Ensuring Food Security of Ukraine in the Conditions of Globalization Dimensions

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Abstract: The purpose of this article is to develop a model that implements the interaction of food security processes through the resource capacity of regions for self-sufficiency in the identification of threatening factors influencing its reproduction. Methodological support for assessing the food security of the country, which on the basis of targeted analytical studies of its domestic needs, reveals interregional relationships between the volume of its own agricultural production and the factors of import dependence of the state on world markets. Sub-indicators and food security indicators have been identified. Methods of research of food security of the country are substantiated. The level of self-sufficiency of food of Ukraine in agricultural and food products in the administrative centers of the country is calculated. The ratio of production and consumption of agricultural products and food products in Ukraine is substantiated. The ratio of imports to market capacity in the country is given. Partial indicators and integrated risk factors for loss of food security of Ukraine have been established. Predicted indicators of food security by land potential of agricultural production of the country, as well as its dependence on cattle, the level of self-sufficiency in fruits and berries, grain production and consumption are calculated. It is proved that given the strengthening of openness of the national economy, expansion of domestic and foreign agri-food markets, as well as European integration intentions of Ukraine, its level of food security should be carried out in the context of simultaneous evaluation of economic and social indicators and effective management.

Keywords: Food Security; Agricultural Products; Food Independence; Import; Export; Market Capacity.

JEL Classification: Q13, Q18

1. INTRODUCTION

Food security is an important component of the state's socio-economic policy from the standpoint of local and global dimensions, because, along with the undeniable mission of ensuring national sovereignty, it determines its status in the international agri-food arena. Such an important and at the same time multi-vector context of the food security formation of Ukraine envisages, firstly, systematic steps towards making managerial decisions in the area of actively seeking opportunities to increase the potential of food security for social growth. Secondly, it stimulates the need for systematic monitoring of the level of food self-sufficiency and constant identification of consumer needs in affordable, high quality, organic food products. Thirdly, it is necessary to develop indicators for assessing the level of food security in the context of the formation of their individual groups in accordance with the imperatives of strategic development in the field of food security.

Under modern conditions of internationalization of the world market and increasing openness of the national economy, the food sector is one of the most important sectors of the economy of any country, which determines the special role and importance of its final products in meeting the needs of the population. Foods are important and indispensable in human life. Therefore, the development of the food industry and agricultural products, which are the basis of nutrition, is a demographic factor. This factor is essential for meeting the
natural needs of a man. Therefore, the study of food security is of great importance and urgency.


However, the issues related to the mechanisms of forming an effective food security system of Ukraine, comprehensive assessment of its current state, identification of food security trends and identification of risks of possible loss of food independence in different perspectives of different food security scenarios need considerable attention. Because the effectiveness of food security depends on the nature of the structured links of the food subsystems of the regions, the influence of internal and external factors, the balance of interregional and foreign economic relations form a mechanism for supplying food market.

The priority of our study is to develop a model that implements the interaction of food security processes through the resource capacity of regions for self-sufficiency in the identification of threatening factors influencing its reproduction.

2. MATERIALS AND METHODS

Food security is a determinant of sustainable development of the country to develop effective tools for analytical research on the state, trends and prospects of the main factors that affect it, shape the transformation of the economy in general and the agro-industrial sector in particular (Zinchuk et al., 2018). The objectivity of the methodological support for assessing the food security of the country, which on the basis of targeted analytical studies of its domestic needs, reveals interregional relationships between the volume of its own agricultural production and factors of import dependence on world markets (Horniak and Salihuk-Kravchenko, 2016). At the same time, the assessment of the resource potential of agricultural production and quantitative measurement of the degree of its realization by producers is aimed at a system of financial and economic indicators that either reflect the level of food security or are quantitative estimates of factors influencing it. These indicators are defined as development landmarks that reflect the limits of negative processes, giving signals to market participants about possible disadvantages, reducing the global level of national security (Kaletnik and Darmohrai, 2016; Mostova, 2017).

In quantitative terms, indicators reflect the state of food security, which provide an assessment of its various forms of manifestation and factors influencing it. Determining the level (i.e. state) of food security necessarily involves comparing the actual values of the indicators with the desired ones. Instead, values that reflect the desired values of food safety indicators are standards (Soloviova, 2016). It is advisable to include relative indicators in food security indicators, which are defined as the ratio of different food security sub-indicators, the values of which should be as close as possible to each other. An example of this type of sub-indicator is the self-sufficiency coefficients, which are calculated as the ratio of production to consumption and should be as close as possible to each other. That is, the analysis of food security involves the definition of indicators that quantify the processes and phenomena that shape it, as well as the calculation of standards (normative values) of food safety indicators that reflect the discrepancy between actual and desired values (Skydan et al., 2019).

