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Transformational Processes of Financial Support for Ukrainian Agricultural Producers in the Context of Exogenous Military Aggression

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Since the beginning of the war in Ukraine, agricultural producers have faced significant risks and shortages of financial resources essential for their operations. This study aims to identify the transformational processes of financial support for Ukrainian agricultural producers amidst exogenous military aggression and assess the impact of the full-scale invasion on the financial support of agricultural enterprises. Using a comprehensive set of methods, including observation, regression analysis, and trend analysis through time series (ARIMA), as well as scenario analysis and stress testing via R-studio software, the research analyzes the current state of the agricultural sector and direct losses attributed to military aggression. The dynamics of agricultural product yields from 2019 to 2023 are examined alongside changes in funding sources for agricultural producers in 2023. Additionally, the effectiveness of government support programs during pre-war and wartime periods and the financial and non-financial assistance provided to producers in 2022 and 2023 by organizations such as USAID AGRO, USAID ERA, and Mercy Corps are explored. The findings indicate that self-financing remains a crucial indicator of effective development for agricultural producers during the wartime period. Ultimately, the results offer valuable insights for agricultural producers in formulating financial support strategies and improving the management of financial resources amidst ongoing challenges.

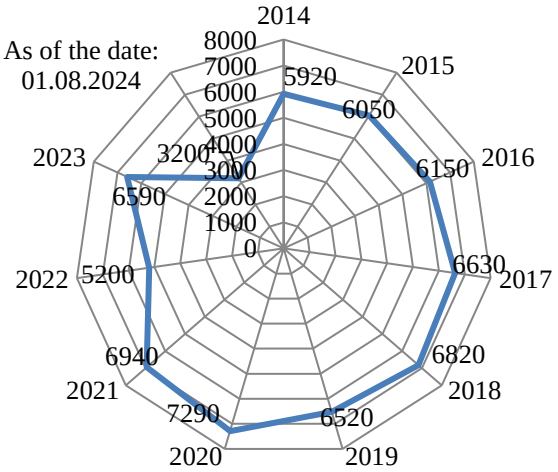
Keywords: agricultural producers, agricultural enterprises, agricultural sector, financial support, funding sources, regression analysis, trend analysis using time series (ARIMA).

1. Introduction

Agriculture has been one of the promising and leading sectors in Ukraine since independence and continues to be so today. However, with the onset of Russia's full-scale invasion of Ukraine, many business entities have faced new challenges that threaten their financial and economic security and put their continued existence as representatives of the business environment in doubt. Ukrainian agricultural producers are no exception; they currently face threats such as ongoing security risks, labor shortages, occupation and landmines in agricultural areas, damage to production facilities, rising costs of fertilizers and fuel, and the blockage of maritime ports, among others. Additionally, many agricultural producers in active combat zones were unable to harvest their crops in 2022-2023, while others could not market them effectively (the Grain Agreement did not fully allow for the realization of the entire volume of harvested produce), and the enemy seized crops on occupied territories and transported them to the aggressor country. All of these threats have significantly impacted the financial stability of Ukrainian agricultural producers. Even in the pre-war period, agricultural producers faced insufficient financial support, and under conditions of exogenous military aggression, they are even more vulnerable to the negative effects of external factors on their economic activities.Ensuring the effective development of agricultural producers can be achieved through the additional mobilization of financial resources. Quality and comprehensive financial support is one of the key factors determining the financial stability of agricultural producers. The availability of financial resources, effective financial management, and the attraction of alternative funding sources depend on the ability of agricultural sector entities to adapt to the current operating conditions and stimulate their development.

The topic of financial support for enterprises is important not only in the scientific field but also holds practical significance, as business entities can utilize scientific research by scholars to improve their financial and economic security and overcome crisis situations. Analyzing the number of publications in the free search engine Google Scholar has shown that the number of Ukrainian-language publications on the search term "financial support of agricultural enterprises" varies from 3,500 to 6,940 publications per year, while the number of English-language publications for the search term "financial support of agricultural enterprises" demonstrates positive dynamics (Figure 1, Part A and Part B).

Part A



Part B

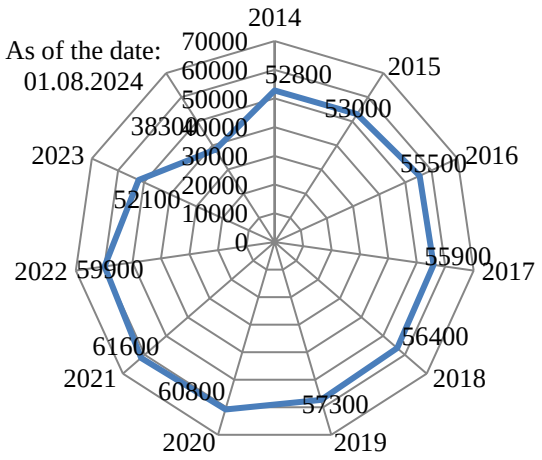


Figure 1. Number of Ukrainian-language publications for the search term "financial support of agricultural enterprises" (Part A) and English-language publications for the search term "financial support of agricultural enterprises" (Part B) in the Google Scholar database from

2014 to August 1, 2024*

*Source: Compiled by the authors

Utilizing the open database of scientific research, ScienceDirect, the search for "financial support of agricultural enterprises" yielded more than 45,595 scientific articles and publications. The dynamics of publications from 2014 to August 1, 2024, are reflected in Figure 2. The results from the database analysis indicate significant interest from the scientific community in the issues of financial support for agricultural producers, confirming the importance of this topic for both theoretical research and the practical activities of business entities.

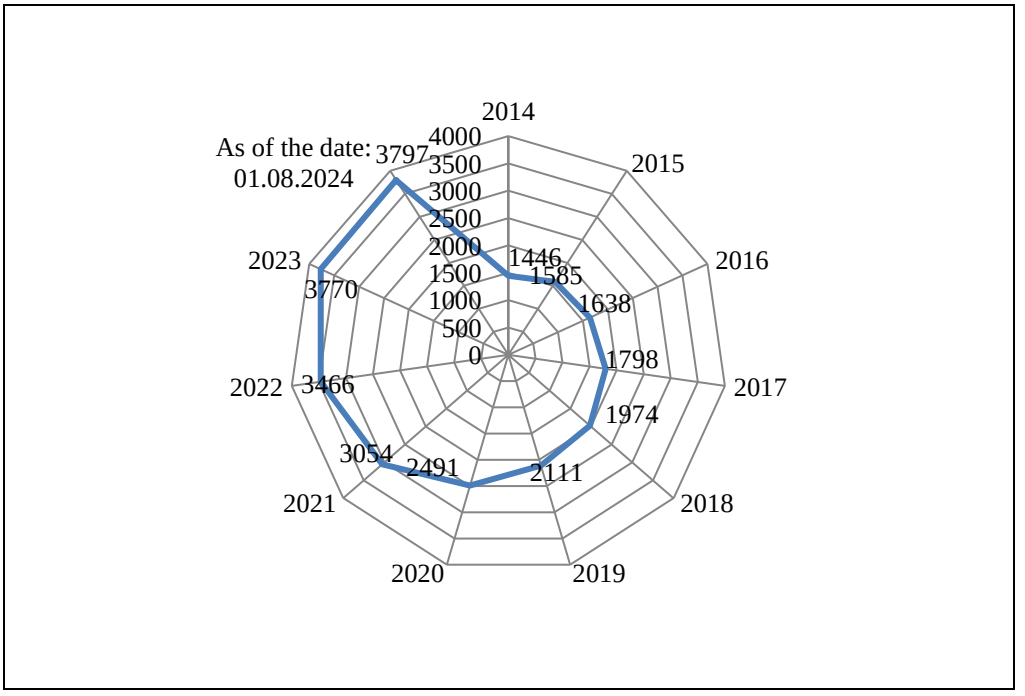


Figure 2. Number of publications for the search term "financial support of agricultural enterprises" in ScienceDirect from 2014 to August 1, 2024*

*Source: Compiled by the authors

Thus, Forkun et al. (2021) studied the impact of financial resources on agricultural enterprises, including the importance of access to financial resources for the production, processing, and storage of agricultural products. The authors noted that the process of forming, attracting, and utilizing financial resources should occur through institutional state support. Trusova et al. (2021a) emphasized the necessity of a synergistic approach to assessing the dynamic flow of resources, which would ensure the generation of internal funding sources that guarantee the continuous reproduction and improvement of the profitability of agricultural producers. Additionally, in the study titled "Modeling of System Factors of Financial Security of Agricultural Enterprises of Ukraine" (Trusova et al., 2021b), it was stated that the importance of financial support for agricultural enterprises is highlighted by the need for a systematic approach to managing financial sources and flows, which ensures a comprehensive assessment

and multifactorial modeling of the stable financial condition of agricultural entities. In the publications by Vdovenko (2020) and Anastasova (2017), issues of financial mechanisms for ensuring the development of agricultural enterprises were discussed, focusing on their characteristics, shortcomings, and proposals for improving financial support in the agricultural sector. The monograph by Zianko et al. (2020) examined the conceptual foundations of innovative development in the agricultural sector of the national economy, emphasizing modern approaches to socio-economic development and financing the innovation process.

