# “Structural modeling of the financial support for the Ukrainian agrarian sector”


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# STRUCTURAL MODELING OF THE FINANCIAL SUPPORT FOR THE UKRAINIAN AGRARIAN SECTOR

## Abstract

Financial support for the agrarian sector is the priority of economic policy in many countries of the world, as it plays a key role in achieving the goals of sustainable development, in particular poverty reduction, food security, environmental improvement, including reducing CO2 emissions, reducing water pollution, etc. In the main, the financial support for the agrarian sector of the various countries is multi-channel and combines budget financing and financial market opportunities. At the same time, for many countries, including Ukraine, the issue of the ratio of these sources of financing and their influence on the development of agricultural production remains unresolved. The analysis of budget financing has shown a lack of stability in the implementation of financial support programs for the agrarian sector of Ukraine, which affects the financial sustainability of enterprises and their ability to attract market financing. In the article, using the structural modeling, the necessary amount of financing for the agrarian sector was determined through budget financing, bank lending and agro-insurance. The results of the calculations showed that the actual size of bank lending to agrarian enterprises is significantly lower than the simulated values. At the same time, budget financing creates conditions for ensuring financial sustainability of agrarian enterprises and encourages them to use bank lending, while increasing budget financing reduces the need for agro-insurance operations, which is a negative consequence of its use.

**Keywords** credit market, agricultural, insurance, economic growth, rural

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## INTRODUCTION

Financial support of the agrarian sector of the economy plays an important role and is one of the priorities of economic policy not only in Ukraine, but also in the whole world. According to the World Bank, around 2.5 billion people are involved in only 500 million farms, without considering those employed in large and medium-sized agribusinesses. The importance of financial provision of agricultural production with financial resources, sufficient and adequate at the price, is determined by the key role played by the agrarian sector in achieving the sustainable development goals, first of all in terms of poverty reduction, especially in rural areas, as well as in ensuring food security, which includes production of quality food products, improvement of the ecological situation, including reduction of CO2 emissions, the source of which, besides the industrial enterprises, is the agrarian sector enterprises, decrease of water pollution due to the reduced use of herbicides, pesticides, insecticides, etc., through qualitative irrigation measures, etc. In Ukraine, the problem of financial provision for agrarian enterprises is quite acute, despite the availability of programs that provide financial support on the part of the state. This is due to many factors, namely, the lack of financial support from the state, with

the problem not only in the volume of financial resources, but also in the inconsistency and discreteness of particular programs that were envisaged in the state budget. Thus, for the period from 2011 to 2018, financial support for agribusiness was envisaged through compensation for lease payments, but actually payments were made only in 2011 and 2017. In addition, during the period from 2015 to 2017, it was envisaged to provide financial support to agricultural enterprises through cheapening loans, which was executed almost 100%. But by 2018, funds from the state budget were not allocated for this program. The state support for the development of the livestock sector is relatively stable, with this program funds were budgeted every year, except for 2013, but the amount of money included varied essentially. So the maximum amount of funds was allocated in 2014 and amounted to USD 888 million, and the minimum amount was allocated in 2016 and amounted to USD 30 million for the analyzed time period. At the same time, the percentage of this budget item implementation had rather sharp fluctuations, the minimum value was 19%, and the maximum almost 100% in 2016 and 2017. In addition, in 2018, the budget for support for the livestock breeding development included USD 4 billion. This situation shows a lack of a strategic vision of the agrarian sector, which needs financial support from the state, and is essentially a post factum reaction to the results of the sector's development. The current situation does not create conditions for the sustainable development of agrarian enterprises, because, given its specificity, namely increased riskiness of activities, seasonality, dependence on environmental conditions, enterprises cannot develop a financial strategy at least in the medium term, not knowing whether they can get financial support for the next year.

On the other hand, the financial market of Ukraine, in particular its banking sector, cannot meet the needs of lending to agrarian enterprises, given the high level of risk of their activities, as well as significant fluctuations in their financial sustainability. Regarding the insurance sector, it should be noted that only a small percentage of agricultural enterprises are using agro-insurance services. In most cases, it is precisely those enterprises that receive bank loans for financing their activities and are required to insure their activities under a loan agreement.

It should also be noted that there are currently no calculations regarding the amount of financing necessary for the agrarian sector development both from the state and from the financial market. The availability of such indicators could become the key targets in developing the strategy for the Ukrainian agrarian sector development and make it possible to optimize both the state budget expenditures and the opportunities for the development of the banking and insurance sectors, in addition, they could be signals for the strategic financial planning of the enterprises themselves.