The result of the quantitative assessment of food security is integrated coefficients, which aggregate the values of partial sub-indicators into synthetic food security coefficients. The hierarchy of food safety quantitative assessments is determined by the set of processes, objects and phenomena that shape food security, taking into account all analytical sources of assessment methods. Such methodologies include national and international methodological approaches (including the FAO methodology) (Fig. 1).

An integrated system of food security indicators should be distributed depending on the impact on the formation of the security process itself. Given the methodology of structural modeling, the process of food security formation can be represented as a gradual transformation of input parameters (signals) into output results (Kozlovskiy et al., 2019). The input signals are the resource potential of the country (region). Output signals are directly the level of food security, which in quantitative terms takes the form of its indicators (Skrypnyk and Starychenko, 2017). Two types of factors influence the process of transformation of resources into food security, namely: 1) factors of direct influence – processes that are directly involved in the transformation of inputs into outputs; 2) factors of indirect influence – factors that affect the efficiency of conversion of inputs to outputs.

The processes during which security is formed (i.e. the transformation of inputs into outputs), are appropriately include: food production (including agricultural production, processing); distribution of available food (distribution between regions, formation of conditions in domestic food markets); food consumption. Among the factors of direct influence, we must also take into account the efficiency of agrarian (especially agricultural) producers (Poltorak, 2015).
Quantitatively, most direct action factors take the form of food security indicators. The main factors that do not shape, but significantly affect the level of food security are the situation on world markets, domestic and international policy (in the field of market, including customs, regulation, tax and fiscal policy, land market policy, etc.), inflationary processes in the state (Yakovenko and Cherevko, 2016). Given the above logic, in Table 1 we systematize sub-indicators and indicators of food security of the state.

### Table 1. Sub-indicators and Indicators of Food Security.

<table>
<thead>
<tr>
<th>Sphere of the Formation</th>
<th>Food Safety Sub-Indicators</th>
<th>Food Security Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formation of resource potential</td>
<td>Available volumes of resources (area of agricultural land, arable land, number of rural population employed in agriculture, cost of material resources), potential volumes of food production</td>
<td>The degree of realization of resource potential</td>
</tr>
<tr>
<td>Food production</td>
<td>Production volumes, production costs (in particular, cost structure)</td>
<td>The level of self-sufficiency in food, the ratio of production and consumption</td>
</tr>
<tr>
<td></td>
<td>Indicators of agricultural production efficiency and activities of agriculture enterprises</td>
<td>Adequacy of reserves</td>
</tr>
<tr>
<td></td>
<td>Stock levels of strategic types of agricultural products</td>
<td></td>
</tr>
<tr>
<td>Distribution of food</td>
<td>The share of food consumed in the region, which was produced in other regions</td>
<td></td>
</tr>
</tbody>
</table>

Exports and imports: The ratio of imports to market capacity, imports to exports.

Domestic prices, the value of the consumer basket, household income, average wages.

Consumption: The structure of food distribution by sales channels, the presence of a retail network per 10 thousand people, the number of outlets in food markets per 10 thousand people, the state of development of wholesale food products, the density of public paved roads and railway tracks.

The ratio of the value of the food basket to wages and income (economic affordability).

Volumes of food consumption by region (in physical units).

Volumes of food consumption per capita (in physical units and in terms of proteins, fats and carbohydrates), energy value of the daily diet – actual and regulatory indicators.

Volumes of food consumption by quintile (20%) by groups depending on the amount of total income.

Fig. (1). The structure of quantitative assessments of food security of the country. Source: improved by the authors according to data (Soloviova, 2016; Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020; The State of Food Security…, 2018).
Ensuring Food Security of Ukraine

**Stage 1: Evaluation of food security**

<table>
<thead>
<tr>
<th>Consumer price and income index</th>
<th>Ratio of consumer price indices to inflation and wage (income) indices</th>
</tr>
</thead>
</table>

**Stage 2: Trend analysis**

- 2.1 Verification of time series of subindicators and indicators of food security for trends
- 2.2 Identification of regions that depend on food production in other regions

**Stage 3: Assessment of the ability of regions to meet their needs**

- 3.1 Distribution of regions by degree of dependence on production in other regions

**Stage 4: Identification of security factors**

- 4.1 Identification of possible factors
- 4.2 Assess the closeness of the relationship between the integral safety factor and its possible factors

**Stage 5: Food security threat assessment**

- 5.1 Food security risk assessment
- 5.2 Multifactor grouping of regions by source of security risks

*Fig. (2).* Research methods of food security of the country.