Tomashuk (2017) addressed the challenges and prospects of financial support for the agricultural sector in the Vinnytsia region, discussing the challenges facing the agricultural sector and ways to overcome them, with particular emphasis on studying the structure of funding sources for agricultural enterprises. In the works of Svirskyi (2017) and Sus (2017), the theoretical foundations of financial potential and the conceptual aspects of financing innovative development in the agricultural sector were addressed, focusing on the methods and tools necessary to stimulate innovation in agriculture. They also emphasized the importance of improving the financial support of agricultural enterprises by utilizing alternative sources of funding and highlighted the significance of state support for the agricultural sector. In the publication by Dankevych (n.d.), the main sources of financing for agricultural development were examined, along with a characterization of the general approaches to state support for the agricultural sector of the economy and its directions in developed countries. Kovalova (2020) researched alternative forms of financial support for agricultural enterprises and their impact on the development of agricultural enterprises. The study by Berest & Dudka (2017) identified the structure of financing sources for agricultural and industrial complexes, while Tanklevska et al. (2023) highlighted the peculiarities of financing Ukrainian agricultural enterprises and found that the majority of financial support comes from equity capital, whereas state aid constitutes the smallest share. The authors noted that in light of the full-scale war in the country and limited own resources, it is advisable to increase the involvement of bank loans and state support in their economic activities (Tanklevska et al., 2023).

In the analytical report by Sobkevych et al. (2023), the priorities for the sustainability of the industrial and agricultural sectors of the Ukrainian economy in the context of the full-scale war were investigated. Garafonova et al. (2023) assessed the damages caused by Russian aggression and identified potential sources of funding for the post-war recovery of de-occupied territories, while also forming the first component of a strategic model for the post-war period. As noted in the study of Kyrylov et al. (2024), by utilizing advancements in precision agriculture, treated water, and the use of eco-friendly materials, productivity, resilience, and overall quality of life can be improved. However, the implementation of these practices requires sufficient funding for agricultural producers, making the research on potential financial instruments to support such innovations extremely relevant. Identifying effective funding sources, such as government subsidies, international grants, investment loans, and the involvement of private capital, is crucial for the successful implementation of these technologies. This also includes developing strategies aimed at maximizing the use of available financial resources, which will enable agricultural producers to effectively adopt cutting-edge technologies, thereby enhancing their competitiveness and resilience in the current environment.

The studies conducted by the aforementioned scholars are significant and noteworthy for a detailed examination and improvement of financial support for agricultural producers. However, they do not fully account for, or partially overlook, critical issues such as the specific impact of the war on the financial stability of agricultural enterprises and the changes in their funding sources during the wartime period. The changes in government support and its effectiveness in the context of exogenous military aggression, as well as the role of international aid and non-governmental organizations in ensuring the stable financial operation of agricultural producers during the crisis period, remain underexplored.

Based on the results of previous research, the authors formulated the following hypotheses:

- H1: Exogenous military aggression significantly affects the structure of financial support for agricultural producers, forcing them to adapt their financial strategies to new realities.
- H2: Government support programs and assistance from international partners significantly contribute to stabilizing the financial condition of agricultural producers but require adaptation to the specifics of wartime.
- H3: Self-financing remains an important source of financial stability for agricultural producers during wartime; however, its effectiveness largely depends on external economic conditions.
- H4: The use of modern analytical methods, such as ARIMA and stress testing, improves the forecasting of financial risks and the adaptation of agricultural producers to the conditions of exogenous military aggression.

The purpose of the article is to conduct a comprehensive analysis of the transformational processes of financial support for Ukrainian agricultural producers in the context of exogenous military aggression.

The novelty of the research lies in the comprehensive analysis of the transformational processes of financial support for Ukrainian agricultural producers during the period of exogenous military aggression, which allows for the exploration of the specifics of changes in the structure of financial support sources and their impact on the stability of agricultural producers. A forecasting model based on ARIMA has been developed, and a stress-testing scenario has been proposed for Ukrainian agricultural producers, which can be used when formulating financial strategies in conditions of economic instability.

2. Methodology

During the study, the authors utilized methods of formal logic, including observation and classification methods, which allowed them to identify and group the phenomena, facts, and data under investigation based on specific characteristics. The method of abstraction and the analysis method were employed to isolate the elements of the phenomena studied and the factors that influenced the funding sources for the agricultural sector as well as the structure of net income for agricultural producers. A systematic approach was used to examine the sources of funding and the income structure as a system that possesses specific statistical

characteristics, factors, and external influences. Additionally, the method of induction was applied in drawing conclusions. The research also incorporated specific research methods, including statistical methods of chronological analysis to determine quantitative and structural parameters of yield dynamics, changes in income structure, and changes in funding sources for agricultural enterprises. Graphical analysis was utilized to visually illustrate the percentage dynamics of changes in funding sources, the structure of net income, the speed of changes, and the results derived from ARIMA analysis. Comparative analysis and structural analysis were conducted to identify and characterize the factors and interdependencies between various indicators, particularly concerning the external environment.

Within the R-studio software, the following analyses were conducted:

a. Regression analysis, which allowed for a clearer examination of the interdependence between various indicators;

b. Trend analysis using time series (ARIMA), which identified the necessity for additional data to account for the influence of the external environment;

c. Scenario analysis and stress testing to analyze and forecast indicators for the period 2023-2027 based on official information about the exchange rate of UAH/USD during the studied period and based on calculated changes in the discount rate of the National Bank of Ukraine over the specified period;

d. An investigation of the rate of change in indicators, which enabled the assessment of the adequacy of the constructed model for forecasting indicators for 2023-2027.

3. Results and Discussion

According to data from OpenStreetMap (2024), after February 24, 2022, Russia occupied 108,007.3 km², of which 43,268.1 km² have been liberated and are under the control of Ukraine as of April 1, 2024. The regions affected by occupation and contamination with explosive remnants include Zhytomyr, Kyiv, Chernihiv, Sumy, Kharkiv, Luhansk, Donetsk, Zaporizhzhia, Kherson, Mykolaiv, and Odesa. As reported by the State Emergency Service (SES) to the Lviv portal (Duliaba, 2024), as of April 1, 2024, a total of 156,000 km² of territory, or 26% of the entire area of the country, remains mined. It is important to note that in the fall of 2023, the mined area was considered to be 174,000 km². Additionally, the Ministry of Internal Affairs has stated that over the past two years, sapper teams have identified and destroyed more than 780,000 explosive objects (Duliaba, 2024). According to calculations from the Food and Land Use Research Center at the Kyiv School of Economics (Ukrinform, 2023), the Ukrainian agricultural sector has suffered $80 billion in direct and indirect losses and damages due to the full-scale invasion (KSE, 2024). The report of Neiter et al. (2024) states that the total cost of destroyed assets of agricultural producers amounts to $10.3 billion, which is 18% higher than in 2023. Agricultural machinery has sustained the most damage, accounting for 56.7% of all losses. Figure 3 illustrates the dynamics of losses and damages in the Ukrainian agricultural sector across key dates.

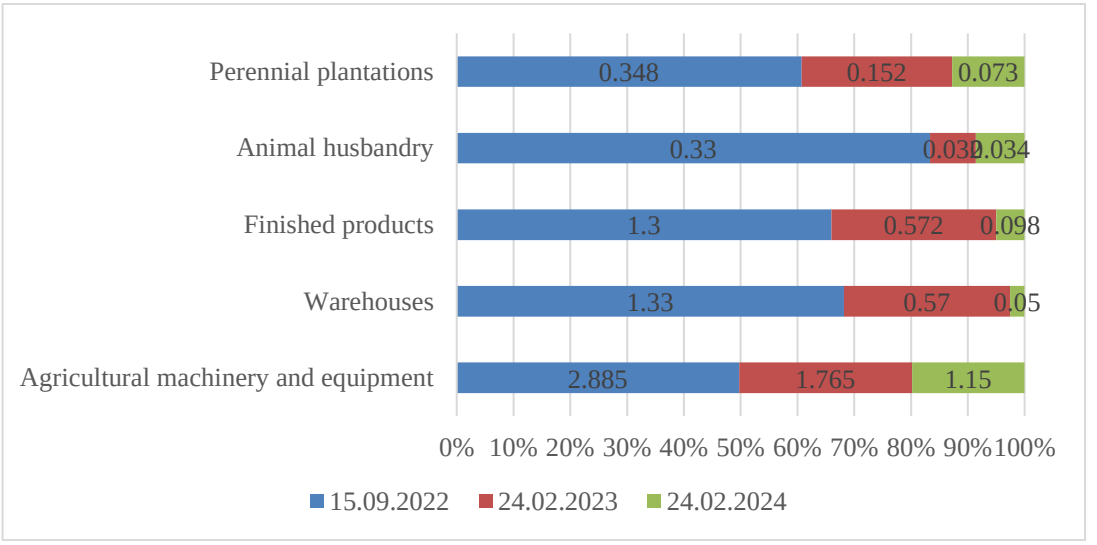


Figure 3. Direct agricultural losses over two years of full-scale invasion by key dates (September 15, 2022; February 24, 2023; February 24, 2024), in billion USD*

*Source: Developed by the authors based on Neiter et al. (2024), Priorities for Ensuring Industry Resilience, 2023

According to a joint study by the Centre for Economic Recovery, Advanter, the Ministry of Economy of Ukraine, and UNDP (2024), 3.8% of agricultural enterprises ceased operations for more than 12 months, 7.7% stopped for 3-6 months, 7.7% for 1-3 months, 3.8% for less than 1 month, and 76.9% did not halt their activities. These enterprises assess their financial losses due to the full-scale invasion as follows: 15% reported losses of over $1 million; 15% reported losses between $500,000 and $1 million; 7% reported losses between $100,000 and $500,000; 19% between $50,000 and $100,000; 22% between $10,000 and $50,000; 19% reported losses of up to $10,000, and only 4% did not incur any financial losses (UNDP, 2024).