## 1. LITERATURE REVIEW

The problem of financial support for the agrarian sector is a prime focus of scientists from different countries, and the issues that are considered in their research are largely common, namely, access to bank loans, financial support from the state, etc. Kandilov and Kandilov (2018) are worth noting in this regard on the problem of cheapening loans for the agrarian sector of the economy using the example of the US and Russia. Tang and Guo (2017) note that bank lending is important for the agrarian sector development, especially in developing countries. Using China as an example, they investigate lending problems and analyze the causes of the emerging an informal credit market, which develops at a quick rate, because the formal market is not very flexible. Tung (2018) studies the role of credit in the development of rural households in Vietnam (in the context of 420 households). Chisasa (2014, p. 348, 349) reveals the problems of attracting bank lending for agribusinesses, especially for farms in South Africa. This is because the loans provided by commercial banks are more expensive, the procedures for issuing loans are lengthy and complex, there are high risks of losing collateral, as well as high transaction costs. In this regard, farmers resort to an informal credit market, namely borrowing from co-operatives, even friends and acquaintances, savings banks, etc. At the same time, it is long-term loans that provide an increase in labor productivity in the agrarian

sector, as they are used to expand the material and technical base by purchasing the necessary agricultural machinery and equipment. The availability of access to loans is equally important.

Quite difficult is the issue of using bank loans for the agrarian sector in Greece, where, in comparison with other EU countries, their share is minimal, while the interest rate for agro-enterprises is much higher than for those of other industries (Karantininis, 2017). Ahmed, Asadullah, and Kambhampati (2016), using rural regions as an example, investigated the effect of formal bank lending on their development and its role in the growth of the local population incomes. The authors state that improving access to financial services, in particular, banking in rural areas, can complement government efforts to increase household incomes and improve rural well-being.

According to Asante-Addo et al. (2017), the lack of Ghanaian farm businesses in credit programs is due to significant fears about a possible default and lack of savings, at the same time, these fears diminished depending on participation in financial inclusion programs, as well as on the growth of savings. Anang et al. (2016), by the example of Ghanaian farms, point out that there is no significant difference in the production efficiency of farmers using and not using loans, respectively with the use of credits, the efficiency was 63.0% versus 61.7% for those who did not use credits. At the same time, the state of the technical support of farms is very low, therefore, the authors insist on the need to develop new financial products that have a targeted orientation specifically for those farms that are ready to commit themselves to improving production through external financing. This approach ensures that a loan is provided to farmers who need it to increase their technical efficiency.

Binswanger et al. (1993) note the importance of an integrated approach to studying agricultural financing problems in India and quantified the relationship between government decisions on financial support, financial institutions and farmers and their combined impact on investment in agriculture. Esposti and Materia (2016) state that co-financing of competitive agrarian projects by both the state and private entities is important and propose their own approach based on the example of the agricultural program operating in Italy to determine the level of co-financing. Ukrainian authors Novak et al. (2016) state that the optimal combination of state financial support and lending is important for the agrarian sector development, in addition, they also emphasize the need to combine both domestic and foreign investments in agrarian enterprises, which will stimulate the development of depressed regions and improve the operating efficiency of enterprises themselves. Popova et al. (2016), based on an SWOT analysis of agribusiness development, point out that the most important problem of agribusiness development in countries having problems with food production (non-food countries) is the lack of financial resources due to high seasonal business, low profitability and, accordingly, low investment attractiveness. They propose to use concessional lending, which allows solving this problem and increasing the availability of financial resources for agribusiness, which enables them to upgrade their equipment and production technology, reduce their production cost, and increase profitability and competitiveness.

Equally important is the agro-insurance component, as mentioned by Carter et al. (2017), because, given that the agrarian sector is high-risk, uninsured risk represents a major obstacle to investment, labor productivity and poverty reduction in agriculture. Particularly interesting are proposals on the use of temperature-based weather derivatives that can help reduce the risks of changing climatic conditions and can be offered by the financial market and insurance companies to agricultural producers. This study was conducted in the context of China's agrarian sector (Ender & Zhang, 2015). Weather derivatives are actively used in the United States and can significantly reduce the risk of loss of agribusinesses' income due to flood or very high temperatures and droughts (Kuwata, Mahmood, & Shibasaki, 2015). It should be noted that this proposal may also be interesting for Ukraine, but the key issue is the presence of a developed stock market, which unfortunately does not work in this direction in Ukraine. Within this context, Vilhelm et al. (2015) highlighted some proposals in the field of agricultural insurance of the Czech Republic in their article on the functioning of The Support and Guarantee Agricultural and Forestry Fund (PGRLF) and the Czech Insurance Association (ČAP). In this case, it is referred to the use of public

financial resources to cover the catastrophic risks of those agricultural producers who are constantly implementing financial and non-financial measures on risk management.