Source: improved by the authors according to data (Soloviova, 2016; Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020).

To measure the level of food security, the theory of fuzzy sets is used, on the basis of which we determine: food security sub-indicators, which are distributed according to the nature of the impact on the spheres of resource provision (indicators of resource potential), production and consumption. In addition, a category of assessments should be identified that will reflect the level of risk of adverse fluctuations in the main sub-indicators. Such estimates include the coefficient of semi-variation, which reflects the variation (variability) of fluctuations around its average value in the unfavorable direction for the country. The higher the value of this factor, the higher the risk and the lower the level of food security. As a result, a vector of food safety sub-indicators $X$ was formed (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020):

$$X = \{x_1, x_2, \ldots, x_i, \ldots, x_n}\,$$

where $x_1, x_2, \ldots, x_i, \ldots, x_n$ – the first, second, ..., $i$-th, ..., $n$-th sub-indicator of food security; $n$ – the number of food security sub-indicators;

threshold levels of each of the food security sub-indicators, as well as risks. In order to simplify the assessment methodology as much as possible, it is necessary to focus on minimizing the limit values of sub-indicators and indicators by risk factors (for example, low, medium and high levels);

the ratio of the actual value of each of the sub-indicators and indicators with dimensionless partial coefficients. It should be noted that the partial coefficients must be characterized by the same dimension and be distributed in the range from 0 to 1;

food security in the MatLab environment of the MatLab Fuzzy Logic Toolbox functionality.

*Fig. (2)* summarizes the methodology for assessing the country food security, which includes the stages of assessing its...
current state, as well as analysis of trends in food interdependence with identified factors that provoke a threat to the country self-sufficiency in agricultural products.

Systematization of the results of the analysis according to the methodology allows to get the perception of the integrated state of food security of the country and regions in the current period with the identification of trends of external threats and promising areas to strengthen resource potential, given the strengthening of competitive positions of agricultural producers in European and world food markets.

Thus, the cluster analysis allows to generalize results of self-sufficiency of regions of the country with food on integral sub-indicators which are divided into such: sub-indicator of self-sufficiency with meat and milk, sub-indicator of self-sufficiency with all basic kinds of food and sub-indicator of dynamics of self-sufficiency with food products (formulas (2)-(4)) (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynysyn, 2020).

\[
K^m_i = \frac{1}{2} \left( \frac{k^f_{\text{meat}}}{k^\text{max}_{\text{meat}}} + \frac{k^f_{\text{milk}}}{k^\text{max}_{\text{milk}}} \right)
\]  

(2)

\[
K^a_i = \frac{1}{n} \sum_{j=1}^{n} \frac{k^f_{ij}}{k^\text{max}_{ij}}
\]  

(3)

\[
K^d_i = \frac{1}{n} \sum_{j=1}^{n} \frac{k^f_{ij}}{k^\text{max}_{ij}}
\]  

(4)

where, \(K^m_i\), \(K^a_i\), \(K^d_i\) – integrated sub-indicators of self-sufficiency of the i-th region of the country, respectively, with meat and milk, as well as with all food products; \(K^d_{ij}\) – sub-indicator of the dynamics of self-sufficiency of the i-th region of the country with food; \(k^f_{ij}\) – actual values of self-sufficiency coefficients of the i-th region of the country, respectively, with meat and milk; \(k^{\text{max}}_{\text{meat}}\), \(k^{\text{max}}_{\text{milk}}\) – the maximum average value of all regions of the country in terms of self-sufficiency indicators of the first type with meat and milk; \(k^f_{ij}\) – the actual value of sub-indicators of self-sufficiency of the i-th region of the country with j-th food product; \(k^{\text{max}}_{ij}\), \(k^{\text{max}}_{ij}\) – respectively, the actual and maximum average value of all regions of the country in terms of the average annual growth rate of self-sufficiency of the i-th region with j-th product; \(n\) – the amount of food.