In today's extraordinary conditions of agricultural activity in Ukraine, agricultural producers are demonstrating significant resilience and the ability to diversify risks. In the article by Rusan & Zhurakovska (2024), it is noted that in 2022, farmers harvested a total yield of over 100 million tons, including 53.9 million tons of grains and legumes. Throughout 2023, farmers managed to increase yield rates to a total harvest of over 115 million tons, of which 59.8 million tons were grains and legumes (Table 1).

Table 1. Dynamics of Agricultural Product Yields from 2019 to 2023, million tons*

	2019	2020	2021	2022	2023	Change during 2019-2021, %	Change during 2021-2022, %	Change during 2022-2023, %	Change during 2019-2023, %
In total	132,7	119,7	146,8	105,5	117,4	+ 10,63	- 28,13	+ 11,28	- 11,53
Cereals and legumes	75,1	64,9	86,0	53,9	59,8	+14,51	- 37,33	+ 10,95	- 20,37
Factory sugar beet	10,2	9,2	10,9	9,9	13,1	+ 6,86	- 9,17	+ 32,32	+ 28,43
Sunflower	15,3	13,1	16,4	11,3	12,8	+ 7,19	- 31,10	+ 13,27	- 16,34

Potato	20,3	20,8	21,4	20,9	21,4	+ 5,42	- 2,34	+ 2,39	+ 5,42
Vegetable crops	9,7	9,7	9,9	7,5	8,3	+ 2,06	- 24,24	+ 10,67	- 14,43
Fruit and berry crops	2,1	2,0	2,2	2,0	2,0	+ 4,76	- 9,09	-	- 4,76

*Source: Developed by the authors based on statistical information of the State Statistics Service (2024).

It is worth noting that despite some increase in overall yield indicators, they have not reached the maximum results of the five-year study period. This is particularly due to the fact that more than 60,000 km² remain under Russian occupation. Additionally, it should be mentioned that in the liberated territories, the prolonged presence of the aggressor country and active combat operations have led to significant contamination of the land with explosive materials. The active phase of demining agricultural lands is ongoing, which hampers the free conduct of agricultural activities. Rusan & Zhurakovska (2024) highlight that there is currently a shortage of financial resources necessary for the stable operation of agricultural producers, which is related to the rising cost of production. In 2022, approximately 21% of agricultural enterprises reported a net loss, while this figure was 11% in 2021. The level of profitability in 2022 stood at 14.1%, compared to 37.8% in 2021. Additionally, the volume of capital investments in agriculture, forestry, and fisheries in 2022 amounted to 51.439 billion UAH, which is a decrease of 26.1% compared to 2021. Before the full-scale invasion, enterprises involved in agriculture in Ukraine were primarily financed through their own funds, loans, leasing, and other traditional financing instruments. For example, in 2010, the following distribution of funding sources was typical for agricultural enterprises in the Zhytomyr region: self-financing – 48%, investor funding – 26%, government funding – 13%, unconventional financing – 4%, and other sources of funding – 2% (Dankevych V., n.d.). In subsequent years, self-financing exhibited various trends; after the start of the anti-terrorist operation in the Luhansk and Donetsk regions, a gradual decline occurred: 2012 – 53.55%, 2013 – 50.09%, 2014 – 41.97%, 2015 – 40.14%. Before the full-scale invasion in 2021, the self-financing rate averaged over 80% across Ukraine (Kovalova, 2020; Berest & Dudka, 2017). The full-scale invasion of Russia into Ukraine in 2022 led to significant changes in the funding sources for agricultural enterprises. The increase in risks and the inability to diversify them forced agricultural businesses to seek unconventional sources of financing, placing greater emphasis on funding tools such as grant applications, assistance from international organizations, and government support programs.

The authors of the study believe that in 2023, the structure of funding sources for agricultural enterprises changed under the influence of the following factors:

a. Due to economic instability and a decrease in sales volume, the profit from the operational activities of many agricultural producers significantly decreased, directly affecting the level of self-financing.

b. Partial or complete destruction of the material and technical base of enterprises, crop losses, and other damages related to the consequences of military actions by the aggressor country compelled business owners to find means of replenishing financial resources by attracting external funding sources.

c. International support from foreign partners, which is partly aimed at assisting agriculture and agricultural producers.

d. An increase in government support programs for various sectors of the economy, including the agricultural sector, to ensure the resilience and recovery of the Ukrainian economy.

e. The possibility of obtaining grants and charitable contributions from international organizations and funds.

f. The search for and attraction of private investors to cover the financial resource shortfall for agricultural producers.

Agricultural enterprises in Ukraine have found new opportunities for funding and supporting their operational activities. Table 2 reflects the government support programs that were in place before the onset of the full-scale invasion.

Table 2. Government Support Programs for Agricultural Producers Before the Full-Scale Invasion, million UAH*

No	Name of the program	2020	2021	Change during 2020-2021, %
1	Decreasing the purchase price of agricultural machinery and equipment	1457,64	1000,00	68,60
2	Lowering the cost of loans	1048,71	1200,00	114,43
3	Development of farms	134,76	200,00	148,41
4	Development of animal husbandry	1046,92	1150,00	109,85
5	Development of horticulture, viticulture and hops	291,95	450,00	154,14
6	"5-7-9%" program	2000,00	4072,00	203,60
7	Other	x	340,00	x

*Source: Compiled by the authors based on (KSE, 2021; AgroPolit, 2021; Kornylyuk & Kornylyuk, 2024)

Before the full-scale invasion, the direction of government programs changed; funding under the "5-7-9%" Program increased by two times, the cost of loans increased by 14.43%, and support for the development of farms increased by 48.41%. At the end of 2021, the government planned to expand financial support programs for farmers for 2022 in the following areas: agricultural insurance, compensation for losses from drought, production of organic products, potato growing, and subsidies for growing buckwheat (AgroPolit, 2021). During the full-scale invasion, programs that were in place before the war continued to operate (Odesa Regional State Administration, 2024), while new supplementary programs emerged, providing greater opportunities for financial support in wartime for ongoing operational activities. Agricultural enterprises can take advantage of the following new programs:

- Grant for Own Business (ranging from 50,000 to 250,000 UAH) – for the purchase of equipment, raw material procurement, rental payments, and leasing of equipment.

- Grant for Veterans and Their Family Members (up to 1 million UAH) – for purchasing furniture, equipment, and vehicles for commercial use, licensed software, raw materials, materials, goods and services necessary for implementing a business plan, as well as for

products or seedlings to create farms, marketing and advertising services, renting non-residential premises, leasing equipment, and purchasing franchises.

- Greenhouse Grant (for 0.4-0.6 hectares – 2 million UAH; for 0.8-1.2 hectares – 3.5 million UAH; for 1.6-2.4 hectares – 7 million UAH, but no more than 70% of the project cost) – for paying any bills related to the construction project of a modular greenhouse included in the budget.

- Orchard Grant (ranging from 140,000 to 400,000 UAH per hectare, but no more than 70% of the cost of the planting project) – for paying invoices to suppliers (vendors) for the materials included in the budget for implementing the project (Avercheva & Yefremov, 2023; Karnaushenko & Yefremov, 2023).

The government is trying to respond to the challenges faced by agricultural producers and the business community due to Russia's full-scale invasion of Ukraine by expanding financial support programs, assistance, and investment opportunities for new projects in the agro-industrial complex (Figure 4).

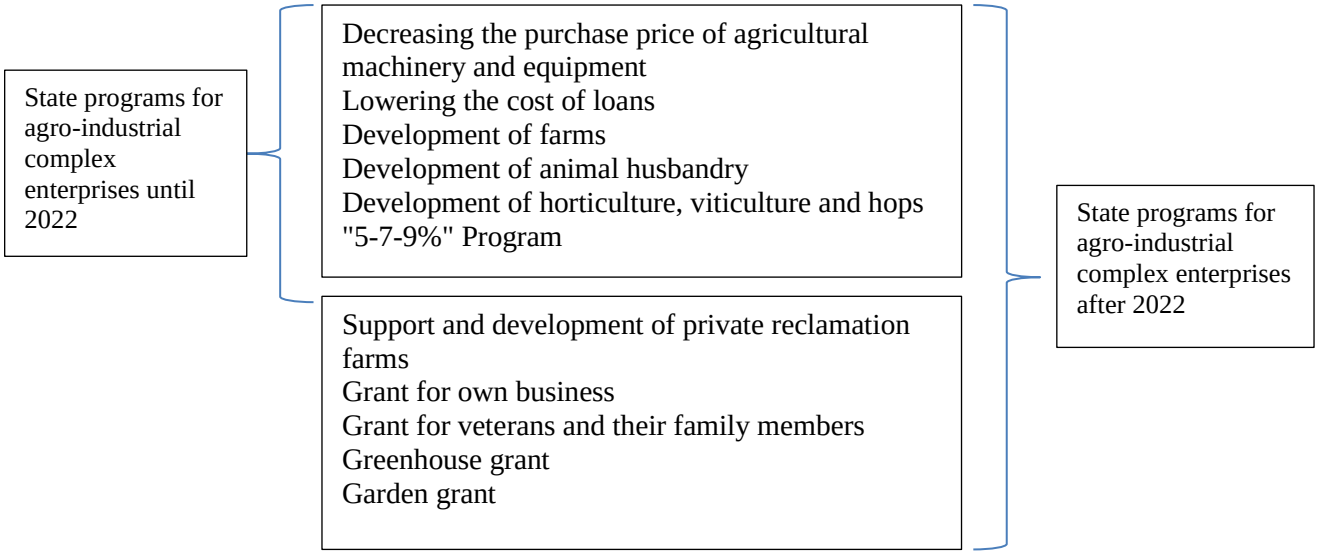


Figure 4. Government Support for Agro-Industrial Complex Enterprises During Wartime*

*Source: Compiled by the authors based on (KSE, 2021; Korniyuk & Korniyuk., 2024; AgroPolit, 2021)

An important element for agricultural producers is international support, which has been implemented even before the onset of the full-scale invasion (Odesa Regional State Administration, 2020): 1. Small Business Support Group in Ukraine from the EBRD; 2. PUM Netherlands Senior Experts; 3. Global Innovation Fund; 4. Mysterious Charitable Foundation "Well-being of Communities"; 5. COSME - European program supporting small and medium-sized enterprises; 6. Support for small projects from the Swiss Cooperation Office; 7. EU4Business Initiative in Ukraine; 8. Women in Business; 9. Initiative East.

