти на світові ринки на тлі розвитку відновлюваних джерел енергії

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Анотація. Енергетична проблема в умовах сучасного економічного розвитку набула особливо великих масштабів: це пов'язано з підвищенням рівнем забруднення навколишнього середовища традиційними джерелами енергії та їх обмеженою кількістю в надрах Землі. Це змушує країни розвивати нові, відновлювальні джерела енергії. Водночас, актуальним є розгляд перспектив розвитку країн-експортерів енергоресурсів, а саме держав-постачальників нафти. Отже, метою цього дослідження є прогнозування тенденцій розвитку цих країн, з огляду на сучасні темпи впровадження відновлюваних джерел енергії у світі. Основними методами при написанні статті були моделювання та прогнозування з урахуванням розробленої в роботі моделі майбутнього розвитку ринку нафти. Автори дійшли висновку, що попит на нафту, принаймні в коротко- та середньостроковій перспективі, буде зростати. Це пов'язано зі значним прогнозованим зростанням світового попиту на енергоносії, який не може бути задоволений лише за рахунок розвитку відновлюваних джерел енергії. У цьому випадку більшість країн-експортерів нафти можуть відчувати збільшення грошових надходжень у майбутньому. Однак, на думку авторів, цим країнам, особливо країнам-членам ОПЕК та Азербайджану, краще почати проводити політику диверсифікації експорту, щоб стати менш залежними у своєму економічному добробуті від тенденцій на ринку енергоносіїв і мати більше джерел доходу у разі виникнення проблем на цьому ринку. Стаття дозволяє по-новому поглянути на сучасні зміни на ринку нафти та роль відновлюваних джерел енергії в його розвитку.

Ключові слова: міжнародна економіка, зелена енергетика, сталий розвиток, світова торгівля, країни-експортери нафти, диверсифікація

**Журнал
«НАУКОВІ ГОРИЗОНТИ»**

**Том 25, № 7
2022**

(Англійською мовою)

Редагування англomовних текстів:

С. Воровський

Літературний редактор:

Д. Кокра

Редагування бібліографічних списків:

Д. Кокра, К. Сосєдко

Комп'ютерна верстка:

К. Сосєдко

Підписано до друку з оригінал-макета xx.xx.2022

Ум. друк. арк. 16

Видавництво Поліський національний університет

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www: <https://sciencehorizon.com.ua>

**Journal
"SCIENTIFIC HORIZONS"**

**Volume 25, No. 7
2022**

Editing English-language texts:
S. Vorovsky

Literary editor:
D. Kokra

Editing bibliographic lists:
D. Kokra, K. Sosiedko

Desktop publishing:
K. Sosiedko

Signed to the print with the original layout xx.xx.2022
Conventional Printed Sheet 16

Publisher: Polissia National University
10008, 7 Staryi Blvd., Zhytomyr, Ukraine
Tel. (0412) 22-04-17;
E-mail: info@sciencehorizon.com.ua
www: <https://sciencehorizon.com.ua/en>