Most growth rates are negative. In this case, the calculation of the integrated self-sufficiency indicator by formula (4) is impossible. To solve this problem, the initial levels of growth rates are adjusted by formula (5) (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynysyn, 2020):

\[
K^{df}_{ij} = k^f_{ij} + \left| \min_k \frac{d^f_{ij}}{k^f_{ij}} \right| K^d_i = \frac{1}{n} \sum_{j=1}^{n} \frac{k^{df}_{ij}}{k^{\text{max}}_{ij}}
\]  

(5)

where, \(K^{df}_{ij}\), \(K^d_i\) – adjusted and actual value of the average annual growth rate of self-sufficiency of the i-th region with j-th food product.

Based on fuzzy estimates, the values of integrated self-sufficiency indicators are divided into three groups, which correspond to low (“L”), medium (“M”) and high (“H”) levels:

self-sufficiency indicator for meat and milk: 0-0.6 – low level; 0.61-0.8 – average level; over 0.8 – high level;

sub-indicator of self-sufficiency for all types of food: 0-0.4 – low level; 0.41-0.7 – average level; over 0.7 – high level;

sub-indicator of self-sufficiency dynamics: 0-0.7 – low level; 0.71-0.9 – average level; over 0.9 – high level.

The generalized synthetic indicator of self-sufficiency of the regions of Ukraine in food is a function of three variables (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynysyn, 2020):

\[
K_t = f(R^m_i, R^a_i, R^d_i)
\]  

(6)

where, \(R^m_{ij}\), \(R^a_i\), \(R^d_{ij}\) – integrated sub-indicators of self-sufficiency of the i-th region of the country, respectively, with meat and milk, as well as with all food products; \(K^d_{ij}\) – an integral sub-indicator of the dynamics of self-sufficiency of the i-th region of the country with food.

3. RESULTS AND DISCUSSION

The basis for effective food security is the potential value of agricultural products, which increases the functionality of the regions, in the context of using the productivity of land, labor and monetary resources as the most effective administrative centers. Analysis of the level of realization by agricultural producers of Ukraine of their resource potential, given the specificity of their food direction, is related to the study of trends in agricultural production and related indicators of economic efficiency of agricultural enterprises (profitability, productivity). According to Table 2, there is a negative trend in the use of labor and monetary resources by agricultural producers of Ukraine. The use of labor resources in Kyiv region is the most effective (2017-2021). At the same time, the maximum value of gross agricultural output per one EUR of invested funds is typical for Volyn and Chernivtsi regions. In general, using the experience of the most productive regions of Ukraine, we note that to increase the total volume and value of gross agricultural output by 70-80% is possible by increasing the efficiency of land use and in 2-4 times – by increasing efficiency of the use of labor and capital resources.

Table 2. Indicators of the Level of Realization of Resource Potential of Ukraine.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ukraine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The cost of agricultural production per 1 thousand hectares of agricultural land, million EUR</td>
<td>0.198</td>
<td>0.189</td>
<td>0.201</td>
<td>0.197</td>
<td>0.214</td>
</tr>
</tbody>
</table>
The cost of agricultural products per 1 thousand employed in agriculture, million EUR

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals and legumes</td>
<td>63.86</td>
<td>60.13</td>
<td>66.09</td>
<td>61.92</td>
<td>70.06</td>
</tr>
<tr>
<td>Potatoes</td>
<td>23.69</td>
<td>20.84</td>
<td>21.75</td>
<td>22.21</td>
<td>22.50</td>
</tr>
<tr>
<td>Vegetables</td>
<td>9.64</td>
<td>9.21</td>
<td>9.41</td>
<td>9.29</td>
<td>9.44</td>
</tr>
<tr>
<td>Meat</td>
<td>2.36</td>
<td>2.32</td>
<td>2.32</td>
<td>2.32</td>
<td>2.35</td>
</tr>
</tbody>
</table>

Source: calculated by the authors according to data (Balances and consumption of basic…, 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020).

From the standpoint of ensuring food security of strategically important agricultural products, sub-indicators of the level of self-sufficiency in food of administrative centers of Ukraine in the ratio of production and consumption in each of them, show a trend of gradual decline (Table 3).