By analyzing the above international programs, the authors established that by 2022, Ukrainian agricultural producers were receiving assistance from various international organizations and funds in multiple directions: from financial support for implementing specific projects to advisory assistance with opportunities for international exchange to gain experience and acquire necessary entrepreneurial skills.

Equally important was and is the support for Ukrainian agricultural producers during the war. International financial and advisory support has increased alongside the economic aid to the country to create conditions for stabilization, recovery, and development of Ukraine's economic sector. Among the largest partners supporting Ukrainian agricultural producers are international programs from USAID AGRO, USAID ERA, and Mercy Corps.

During 2022-2023, the USAID AGRO program continued to provide substantial support to the Ukrainian agricultural sector. In 2023, the program assisted over 8,200 agricultural producers with fertilizers and seeds, specifically: 6,300 agricultural producers received mineral fertilizers; 1,214 agricultural producers received sunflower seeds; and 709 agricultural producers received corn seeds (DZI, 2023). In addition, USAID AGRO supported agricultural producers through sub-grants for the development of elevator capacity, which allowed for increased volumes and quality of grain storage (KSE, 2024b). The USAID ERA program provided support to a large number of agricultural producers in Ukraine (2022-2023), particularly within the framework of the AGRI-Ukraine initiative, aimed at ensuring food security and improving the export capabilities of the agricultural sector (DAI, 2024). While the authors of the study did not establish an exact number of agricultural producers who received support due to the lack of such information in public reports, it is known that USAID ERA implemented large-scale projects to improve infrastructure, support exports, and enhance logistical capabilities. With the help of USAID ERA, over $77 million in private investments were attracted, and assistance was provided to more than 7,494 vulnerable groups in the population (DAI, 2024).

Mercy Corps (2024) actively supported Ukrainian agricultural producers during 2022-2023 – over 750,000 individuals, including agricultural producers, received assistance from Mercy Corps (Mercy Corps, 2024), in the form of financial grants and technical support. The main focus is on assisting small and medium agricultural producers who suffered significant losses due to combat operations. The program included providing grants for restoring agricultural infrastructure, support for purchasing necessary equipment and materials, as well as assistance in overcoming challenges related to labor shortages and reduced domestic demand for products (KSE, 2024b). In addition to the aforementioned international partners, Ukrainian agricultural producers can receive financial support from the Czech organization "People in Need" through the "Trust" program, providing up to $5,000, NMFA through the program "Expression of Interest (EoI)/Application for Participation in Project of Grants for Relocation/Restabilization of Microbusinesses" also up to $5,000, and a joint project between Ukrainian businesses and the German Government, offering up to €20,000 for business development, among others (DZI, 2023). Long-standing Ukrainian partners continue to support agricultural producers, including the European Bank for Reconstruction and Development, the European Investment Bank, and the European Union (Funding for the Agricultural Sector…, 2024).

During the war, Ukrainian agricultural producers have a sufficient selection of financial

instruments for additional funding of their operational activities or investment projects aimed at revitalization or further development. To understand the effects of support programs for agricultural producers, the authors investigated the structure of funding volumes for agricultural activities, expressed in monetary units for the period from 2014 to 2022 (Table 3).

Table 4. Dynamics of Funding Volumes for Agricultural Producers from 2014 to 2022*

Year	Total, million UAH	Own capital, million UAH	Long-term liabilities and security, million UAH	Current liabilities and security, million UAH	Liabilities related to non-current assets held for sale and disposal groups and net value of non-state pension fund assets, million UAH	Percentage ratio of equity to total liabilities, %
2014	390607,0	163931,7	62975,4	163616,6	83,3	41,97
2015	685845,0	275303,8	68127,2	342359,0	55,0	40,14
2016	1537319,2	369370,9	61898,2	1105991,9	58,2	24,03
2017	911614,0	436337,6	59080,5	416146,2	49,7	47,86
2018	983593,5	482978,7	82253,9	418283,2	77,7	49,10
2019	1030366,8	522778,7	92966,4	414566,5	55,2	50,74
2020	1130304,9	612250,9	76799,5	441177,6	76,9	54,17
2021	1344872,4	796549,7	87165,9	461099,6	57,2	59,23
2022	1441179,1	810270,4	99633,3	531217,8	57,6	56,22

*Source: Compiled by the authors based on the State Statistics Service of Ukraine, 2024

Thus, according to the provided information, we understand that the primary source of funding for entrepreneurial activities is considered to be equity capital by agricultural producers, as evidenced by the percentage ratio. During the period from 2014 to 2022, there was a decrease in the share of additional funding in the form of any obligations (Figure 7).

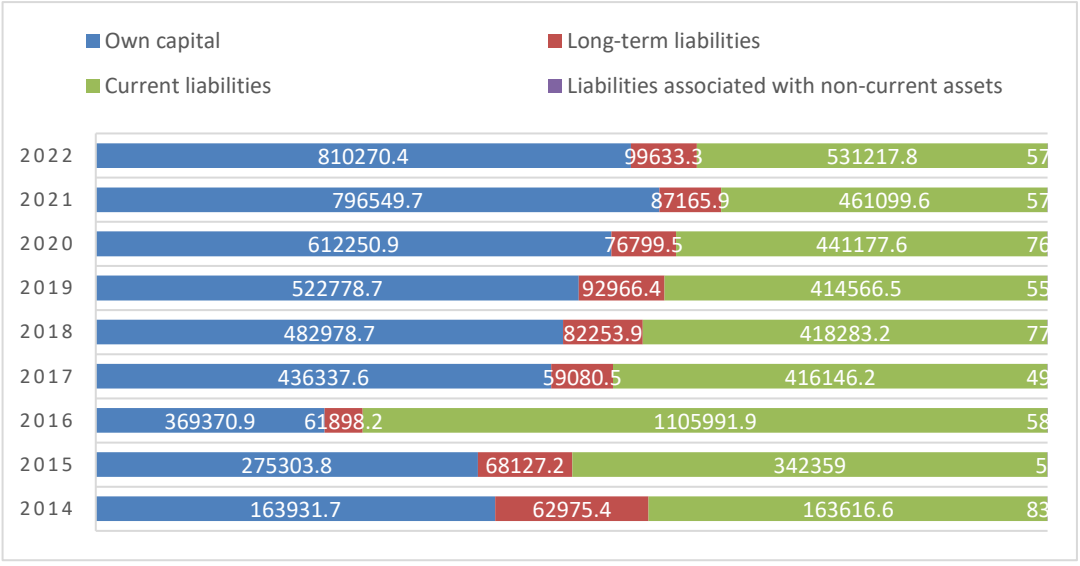


Figure 5. Structure of sources of financing in the agricultural sector of Ukraine during 2014-2022, %*

*Source: Compiled by the authors based on the State Statistics Service of Ukraine, 2024

Own capital plays a key role in running an agricultural business, which, according to this study, is connected with the instability of the global and domestic economy (in particular, the crisis of 2014-2015, Russia's occupation of the Autonomous Republic of Crimea and the waging of a hybrid war with Ukraine in Donbas, the COVID-19 pandemic, the beginning of a full-scale invasion, etc.). To carry out an analysis of changes in the financing of agricultural producers, it is also worth investigating the structure of their incomes (Table 5, Figure 6).

Table 5. Dynamics of the income of agricultural producers in Ukraine for the period 2014-2022*

Year	Total revenues, million UAH	Net income from the sale of products, million UAH	Other operating income, million UAH	Other incomes, million UAH	Change in total income in % compared to the previous year, %
2014	262207,8	214972,5	41820,5	5414,5	-
2015	451008,4	366966,4	68659,2	15378,1	+ 72,00
2016	456910,9	402597,4	47501,8	6811,2	+ 1,31
2017	499974,9	452760,1	40368,2	6846,6	+ 9,43
2018	588554,0	528657,8	49067,2	10828,4	+ 17,72
2019	671617,7	560598,7	94702,7	16315,4	+ 14,11
2020	681306,2	602684,4	67388,0	11223,3	+ 1,44
2021	895298,7	770262,8	110758,2	14270,9	+ 31,41
2022	731208,4	642745,7	76954,2	11507,4	- 18,33

*Source: Compiled by the authors based on the State Statistics Service of Ukraine, 2024