Microfinance lending plays an important role in the financial support of agribusiness, especially in countries with low or below average income levels. In their book, Mahmud and Osmani (2016) conducted a deep fundamental analysis of the theory and practice of microlending in the context of Bangladesh, a country that initiated this type of financial provision. Khandker and Koolwal (2016, p. 355), using panel data over the past 20-year development of Bangladesh's farm enterprises, have investigated the impact of rural lending expansion (both micro-lending and formal banking channels) on the results of their activities and noted that microlending has improved households' efficiency. Ibrahim et al. (2018, p. 350), based on the data of 57 microfinance institutions from the Organization of Islamic Cooperation (OIC) countries, revealed that the established interest rate and market period have significant positive relationship with financial performance indicators, and also that credit unions, cooperatives, as well as non-bank financial institutions and non-governmental organizations have significantly better financial results, given that they are aimed at working with low-income clients. Islam et al. (2016, p. 354) argue that microlending affects various measures to ensure food security and state that microlending programs help farmers in gaining an access to the financial capital that can help improve the food security situation. At the same time, the authors believe that the effect of microlending on food security may be nonlinear, since in the short term indicators may deteriorate but substantially increase in the long run. The results obtained explain why the existing short-term microcredit estimates sometimes do not show positive effects. Wang (2016) suggests using the model of P-to-P crediting of farms using the capabilities of the crowdfunding platforms as an element of microfinance lending, since currently, crowdfunding is an alternative source of funding with a very high potential. Despite a rather powerful legislative framework of the European Union, as well as the experience of microfinance lending, Romania's microfinance market is only in its initial stage of development, and the problems of its introduction for agrarian production were investigated by Manta (2015).

It should be noted that there are common problems of financing the agrarian sector in Ukraine and in different countries of the world, in particular the high level of risk, and as a result of high interest rates, rather complicated procedures for issuing loans, lack of support, or its lack to finance the development of enterprises. To address this problem, especially in developing countries with a per capita income below average, it is necessary to have clear and transparent guidelines for the agrarian sector financing, both from the state and from the enterprises themselves and from the financial market. In order to determine the optimum size of financial support in Ukraine, the method of structural modeling was used in this study.

Quite often, a situation is encountered when it is not enough to limit the qualitative research to revealing only explicit connections between real-world indicators. As experience shows, many of the social life phenomena are provoked by implicit or concealed factors, the strength and direction of which are very difficult to determine. Warfield (1973), Professor and Director of the Institute for Advanced Study in the Integrative Sciences at the George Mason University, Virginia, was the first who began to develop this trend. In 1973, based on the discrete mathematics foundations, he developed a methodology for structural equation modeling, which allows the investigation of various complex systems based on the detection of hidden links between them. The first resonant research by Warfield, where he used the developed methodology, was devoted to the analysis of complex socio-economic systems. For a long time, this technique has been closed to the general public, since it was considered very complex, from the stage of input data formation to the interpretation of the results obtained. Later, when necessary mathematical calculations were automated through special software, the high cost of such products became a new obstacle to this modeling method popularization. However, today these problems have taken the second place and one can state with assurance that the use of structural modeling is one of the most popular methods of scientific research in various spheres of human life.

It is worth noting that structural equation modeling is currently a powerful economic and statistical tool, which is based on the use of statistical data and

qualitative cause-effect assumptions. According to Kirby and Bollen, structural equation modeling as a method of estimation widely uses the maximum likelihood method with complete information. At the same time, interest in evaluation algorithms with the use of limited information remains due to their robustness with respect to the form of distribution and their lower sensitivity to the errors of the structural specification (2009). Given that this method takes into account analytical advantages of psychometry and econometrics, it enables to combine the existing relations between latent variables and observation indicators and the possibility of simulating the relations between the observable variables. It is used to conduct research in various scientific fields, namely economics, sociology, psychology, biology, etc. Karimi and Meyer (2014) disclosed the history of development and features of using structural equation modeling in more detail. Artemenko (2015), using the structural modeling of connections between explicit and latent variables, revealed the relationship between the state of financial support for the regions and the quality of the social sphere and made certain conclusions about the quality of life of the population in different regions of Ukraine. Thus, the purpose of this study is to determine the features of financial support for the Ukrainian agrarian sector through constructing a system of structural equations, which will allow to form a general picture of existing problems in the area under study.

On the one hand, it is essentially an independent method of research, and on the other hand, it allows to expand the existing possibilities of correlation-regression analysis.

## 2. METHODOLOGY

As a rule, in modern studies, structural modeling is used to perform the following tasks:

- establishing causal relationships between variables that are both obvious and hidden, causation hypotheses verification, definition of explicit and latent variables;
- researching factors on the existence of correlation relations between them and the structure of their loads;
- modification of factor analysis in the factor analysis of the second order and construction of the correlation matrix between general factors;
- implementing the modified multidimensional linear regression analysis through the regression coefficients analysis, provided that they can be fixed and equal to each other;
- modeling the covariance structure by checking the hypothesis for the presence of a certain correlation matrix and the equality/inequality of variances of the variables under study;
- modeling the correlation structure based on testing the hypothesis for the presence of a correlation matrix of a certain type; and
- simultaneous analysis of dispersions and covariances.