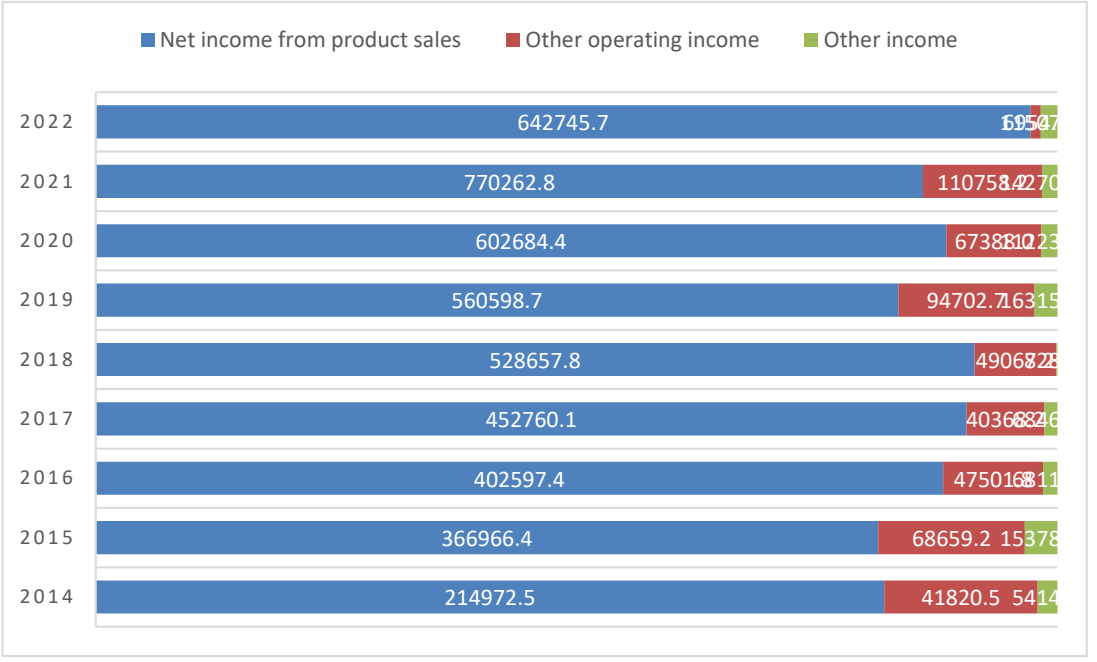


Figure 6. Income structure of agricultural producers in Ukraine for the period 2014-2022, %*

*Source: Compiled by the authors based on the State Statistics Service of Ukraine, 2024

To identify patterns in the collected data, as presented in Tables 4 and 5, between net income and the structure of funding sources for agricultural producers, we will conduct a trend analysis using time series ARIMA. As noted in the study by Ray et al. (2023), ARIMA consists of three components: autoregressive (AR), integrated (I), and moving average (MA). The AR term expresses the autocorrelation between past and current observations, while the MA term denotes the autocorrelation structure of the residuals (errors) and indicates that most univariate time series data follow upward and downward trends. The I term reflects the need for differencing the data to achieve stationarity, meaning that trends or seasonality are removed from the time series (Ray et al., 2023).

The ARIMA model is used for forecasting because it can represent complex interrelationships within time series data, incorporating both long-term trends and short-term fluctuations. By combining these three components, ARIMA can provide accurate forecasts in situations where other methods may not account for all significant aspects of the data (Fotedar, n.d.). The data for conducting the trend analysis using time series ARIMA is shown in Table 6.

Table 6. Data for Conducting Trend Analysis Using Time Series*

Year	Total net income, million UAH	Own capital, million UAH	Long-term liabilities, million UAH	Current liabilities, million UAH	Liabilities related to non-current assets, million UAH
2014	262207,8	163931,7	62975,4	163616,6	83,3
2015	451008,4	275303,8	68127,2	342359,0	55,0
2016	456910,9	369370,9	61898,2	1105991,9	58,2
2017	499974,9	436337,6	59080,5	416146,2	49,7
2018	588554,0	482978,7	82253,9	418283,2	77,7
2019	671617,7	522778,7	92966,4	414566,5	55,2
2020	681306,2	612250,9	76799,5	441177,6	76,9
2021	895298,7	796549,7	87165,9	461099,6	57,2
2022	731208,4	810270,4	99633,3	531217,8	57,6

*Source: Compiled by the authors based on the State Statistics Service of Ukraine, 2024

First of all, it is essential to understand the interdependence of net income with the provided indicators; for this purpose, linear regression analysis should be employed. In this analysis, the dependent variable (Y) is the category "Total Income, million UAH," while the independent variables are: "Equity, million UAH" - X1, "Long-term Liabilities, million UAH" - X2, "Current Liabilities, million UAH" - X3, and "Liabilities Related to Non-Current Assets, million UAH" - X4. In total, we have 5 variables. The data sample for these variables should cover 9 years: from 2014 to 2022.

The linear regression analysis was conducted using R-studio software. In forming the code with the general data, we use the following designations: Year – year, Income – total net income, million UAH, Equity – equity, million UAH, LongTermLiabilities – long-term liabilities, million UAH, CurrentLiabilities – current liabilities, million UAH, FixedLiabilities – liabilities related to non-current assets, million UAH.

To build the linear regression model, we use the following code in R-studio:

```
data = data.frame(
  Year = c(2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022),
  Income = c(262207.8, 451008.4, 456910.9, 499974.9, 588554.0, 671617.7, 681306.2, 895298.7, 731208.4),
  Equity = c(163931.7, 275303.8, 369370.9, 436337.6, 482978.7, 522778.7, 612250.9, 796549.7, 810270.4),
  LongTermLiabilities = c(62975.4, 68127.2, 61898.2, 59080.5, 82253.9, 92966.4, 76799.5, 87165.9, 99633.3),
  CurrentLiabilities = c(163616.6, 342359.0, 1105991.9, 416146.2, 418283.2, 414566.5, 441177.6, 461099.6, 531217.8),
  FixedLiabilities = c(83.3, 55.0, 58.2, 49.7, 77.7, 55.2, 76.9, 57.2, 57.6)
)
model = lm(Income ~ Equity + LongTermLiabilities + CurrentLiabilities + FixedLiabilities, data = data)
summary(model)
```

As a result of this code, we have automatic output of the following information:

```
Call:
lm(formula = Income ~ Equity + LongTermLiabilities + CurrentLiabilities +
    FixedLiabilities, data = data)

Residuals:
      1       2       3       4       5       6       7       8       9
-44294.3 29048.2   239.3 -37759.6 26127.2 42594.0 26976.3 70323.7 -113254.8

Coefficients:
                    Estimate     Std. Error   t value  Pr(>|t|)
(Intercept)         2.253e+05    2.654e+05    0.849    0.444
Equity              7.506e-01    2.275e-01    3.299    0.030 *
LongTermLiabilities 9.670e-01    3.304e+00    0.293    0.784
CurrentLiabilities -3.423e-02    1.224e-01   -0.280    0.794
FixedLiabilities   -1.166e+03    2.514e+03   -0.464    0.667
---
```

```
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 79420 on 4 degrees of freedom

Multiple R-squared:  0.9099,    Adjusted R-squared:  0.8199

F-statistic:  10.1 on 4 and 4 DF,  p-value: 0.02287
```

It is appropriate to explain the derived data as follows: (1) Since the p-value for the F-statistic is less than 0.05, we can conclude that the model presented is statistically significant overall. (2) The coefficient for Equity (Equity, million UAH) is statistically significant (with a value of 0.030), indicating a strong influence of this variable on Income (Total Net Income, million UAH). (3) Other variables, such as LongTermLiabilities (long-term liabilities, million UAH), CurrentLiabilities (current liabilities, million UAH), and FixedLiabilities (liabilities related to non-current assets, million UAH), are not statistically significant at the significance level of 0.05. (4) The R^2 value of 0.9099 indicates that the model explains a substantial amount of the variance in net income. (5) The adjusted R^2 value of 0.8199 reflects the consideration of the number of variables in the presented model and shows slightly lower conformance, yet remains high.

Next, what is necessary for effective analysis is to conduct a trend analysis using time series (building the ARIMA model). For this purpose, we need to supplement our code with the following lines:

```
residuals = residuals(model)

plot(data$Year, residuals, type = "b", main = "Residuals Over Time", xlab = "Year", ylab = "Residuals")

abline(h = 0, col = "red")


acf(residuals, main = "ACF of Residuals")

pacf(residuals, main = "PACF of Residuals")


install.packages("forecast")

library(forecast)

arima_model = auto.arima(residuals)

summary(arima_model)


forecast_residuals = forecast(arima_model, h = 5)

plot(forecast_residuals)
```

Using the obtained code in R-studio, we automatically calculate the residuals of the regression

model (the difference between the actual values and the values predicted by the regression model) and create a plot of the residuals over the years. This allows us to visually assess whether there are any trends or patterns in the residuals, with the red line at the level of 0 helping to identify deviations of the residuals from zero (Figure 7).