Thus, structural modeling can reveal certain hidden factors, the links between which to some extent precisely explain the structure of the phenomenon under study.

In the context of the mathematical representation of structural equation systems, the systems of independent (1) and interrelated (recursive, common, simultaneous) (2) equations are distinguished.

$$\begin{cases} Y_1 = a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + \varepsilon_1 \\ Y_2 = a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + \varepsilon_2 \\ \hline Y_m = a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n + \varepsilon_m \end{cases}, \quad (1)$$

$$\begin{cases} Y_1 = a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + \varepsilon_1 \\ Y_2 = b_{21}Y_1 + a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + \varepsilon_2 \\ Y_3 = b_{31}Y_1 + b_{32}Y_2 + a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + \varepsilon_2 \\ \hline Y_m = b_{m1}Y_1 + b_{m,m-1}Y_{m-1} + a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n + \varepsilon_m \end{cases}. \quad (2)$$

The main difference between the presented systems of equations is the nature of the variables representation. Variables can be measurable, observable, or more precisely explicit, in this case, their value is formed on the basis of reporting, other variables are implicit or latent, the latter are determined in the study process, based on the researcher' understanding of the existing relationships. Unlike in-

dependent systems, where each system equation is actually a separate regression equation, both dependent ($Y_n$) and independent ($x_n$) variables in the systems of interdependent equations act mutually in different equations, that is, latent and observable variables can be determined by both latent and observable variables. In addition, the variables are related to each other, but one cannot say with certainty that one of them is a cause, and the other is an effect. Therefore, each subsequent equation of this system cannot be considered without considering the previous one. It is precisely the systems of simultaneous structural equations that have become most widely used in scientific research, since they allow to detect the presence of those hidden links between the variables studied.

Considering the basic terminology of the system of simultaneous structural equations, it is worth noting that instead of dependent ($Y_n$) and independent (factor) ($x_n$) variables, it is customary to use synonyms such as endogenous and exogenous variables, respectively. In fact, the number of endogenous variables depends on the number of equations in the system and, based on the specificity of the study, variables can replace each other. Near each endogenous and exogenous variable, are the coefficients $b_{ik}$ and $a_{ij}$, respectively, the structural coefficients of the model. In addition, in each equation of the system, there is a residual $\varepsilon_j$, while the free term is absent.

Let's consider gradually the process of modeling any phenomenon using a system of structural simultaneous equations (Figure 1).

*The first step.* Model visualization. At the first step, you need to use the visual tools, usually graphically (path diagram), to represent the structure of the dependencies between explicit and latent variables. This is required to clearly understand the model complexity, which simplifies the process of entering the necessary parameters when computing in a special software.

*The second step.* Software formalization of the model. After the graphic representation of the interrelation structure in the model, you can proceed with the program implementation. At this step, you must specify all required parameters for calculation.

*The third step.* The first stage of program validation of model compliance. At this step, the variances and covariances received are automatically checked in the corresponding software module, in which structural equations are constructed. If they meet all the requirements of the study process, then the program will move to the next step.

*The fourth step,* working out the results of the model, involves replacing the obtained structural coefficients of the model and the residual