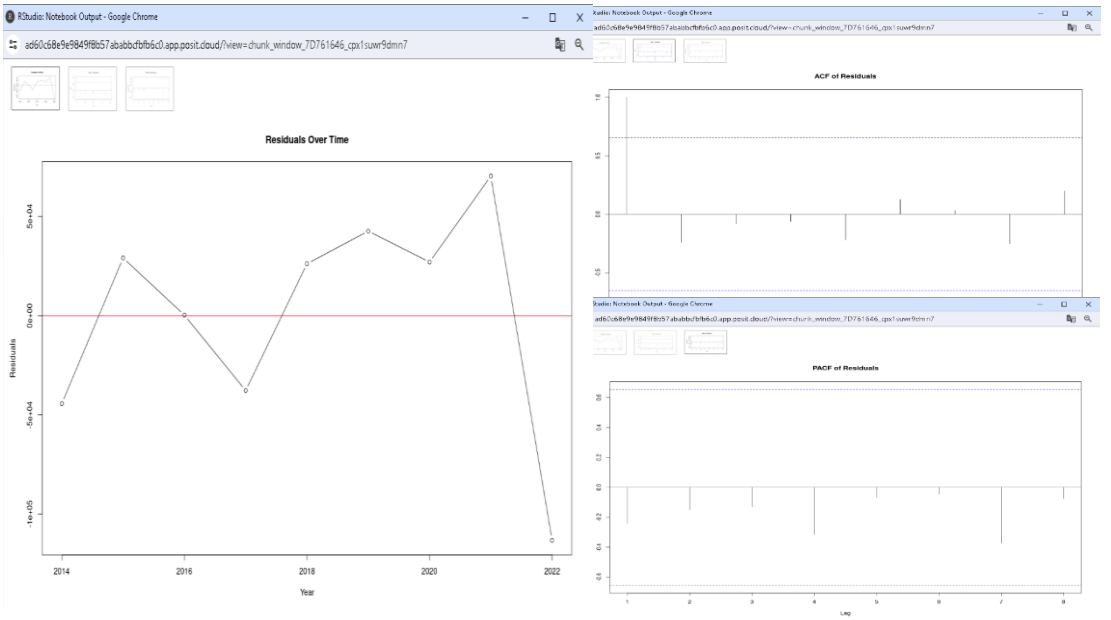


Figure 7. Graphs of balances by year*

*Source: Generated by the authors using R-studio software based on the code

Using the code, the authors of the study determined the autocorrelation function (ACF) and the partial autocorrelation function (PACF) of the residuals, which helps to identify any dependencies of the residuals on their previous values. The "auto.arima" function allows for automatic selection of the best ARIMA model for the residuals and provides details about the fitted model. The function "forecast_residuals = forecast(arima_model, h = 5)" forecasts the residuals for 5 periods ahead. For clarity, we use "plot(forecast_residuals)", which constructs a forecast plot (Figure 8).

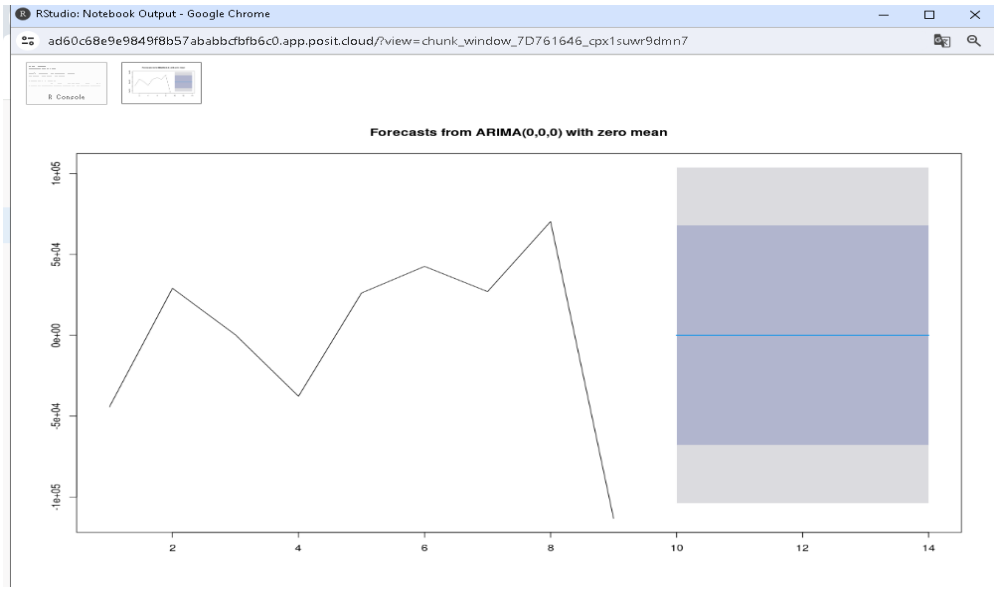


Figure 8. ARIMA Model*

*Source: Generated by the authors using R-studio software based on the code

Important to understand is not only the graphical representation of the ARIMA model, but also the calculations generated by R-studio:

Series: residuals

ARIMA(0,0,0) with zero mean

sigma^2 = 2.803e+09: log likelihood = -110.66

AIC=223.33 AICc=223.9 BIC=223.52

Training set error measures:

	ME	RMSE	MAE	MPE	MAPE
Training set	1.21187e-12	52944.72	43401.94	100	100

	MASE	ACF1
Training set	0.7498484	-0.2410325

As it can be seen, the ARIMA model (0,0,0) with a zero mean indicates that the best model for the residuals is a simple constant, suggesting the absence of autocorrelation in the residuals. This confirms that the regression model effectively explains most of the variance in the dependent variable and that the residuals do not exhibit a significant structure that could be modeled using ARIMA. However, the high variance of the residuals (sigma²) and elevated values for RMSE and MAE indicate considerable volatility in the residuals, which may signal

the need for further investigation into potential influences that were not included in the initial model. Therefore, it is necessary to add external factors, such as the UAH/USD exchange rate and the average annual discount rate of the National Bank of Ukraine (%), (Table 7).

Table 7. Data for Conducting a Re-Linear Regression Analysis Considering Additional Indicators and Data for Scenario Analysis and Stress Testing of the Model*

Year	Total revenues, million UAH	Own capital, million UAH	Long-term liabilities, million UAH	Current liabilities, million UAH	Liabilities related to non-current assets, million UAH	Exchange rate UAH/USD, UAH	NBU discount rate (on average for the year), %
2014	262207,8	163931,7	62975,4	163616,6	83,3	11,89	11,04
2015	451008,4	275303,8	68127,2	342359,0	55,0	21,84	24,21
2016	456910,9	369370,9	61898,2	1105991,9	58,2	25,55	17,96
2017	499974,9	436337,6	59080,5	416146,2	49,7	26,60	13,25
2018	588554,0	482978,7	82253,9	418283,2	77,7	27,20	15,63
2019	671617,7	522778,7	92966,4	414566,5	55,2	25,85	18,29
2020	681306,2	612250,9	76799,5	441177,6	76,9	26,96	7,46
2021	895298,7	796549,7	87165,9	461099,6	57,2	27,29	6,83
2022	731208,4	810270,4	99633,3	531217,8	57,6	32,34	17,42

*Source: Compiled by the authors based on the State Statistics Service of Ukraine, 2024; NBU, 2024

Conducting regression analysis is vital for revealing the interdependence between equity indicators and the additional data indicators. In this case, the dependent variable (Y) is the category "Equity, million UAH," while the independent variables are: "UAH/USD Exchange Rate, UAH" - X1 and "NBU Discount Rate (average for the year), %" - X2. In total, there are 3 variables. The data sample for these variables should cover 9 years: from 2014 to 2022.

First of all, in R-studio, we create a dataframe with the data we have, and for better analysis, we scale the data (transforming the values of the variables so that they fall within a specific range or possess certain statistical properties). This is done to ensure that different variables are comparable with one another, especially when they are expressed in different units of measurement, such as in our dataframe—million UAH, UAH, and percentages. After scaling, we conduct linear regression analysis for these variables. Thus, the code in R-studio looks the following way:

```
data = data.frame(

  Year = c(2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022),

  Income = c(262207.8, 451008.4, 456910.9, 499974.9, 588554.0, 671617.7, 681306.2, 895298.7, 731208.4),

  Equity = c(163931.7, 275303.8, 369370.9, 436337.6, 482978.7, 522778.7, 612250.9, 796549.7, 810270.4),

  LongTermLiabilities = c(62975.4, 68127.2, 61898.2, 59080.5, 82253.9, 92966.4, 76799.5, 87165.9, 99633.3),
```

```
  CurrentLiabilities = c(163616.6, 342359.0, 1105991.9, 416146.2, 418283.2, 414566.5, 441177.6, 461099.6, 531217.8),
  FixedLiabilities = c(83.3, 55.0, 58.2, 49.7, 77.7, 55.2, 76.9, 57.2, 57.6),
  ExchangeRate = c(11.89, 21.84, 25.55, 26.60, 27.20, 25.85, 26.96, 27.29, 32.34),
  InterestRate = c(11.04, 24.21, 17.96, 13.25, 15.63, 18.29, 7.46, 6.83, 17.42)
)

normalize = function(x) {
  return ((x - mean(x)) / sd(x))
}

data_norm = as.data.frame(lapply(data[, c("Equity", "ExchangeRate", "InterestRate")], normalize))
data_norm$Year = data$Year

model2 = lm(Equity ~ ExchangeRate + InterestRate, data = data_norm)
summary(model2)
```