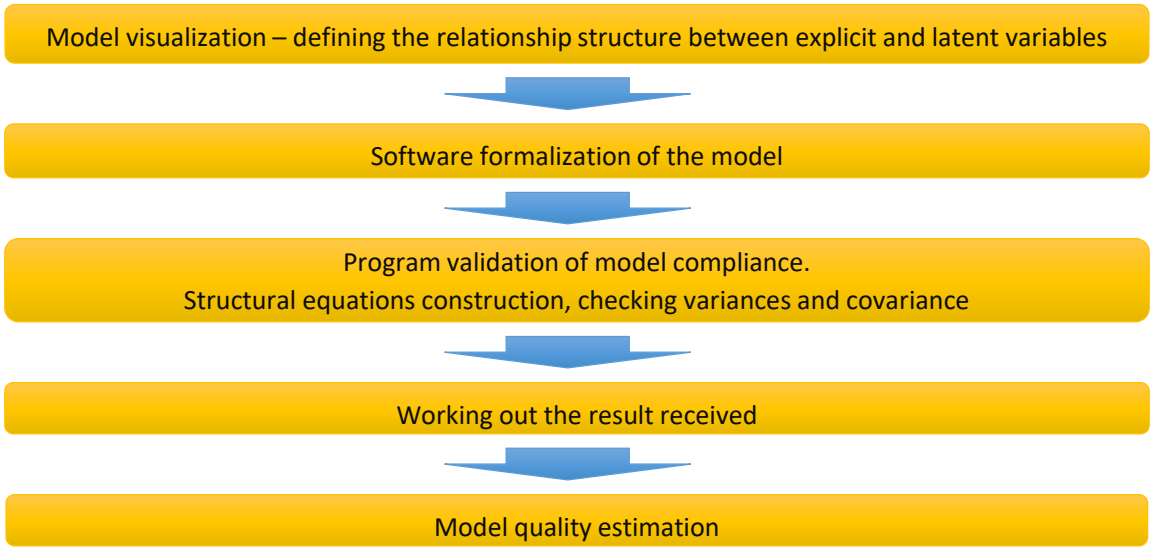



**Figure 1.** The structural modeling formation

**Table 1.** Funding allocation for agriculture in Ukraine during 2009–2017

| Year | Expenditures of the Ukraine's state budget on agriculture (UAH mln) | Loans granted to agriculture (UAH mln) | Amount of agro-insurance premiums (UAH mln) | Adjusted net savings (% GNI) |
|---|---|---|---|---|
| 2009 | 5,714 | 5.8 | 42 | 10.7 |
| 2010 | 6,605 | 9.7 | 72.1 | 8.5 |
| 2011 | 6,776.3 | 12 | 136.3 | 5.6 |
| 2012 | 8,005.5 | 13 | 130.4 | 7.4 |
| 2013 | 6,776 | 14.2 | 135.4 | 6.1 |
| 2014 | 2,636.8 | 11 | 72.8 | –3.7 |
| 2015 | 2,123.7 | 48.4 | 77.7 | –4.7 |
| 2016 | 2,188.8 | 55.4 | 157 | –2.7 |
| 2017 | 2,039.4 | 60.3 | 204.4 | 0.6 |

values in the general form of representing the structural dependencies between the variables.

*The fifth step.* Model quality estimation. At the final stage, based on a set of different statistical indicators, the quality of the constructed model is estimated and the adequacy of the results obtained is checked.

## 3. OUTPUT DATA OF RESEARCH

State budget funds are the main source of funding for the Ukrainian agrarian sector. Given the international experience, many countries provide multi-channel financial support to the agrarian sector, actively combining various forms, namely budget financing, bank lending, agro-insurance, etc. The statistics on these indicators (see Table 1) do not give a clear answer as to the sufficiency of allocated funds for the agrarian sector, therefore, it was decided to include an indicator in the study that would clearly characterize the level of the sector development. Given that the study considers the agrarian sector from the point of view of the impact on the economy's sustainable development, the adjusted net saving indicator has been used, given that, as a result of a significant number of scientific studies, the GDP indicator, which is recognized as the base, does not take into account how depleted are the natural resources for its growth, as well as the negative impact of growth on the environmental health.

## 4. FINDINGS

Structural modeling in this case will be used to determine the optimal level and vector of non-budget financing of the agrarian sector in Ukraine. In accordance with the above structural modeling process steps, it is necessary to visualize the system of links between variables. In fact, two models will be constructed: the first one, which will determine the optimal amount of non-state financing, namely, the agrarian sector financing ($NON_GOV_{cred}$), taking into account the existing governmental provision ($GOV$) and the general state of the sector ($SG$), and the second one, which will calculate the optimal amount of non-state financing, namely agro-insurance premiums ($NON_GOV_{insur.}$), taking the same indicators into account. In the system of structural equations, the variables listed will act as latent ones, the visual representation of which is depicted in Figures 2 and 3. Variables listed in Table 1 will fulfill the role of explicit variables in relation to latent ones.

The software formalization of the constructed models will take place using the software package STATISTICA 10. The program realization in parallel for two models will be implemented.

At the next step, the structural dependencies between the variables for both models must be specified based on their graphical representation (see Figures 2 and 3).

The structural equations model for both cases is as in Figure 4.

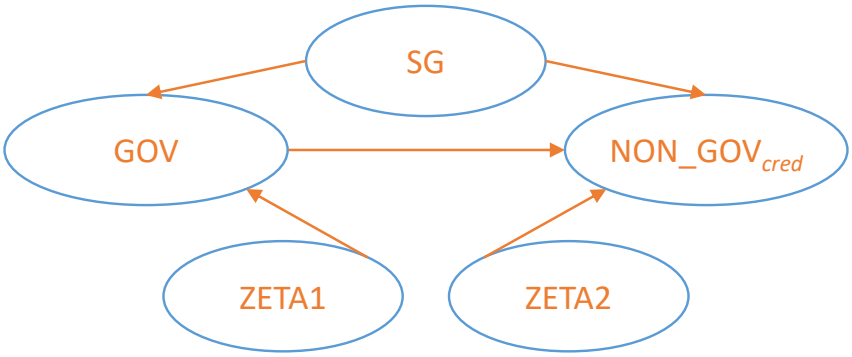



**Figure 2.** Regression relationships between latent variables for the first model, where *ZETA1* and *ZETA2* are the residuals