Власне, виконуючи цю команду, маємо такі результати:

```
Call:
lm(formula = Equity ~ ExchangeRate + InterestRate, data = data_norm)
Residuals:
    Min      1Q  Median      3Q     Max
-0.6048 -0.3162  0.1272  0.2515  0.5383

Coefficients:
                Estimate   Std. Error  t value  Pr(>|t|)
(Intercept)     2.864e-17  1.590e-01   0.000    1.00000
ExchangeRate    8.395e-01  1.688e-01   4.973    0.00252 **
InterestRate    -3.885e-01 1.688e-01   -2.301   0.06101 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Residual standard error: 0.4771 on 6 degrees of freedom

Multiple R-squared: 0.8293, Adjusted R-squared: 0.7723

F-statistic: 14.57 on 2 and 6 DF, p-value: 0.004978

Based on this information, we can draw the following conclusions:

- Since the p-value for the F-statistic is less than 0.05, we can conclude that the presented model is statistically significant overall.
- The coefficient for ExchangeRate (UAH/USD Exchange Rate, UAH) is statistically significant (with a value of 0.00252), indicating a strong influence of this variable on Equity (Equity, million UAH).
- The coefficient for InterestRate (NBU Discount Rate, % average for the year) is not fully statistically significant at the 0.05 significance level, meaning that the impact of this variable on Equity (Equity, million UAH) is not statistically significant.
- The coefficient of determination $R^2 = 0.8293$ indicates that the model explains approximately 83% of the variance in the Equity variable (Equity, million UAH).
- The adjusted R^2 coefficient at 0.7723 accounts for the number of dependent variables and shows a slightly lower yet still high correspondence of the model to the data.

As it has been determined that the change in the category "Total Net Income, million UAH" depends on the category "Equity, million UAH," which, in turn, is influenced by the external factor "UAH/USD Exchange Rate, UAH," we will conduct a scenario analysis and stress testing of the model, considering that in 2023 the average annual exchange rate was 36.57 UAH, and in 2024, according to the Law of Ukraine "On the State Budget of Ukraine for 2024" (Verkhovna Rada of Ukraine, 2023), it will be 40.7 UAH. According to the Cabinet of Ministers of Ukraine's Resolution "On Approval of the Budget for 2025-2027" (Verkhovna Rada of Ukraine, 2024), the exchange rate is projected to be 45.0 UAH in 2025, 46.5 UAH in 2026, and 46.4 UAH in 2027. Also, according to official data, the discount rate of the National Bank of Ukraine in 2023 (2024) was 22% on average for the year, taking into account the current trend of discount rate reduction and with the calculations of the first half of the year, we predict that the average annual rate of the NBU in 2024 will be 13, 7%, for the presented model we substitute our values of the positive forecast of the reduction of the average discount rate of the NBU: in 2025 to 12.0%, in 2026 to 10.0%, in 2027 to 7.5%. According to the above data, the following code was obtained:

```
data = data.frame(
  Year = c(2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022),
  Income = c(262207.8, 451008.4, 456910.9, 499974.9, 588554.0, 671617.7, 681306.2, 895298.7, 731208.4),
  Equity = c(163931.7, 275303.8, 369370.9, 436337.6, 482978.7, 522778.7, 612250.9, 796549.7, 810270.4),
```

```
  LongTermLiabilities = c(62975.4, 68127.2, 61898.2, 59080.5, 82253.9, 92966.4, 76799.5, 87165.9, 99633.3),
  CurrentLiabilities = c(163616.6, 342359.0, 1105991.9, 416146.2, 418283.2, 414566.5, 441177.6, 461099.6, 531217.8),
  FixedLiabilities = c(83.3, 55.0, 58.2, 49.7, 77.7, 55.2, 76.9, 57.2, 57.6),
  ExchangeRate = c(11.89, 21.84, 25.55, 26.60, 27.20, 25.85, 26.96, 27.29, 32.34),
  InterestRate = c(11.04, 24.21, 17.96, 13.25, 15.63, 18.29, 7.46, 6.83, 17.42)
)

normalize = function(x) {
  return ((x - mean(x)) / sd(x))
}

data_norm = as.data.frame(lapply(data[, c("Equity", "ExchangeRate", "InterestRate")], normalize))
data_norm$Year = data$Year

model2 = lm(Equity ~ ExchangeRate + InterestRate, data = data_norm)

summary(model2)

future_scenarios = data.frame(
  Year = c(2023, 2024, 2025, 2026, 2027),
  ExchangeRate = c(36.57, 40.7, 45.0, 46.5, 46.4),
  InterestRate = c(22.0, 13.7, 12.0, 10.0, 7.5)
)

mean_exchange_rate = mean(data$ExchangeRate)
sd_exchange_rate = sd(data$ExchangeRate)
mean_interest_rate = mean(data$InterestRate)
sd_interest_rate = sd(data$InterestRate)
```

```
future_scenarios_norm = data.frame(
  ExchangeRate = (future_scenarios$ExchangeRate - mean_exchange_rate) / sd_exchange_rate,
  InterestRate = (future_scenarios$InterestRate - mean_interest_rate) / sd_interest_rate,
  Year = future_scenarios$Year
)

predictions = predict(model2, newdata = future_scenarios_norm)

mean_equity = mean(data$Equity)
sd_equity = sd(data$Equity)

predicted_equity = data.frame(
  Year = future_scenarios$Year,
  PredictedEquity = predictions * sd_equity + mean_equity
)

print(predicted_equity)
```

The results of this code provide a forecast for the value of the category "Equity, million UAH" (see Table 8). The forecast includes data from 2023 and 2024, as there are currently no published official data regarding this indicator for 2023 and the full year of 2024.

Table 8. Forecast of "Equity, million UAH" Values for 2023-2027*

Year	PredictEquity
2023	761302,9
2024	1021525,6
2025	1187466,5
2026	1266633.5
2027	1301185,2

*Source: Calculated by the authors using R-studio software

The next calculations will focus on determining the forecasted value for the category "Total Income, million UAH":

```
data = data.frame(
  Year = c(2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022),
  Income = c(262207.8, 451008.4, 456910.9, 499974.9, 588554.0, 671617.7, 681306.2, 895298.7, 731208.4),
```

```
  Equity = c(163931.7, 275303.8, 369370.9, 436337.6, 482978.7, 522778.7, 612250.9, 796549.7, 810270.4),
  LongTermLiabilities = c(62975.4, 68127.2, 61898.2, 59080.5, 82253.9, 92966.4, 76799.5, 87165.9, 99633.3),
  CurrentLiabilities = c(163616.6, 342359.0, 1105991.9, 416146.2, 418283.2, 414566.5, 441177.6, 461099.6, 531217.8),
  FixedLiabilities = c(83.3, 55.0, 58.2, 49.7, 77.7, 55.2, 76.9, 57.2, 57.6),
  ExchangeRate = c(11.89, 21.84, 25.55, 26.60, 27.20, 25.85, 26.96, 27.29, 32.34),
  InterestRate = c(11.04, 24.21, 17.96, 13.25, 15.63, 18.29, 7.46, 6.83, 17.42)
)

predicted_equity = c(761302.9, 1021525.6, 1187466.5, 1266633.5, 1301185.2)

mean_longterm_liabilities = mean(data$LongTermLiabilities)
mean_current_liabilities = mean(data$CurrentLiabilities)
mean_fixed_liabilities = mean(data$FixedLiabilities)

future_data = data.frame(
  Year = c(2023, 2024, 2025, 2026, 2027),
  Equity = predicted_equity,
  LongTermLiabilities = rep(mean_longterm_liabilities, 5),
  CurrentLiabilities = rep(mean_current_liabilities, 5),
  FixedLiabilities = rep(mean_fixed_liabilities, 5)
)

coefficients = c(Intercept = 2.253e+05, Equity = 7.506e-01, LongTermLiabilities = 9.670e-01, CurrentLiabilities = -3.423e-02, FixedLiabilities = -1.166e+03)

predicted_income = coefficients["Intercept"] +
  coefficients["Equity"] * future_data$Equity +
  coefficients["LongTermLiabilities"] * future_data$LongTermLiabilities +
  coefficients["CurrentLiabilities"] * future_data$CurrentLiabilities +
```

```
  coefficients["FixedLiabilities"] * future_data$FixedLiabilities


future_data$PredictedIncome = predicted_income


print(future_data)
```

As a result, the predicted values for the category "Total Income, million UAH" for the years 2023-2027 have been obtained (Table 9).

Table 9. Forecasted Values for "Total Income, million UAH" for the Period 2023-2027*

Year	PredictIncome
2023	780683,8
2024	976006,9
2025	1100562,2
2026	1159984,9
2027	1185919,4

*Source: Calculated by the authors using R-studio software

The next step is to find other forecasted values for the indicators "Long-term Liabilities, million UAH," "Current Liabilities, million UAH," and "Liabilities Related to Non-Current Assets, million UAH." For this, the code should look as follows:

```
data = data.frame(
  Year = c(2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022),
  Income = c(262207.8, 451008.4, 456910.9, 499974.9, 588554.0, 671617.7, 681306.2, 895298.7, 731208.4),
  Equity = c(163931.7, 275303.8, 369370.9, 436337.6, 482978.7, 522778.7, 612250.9, 796549.7, 810270.4),
  LongTermLiabilities = c(62975.4, 68127.2, 61898.2, 59080.5, 82253.9, 92966.4, 76799.5, 87165.9, 99633.3),
  CurrentLiabilities = c(163616.6, 342359.0, 1105991.9, 416146.2, 418283.2, 414566.5, 441177.6, 461099.6, 531217.8),
  FixedLiabilities = c(83.3, 55.0, 58.2, 49.7, 77.7, 55.2, 76.9, 57.2, 57.6),
  ExchangeRate = c(11.89, 21.84, 25.55, 26.60, 27.20, 25.85, 26.96, 27.29, 32.34),
  InterestRate = c(11.04, 24.21, 17.96, 13.25, 15.63, 18.29, 7.46, 6.83, 17.42)
)


predicted_equity = c(761302.9, 1021525.6, 1187466.5, 1266633.5, 1301185.2)
predicted_income = c(780683.8, 976006.9, 1100562.2, 1159984.9, 1185919.4)
```

```
mean_longterm_liabilities = mean(data$LongTermLiabilities)
mean_current_liabilities = mean(data$CurrentLiabilities)
mean_fixed_liabilities = mean(data$FixedLiabilities)

future_data = data.frame(
  Year = c(2023, 2024, 2025, 2026, 2027),
  Equity = predicted_equity,
  PredictedIncome = predicted_income,
  LongTermLiabilities = rep(mean_longterm_liabilities, 5),
  CurrentLiabilities = rep(mean_current_liabilities, 5),
  FixedLiabilities = rep(mean_fixed_liabilities, 5)
)

model_longterm = lm(LongTermLiabilities ~ Income, data = data)
summary(model_longterm)

predicted_longterm = predict(model_longterm, newdata = data.frame(Income = future_data$PredictedIncome))
future_data$PredictedLongTermLiabilities = predicted_longterm

model_current = lm(CurrentLiabilities ~ Income, data = data)
summary(model_current)

predicted_current = predict(model_current, newdata = data.frame(Income = future_data$PredictedIncome))
future_data$PredictedCurrentLiabilities = predicted_current

model_fixed = lm(FixedLiabilities ~ Income, data = data)
summary(model_fixed)
```

```
predicted_fixed = predict(model_fixed, newdata = data.frame(Income = future_data$PredictedIncome))
future_data$PredictedFixedLiabilities = predicted_fixed

print(future_data)
```

As a result, the following outcomes were obtained, which are presented in Table 10, along with the forecasted values that depend on external factors, specifically the UAH/USD exchange rate and the National Bank of Ukraine's discount rate (average for the year), expressed in percentage terms.

Table 10. Forecasted Values of Net Income and Funding Sources for Agricultural Activities from 2023 to 2027*

Year	Total revenues, million UAH	Own capital, million UAH	Long-term liabilities, million UAH	Current liabilities, million UAH	Liabilities related to non-current assets, million UAH	Exchange rate UAH/USD, UAH	NBU discount rate (on average for the year), %
2014	262207,8	163931,7	62975,4	163616,6	83,3	11,89	11,04
2015	451008,4	275303,8	68127,2	342359,0	55,0	21,84	24,21
2016	456910,9	369370,9	61898,2	1105991,9	58,2	25,55	17,96
2017	499974,9	436337,6	59080,5	416146,2	49,7	26,60	13,25
2018	588554,0	482978,7	82253,9	418283,2	77,7	27,20	15,63
2019	671617,7	522778,7	92966,4	414566,5	55,2	25,85	18,29
2020	681306,2	612250,9	76799,5	441177,6	76,9	26,96	7,46
2021	895298,7	796549,7	87165,9	461099,6	57,2	27,29	6,83
2022	731208,4	810270,4	99633,3	531217,8	57,6	32,34	17,42
2023	780683,8	761302,9	88831,96	503923,2	59,45	36,57	22,0
2024	976006,9	1021525,6	100693,72	530233,0	55,55	40,7	13,7
2025	1100562,2	1187466,5	108257,83	547010,4	53,06	45,0	12,0
2026	1159984,9	1266633.5	111866,5	555014,6	51,87	46,5	10,0
2027	1185919,4	1301185,2	113441,48	558507,9	51,36	46,4	7,5

*Source: Calculated by the authors using R-studio software

It is important to create a graph of the rate of change for the specified indicators, as this allows for the analysis and visualization of changes over time. The main advantages of a rate of change graph include: identifying trends and cycles, comparing dynamics, determining points of change, identifying relationships, and visualizing the presented forecasts. By utilizing the rate of change graph, we can assess the adequacy of the created scenario forecast and stress testing; in the case of significant fluctuations relative to known data, it can be concluded that the model is incorrectly built and cannot be used as an adequate forecast. To create the rate of change graph, we apply the following code:

```
data = data.frame(
  Year = c(2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027),
```

```
  Income = c(262207.8, 451008.4, 456910.9, 499974.9, 588554.0, 671617.7, 681306.2, 895298.7, 731208.4, 780683.8, 976006.9, 1100562.2, 1159984.9, 1185919.4),
  Equity = c(163931.7, 275303.8, 369370.9, 436337.6, 482978.7, 522778.7, 612250.9, 796549.7, 810270.4, 761302.9, 1021525.6, 1187466.5, 1266633.5, 1301185.2),
  LongTermLiabilities = c(62975.4, 68127.2, 61898.2, 59080.5, 82253.9, 92966.4, 76799.5, 87165.9, 99633.3, 88831.96, 100693.72, 108257.83, 111866.5, 113441.48),
  CurrentLiabilities = c(163616.6, 342359.0, 1105991.9, 416146.2, 418283.2, 414566.5, 441177.6, 461099.6, 531217.8, 503923.2, 530233.0, 547010.4, 555014.6, 558507.9),
  FixedLiabilities = c(83.3, 55.0, 58.2, 49.7, 77.7, 55.2, 76.9, 57.2, 57.6, 59.45, 55.55, 53.06, 51.87, 51.36),
  ExchangeRate = c(11.89, 21.84, 25.55, 26.60, 27.20, 25.85, 26.96, 27.29, 32.34, 36.57, 40.7, 45.0, 46.5, 46.4),
  InterestRate = c(11.04, 24.21, 17.96, 13.25, 15.63, 18.29, 7.46, 6.83, 17.42, 22.0, 13.7, 12.0, 10.0, 7.5)
)

data_diff = data.frame(Year = data$Year[-1])
variables = colnames(data)[-1]  # Виключаємо стовпець Year

for (var in variables) {
  data_diff[[var]] = diff(data[[var]])
}

data_melt = melt(data_diff, id.vars = "Year")

ggplot(data_melt, aes(x = Year, y = value, color = variable)) +
  geom_line() +
  geom_point() +
  labs(title = "Швидкість зміни економічних показників",
       x = "Рік",
       y = "Швидкість зміни",
       color = "Показник") +
  theme_minimal() +
```

```
theme(legend.position = "bottom",
      axis.text.x = element_text(angle = 45, hjust = 1))
```

As a result, a visual graph of the rate of change of indicators was obtained (Figure 9).

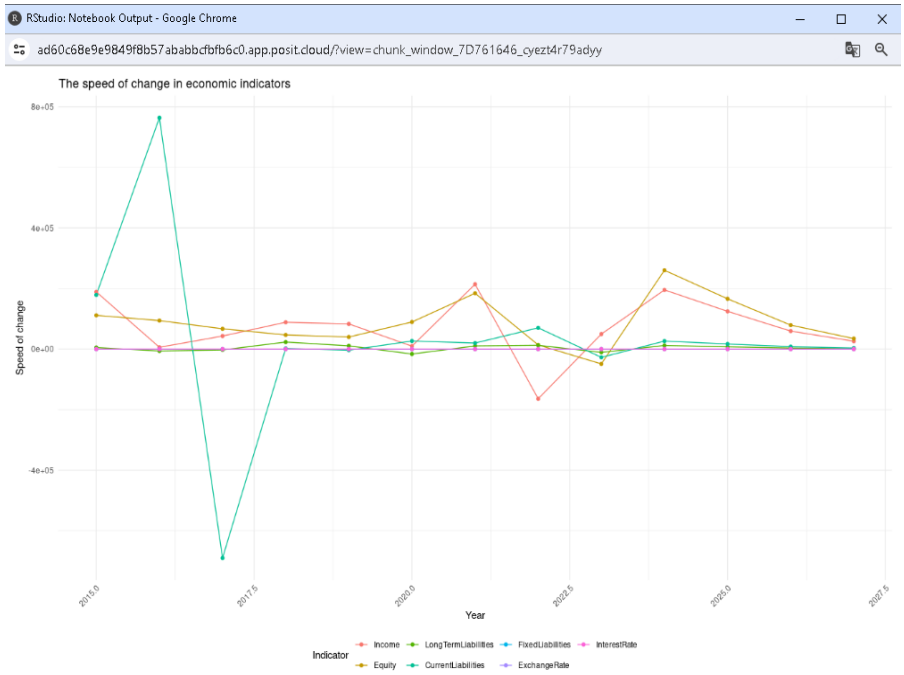


Figure 9. Rate of Change Graph of Indicators*

*Source: Generated by the authors using R-studio software based on the code

Thus, it has been established that the model developed through scenario analysis and stress testing is adequate, as the rate of change of the investigated indicators is within normal limits, indicating a potentially favorable development for agricultural producers according to the forecast.

4. Conclusion

The increase in these programs was driven by the need to ensure the resilience of Ukraine's agricultural sector, given that Ukraine is a key player on the international stage in providing food products to other countries. The regression analysis conducted revealed a clear interdependence between the stability of agricultural enterprises and their potential high income derived from equity capital. Thus, a trend has emerged where agricultural producers strive to minimize their obligations and increase self-financing to support their operational activities. Government support is, therefore, essential and is used by such enterprises in cases of financial instability or for the modernization of their infrastructure, equipment, and methods

of conducting business, though it is not the primary focus. After performing trend analysis using time series (ARIMA), it was found that to refine the assessment, data regarding the external environment needed to be incorporated. Consequently, data on the exchange rate and the discount rate of the National Bank of Ukraine (2024) were chosen, as they impact export/import revenues and access to credit. Following a repeated linear regression analysis that accounted for the external environment, it was discovered that the most influential factor on the economic activity of agricultural producers is the exchange rate. Thus, having obtained the necessary data on interdependencies related to the external environment, scenario analysis and stress testing of the model for the period 2023-2027 were conducted, providing insights into the future development indicators for agricultural producers that turned out to be positive, despite the planned increase in the exchange rate during this period. Additionally, to validate this model, the rate of change of indicators was calculated, revealing that the rate of change is within an acceptable range, indicating the adequacy of the projected model. Thus, the authors of the study concluded that the financial support for Ukrainian agricultural producers under conditions of exogenous military aggression relies heavily on self-financing of their economic activities, while support from international investors and the government remains a significant component. Furthermore, it is essential to create a responsive mechanism for "target" enterprises that have suffered direct losses from the armed aggression of the Russian Federation against Ukraine. This could include establishing special conditions for recovery and operational activities, such as preferential taxation, subsidized lending, and other fiscal or material assistance methods. In light of the above, the hypotheses proposed during the course of the study have been proven and confirmed.

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