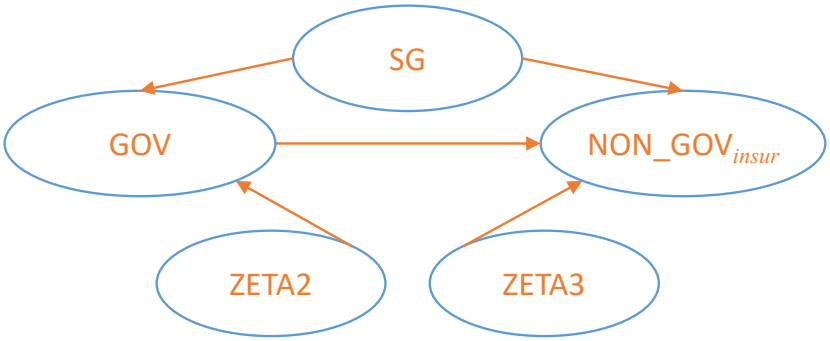



**Figure 3.** Regression relationships between latent variables for the second model, where *ZETA2* and *ZETA3* are the residuals

(SG)-1→[Net saving]
(DELTA1)→[Net saving]
(DELTA1)-2-(DELTA1)
(GOV)→[Expenditures]
(NON_GOV)→[Lending]
(EPSILON1)→[Expenditures]
(EPSILON2)→[Lending]

(EPSILON1)-3-(EPSILON1)
(EPSILON2)-4-(EPSILON2)

(ZETA1)→(GOV)
(ZETA2)→(NON_GOV)
(ZETA1)-5-(ZETA1)
(ZETA2)-6-(ZETA2)

(SG)-7→(GOV)
(SG)-8→(NON_GOV)
(GOV)-9→ (NON_GOV)

**Figure 4.** Overall view of the structural equations model for both cases

**Table 2.** Results of structural modeling of the indices relationship for the overall situation in agriculture, state and non-state financing, i.e., lending

| | Model estimation (Table. sta) | | | |
|---|---|---|---|---|
| | **Parameter estimation** | **Standard error** | **T-statistics** | **Probability** |
| (SG)-1⟶[Net saving] | –3,773 | 1,044 | –3,613 | 0,000 |
| (DELTA1)⟶[Net saving] | | | | |
| (DELTA1)-2-(DELTA1) | 1,530 | 0,000 | | |
| (GOV)⟶[Expenditures] | | | | |
| (NON_GOV)⟶[Lending] | | | | |
| (EPSILON1)⟶[Expenditures] | | | | |
| (EPSILON2)⟶[Lending] | | | | |
| (EPSILON1)-3-(EPSILON1) | 1049998,741 | 525053,820 | 2,000 | 0,046 |
| (EPSILON2)-4-(EPSILON2) | 0,500 | 0,000 | | |
| (ZETA1)⟶(GOV) | | | | |
| (ZETA2)⟶(NON_GOV) | | | | |
| (ZETA1)-5-(ZETA1) | 7,217 | 0,000 | | |
| (ZETA2)-6-(ZETA2) | 932,773 | 516,679 | 1,805 | 0,071 |
| (SG)-7⟶(GOV) | –34,015 | 0,000 | | |
| (SG)-8⟶(NON_GOV) | 10,821 | 13,551 | 0,799 | 0,425 |
| (GOV)-9⟶(NON_GOV) | 1,170 | 0,000 | | |

**Table 3.** Results of structural modeling of the indices relationship for the overall situation in agriculture, state and non-state financing, i.e., agro-insurance

| | Model estimation (Table. sta) | | | |
|---|---|---|---|---|
| | **Parameter estimation** | **Standard error** | **T-statistics** | **Probability** |
| (SG)-1⟶[Net saving] | 2,704 | 0,668 | 4,046 | 0,000 |
| (DELTA1)⟶[Net saving] | | | | |
| (DELTA1)-2-(DELTA1) | 0,000 | 0,000 | | |
| (GOV)⟶[Expenditures] | | | | |
| (NON_GOV)⟶[Agro-insurance] | | | | |
| (EPSILON1)⟶[Expenditures] | | | | |
| (EPSILON2)⟶[Agro-insurance] | | | | |
| (EPSILON1)-3-(EPSILON1) | 1021789,429 | 510894,715 | 2,000 | 0,046 |
| (EPSILON2)-4-(EPSILON2) | 0,500 | 0,000 | | |
| (ZETA1)⟶(GOV) | | | | |
| (ZETA2)⟶(NON_GOV) | | | | |
| (ZETA1)-5-(ZETA1) | 0,000 | 0,000 | | |
| (ZETA2)-6-(ZETA2) | 1212,704 | 606,602 | 1,999 | 0,046 |
| (SG)-7⟶(GOV) | 217,271 | 0,000 | | |
| (SG)-8⟶(NON_GOV) | 241,019 | 12,435 | 19,382 | 0,000 |
| (GOV)-9⟶(NON_GOV) | -1,142 | 0,000 | | |

Due to all the necessary settings, the following simulation results were obtained for both situations (Tables 2 and 3).

Thus, according to the results obtained in the first columns of Tables 2 and 3, it is possible to form equation systems (3, 4) for both cases.

$$\begin{cases} NON_GOV_{cred} = 10,821SG + \\ +1,170GOV + 932,773 \\ GOV = -34,015SG + 7,217 \\ Expenditures = GOV + 1049998,7 \\ Lending = NON_GOV_{cred} + 0,5 \end{cases}, \quad (3)$$

$$\begin{cases} NON_GOV_{insur} = 241,019SG - \\ -1,142GOV + 1212,704 \\ GOV = 217,271SG + 0,0001 \\ Expenditures = GOV + 1021789,43 \\ Agroinsurance = NON_GOV_{cred} + 0,5 \end{cases}. \quad (4)$$

Having carried out a series of mathematical transformations of the equations system to determine non-state financing of agriculture for both cases, the following equation systems of (5 and 6) are obtained.

$$\begin{cases} NON_GOV_{cred} = 10,821SG + \\ +1,170Expenditures - 1227565,206 \\ NON_GOV_{cred} = \dfrac{Expenditures}{Lending} \cdot 100\%, \\ NON_GOV_{cred} = \dfrac{Expenditures}{Lending\%_{average}/100} \end{cases} \quad (5)$$

$$\begin{cases} NON_GOV_{insur} = 241,019SG - \\ -1,142Expenditures + 1168096,734 \\ NON_GOV_{insur} = \dfrac{Expenditures}{Agroinsurance} \cdot 100\% \\ NON_GOV_{insur} = \dfrac{Expenditures}{Agroinsurance\%_{average}/100} \end{cases} \quad .(6)$$

In order to estimate the quality of the constructed models, three main indicators were used: the cosine maximum of residuals, the RMSs index and the reflector matrix.

The criterion for the cosine maximum of residuals shows how well the process of iteration coincided. If this indicator is close to zero, this means the successful completion of the iterations process.

The RMS index evaluates the quality of the model's fit. The fitting of the model is considered qualitative if the given index is less than 0.05. If the value of the index exceeds 0.1, this means that the constructed model does not adequately describe the data.

The reflector matrix is used to test the model for stability before changing the scale of input data measurement. A model is considered more stable if the values of the elements of this matrix are approaching each other.

After analyzing both models, one can conclude that the results obtained are adequate and can be used for further research.

A new array of indicators of non-state financing of Ukrainian agriculture in terms of sector lending and agro-insurance are presented in Table 4.

**Table 4.** Simulated values of non-state financing of Ukrainian agriculture in terms of sector lending and agro-insurance

| Year | Credits granted to agriculture (UAH mln) | Amount of agro-insurance premiums (UAH mln) |
|---|---|---|
| 2009 | 1,464,370 | 17.37 |
| 2010 | 1,692,713 | 20.07 |
| 2011 | 1,736,614 | 20.59 |
| 2012 | 2,051,630 | 24.33 |
| 2013 | 1,736,537 | 20.59 |
| 2014 | 675,752.7 | 8.01 |
| 2015 | 544,256.7 | 6.45 |
| 2016 | 560,940.4 | 6.65 |
| 2017 | 522,652.5 | 6.20 |

As Table 4 shows, the existing amount of lending to agriculture is not sufficient and, according to the calculated values, should be much higher and approximate to the amount of public financing (Figures 5 and 6).

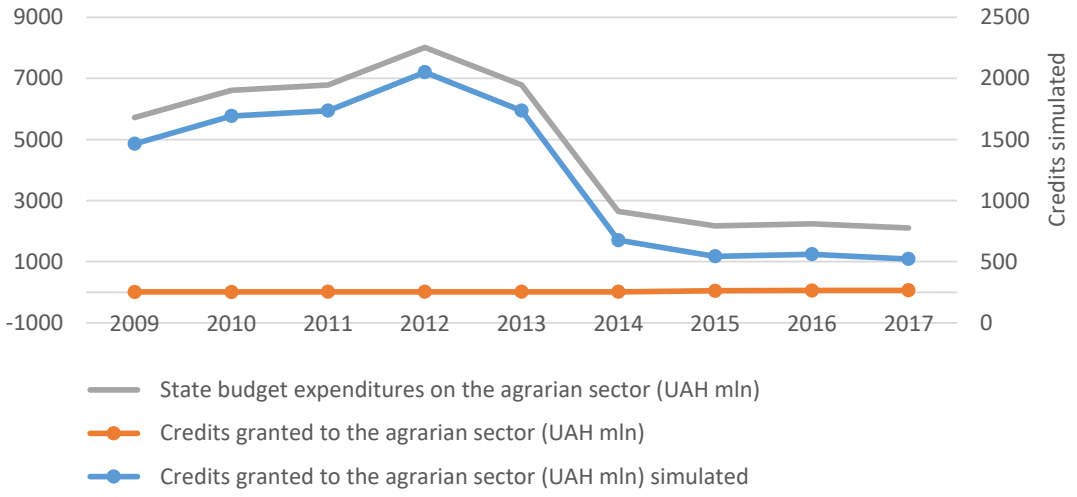



**Figure 5.** Dynamics of changes in the real and simulated levels of lending to agriculture as to public sector financing

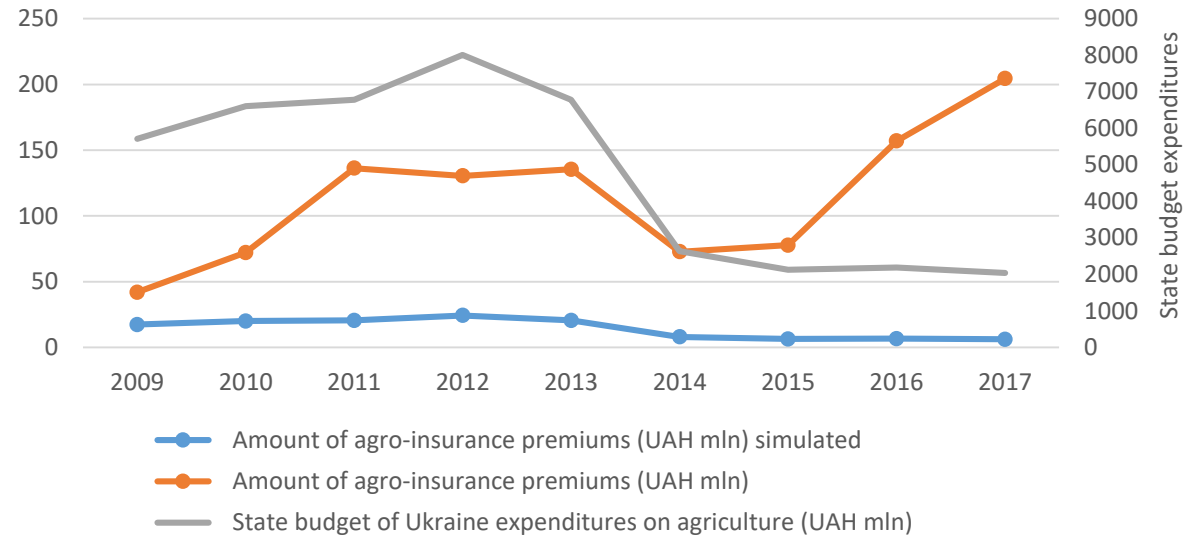



**Figure 6.** Dynamics of changes in the real and simulated levels of agricultural insurance as to public financing of the sector

This situation is due to the fact that, as noted above, the financial activity of agrarian enterprises is accompanied by the risks arising from operating activities, namely the significant influence of climatic conditions and production seasonality. At the same time, the lack of stable support from the state, fluctuations in the amount of financial resources included into the state budget to support the agrarian sector lead to a reduction in financial sustainability of enterprises, which in turn increases the financial risks of activities and does not allow considering such enterprises as reliable borrowers on the part of banks. In addition, the increase of the National Bank of Ukraine requirements to banks themselves in terms of risk management compels banks to impose more stringent requirements on borrowers and refuse to grant loans, in particular to agrarian enterprises as risky clients, despite certain liquidity surpluses.

Regarding the agro-insurance situation, the simulated values indicate the need to reduce this type of financial security. Such results are not entirely correct, but given that the linkages have been identified with the financial support from the state, which in most cases do not involve the formation of a reverse flow of money, it is evident that with the public funding growth, the need for protection will be reduced. This, in turn, proves the necessity of developing a comprehensive strategy for financial support of agrarian enterprises, which would include both budget and market financial support.

## CONCLUSION

It can be concluded that the financial support for agrarian enterprises is not only extremely important for the development of the agricultural sector but also of the country as a whole. This issue is complex and relevant not only for Ukraine, but also for many countries of the world, especially for those with low and lower than average income levels. At the same time, government financing, bank loans and agro-insurance are the main elements for agricultural production in the context of financial support. In addition, microfinance lending is being actively implemented in developing and low-income countries in more recent times, which is mainly used for farmers and medium-sized agricultural enterprises. In Ukraine, the key sources of agrarian enterprises financing are state budget funds allocated for agriculture support and bank loans. Unfortunately, agro-insurance is not sufficiently developed, and is usually carried out by those enterprises that use bank loans, as insurance is a provision of a loan agreement.

The use of the structural modeling method has made it possible to determine the existence of a relationship between budget and market sources of financing, while budget funding itself is a factor that can provide minimum conditions for the financial sustainability of agrarian enterprises in order to develop market mechanisms and stimulate lending and insurance in the agrarian sector.

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