Table 3. The Volume of Food Production in Ukraine.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural products, million tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals and legumes</td>
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</tr>
</tbody>
</table>

Review of Economics and Finance, 2022, Vol. 20, No. 1 429

The ability to self-sufficiency in meat and milk within 12.5% is demonstrated by three administrative centers of
Ukraine, namely: Vinnytsia, Volyn and Cherkasy regions (Fig. 4).

Mykolaiv and Odesa regions are the most dependent on foreign production. However, in almost 60% regions during 2017-2021 there is a tendency to reduce the level of self-sufficiency in meat. The magnitude of the variation (the difference between the minimum (in Chernihiv region 0.39) – and the maximum (in Cherkasy region 3.40)) values of the level of self-sufficiency in meat in 2021 was 3.36, that in 8.7 times more (against 6.4 times in 2017) than in Chernihiv region. This trend is a negative challenge to the food security of the country.

One of the least supplied with own milk is Dnipro region (24% from the minimum need), which, at the same time, is almost 100% provided with its own meat production (Fig. 5).

For all types of both agricultural and food products, there is an excess of the ratio of production to consumption (Fig. 6).

In particular, during 2017-2021 there was a significant increase in exports, mainly to all strategically important product groups for the country food security. The only exceptions were fruits and berries, the export of which decreased by about 5% every year. As for the volume of imports, along with the increase in exports of potatoes, vegetables, eggs, milk and dairy products, the volume of their imports decreased significantly (by 30%, 16%, 43% and 50%, respectively). The above gives grounds to claim that during 2017-2021 there was a strengthening of food security of Ukraine within these types of food.

The annual increase in exports of meat and meat products is about 16%, milk and dairy products – 12%, vegetables – by 10%. However, in parallel with these trends, there is a growing trend of imports of meat and meat products (annually by 9%). As the growth of the ratio of imports to market capacity (by 46% for 2017-2021) is unfavorable for the food security of Ukraine, we checked the ways of redirection of meat imports to the domestic market (Figure 7-8).
Fig. (5). The level of self-sufficiency in milk of the administrative centers of Ukraine for 2017-2021.
Source: calculated by the authors according to data (Balances and consumption of basic..., 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020; Development of trade and consumer protection, 2021).

Fig. (6). The level of the ratio of production and consumption of agricultural products and food products in Ukraine for 2017-2021.
Source: calculated by the authors according to data (Balances and consumption of basic..., 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020; Development of trade and consumer protection, 2021).

Fig. (7). The ratio of imports to exports in Ukraine for 2017-2021.
Source: calculated by the authors according to data (Meyers et al., 2018; Development of trade and consumer protection, 2021; Fryzorenko, 2019).
The country food security is always accompanied by threats and risks of losing food independence. Trends in food security in Ukraine involve the use of risk management tools in terms of each of the groups of food security indicators that operate in both domestic and foreign markets in the field of resource potential, food production, and food distribution and consumption.

Based on dynamic series, the risk coefficient of negative deviations of crop yields and livestock is determined, level trends are constructed and coefficients of semi-variation, loss of food independence are calculated (sown area, population and ratios of wage indices and inflation) by formula (7) (Kozlovskiyi et al., 2019; Levkina et al., 2019):

$$r_i = \omega_i \times SSV_i,$$

where, $r_i$ – the risk factor for negative fluctuations of the i-th food security indicator; $\omega_i$ – the coefficient of risk weight of negative fluctuations of the i-th indicator of food security; $SSV_i$ – the coefficient of risk of negative fluctuations of the i-th indicator of food security.

For indicators with elasticity coefficients from 0.1 to 1, the weights are set at 1.2, and from 1 to 2 - 1.5. For other risk indicators, the coefficients of elasticity are equal 1. The calculated risk indicators are presented in Fig. (9).

The established levels of risk in crop production and animal husbandry confirm that the risks in animal husbandry are much lower than in crop production. The integrated risk factor in the field of crop production is 15.37, livestock – 7.04. The weighted risk factor for agriculture as a whole is 14.03. The high risk of losing food independence in the field of crop production indicates the need for active action in this direction by the state. The declining trend in livestock is seen as a manifestation of low risk, but confirms the high probability of declining livestock production due to well-predicted and determined factors. The coefficient of semi-variation in calculating the ratio of the average annual wage index to the consumer price index at the level 45.26% indicates an in-
Ensuring Food Security of Ukraine

Review of Economics and Finance, 2022, Vol. 20, No. 1 433

creased risk of negative fluctuations in the economic affordability of food in Ukraine.

An effective food security system, as one of the key tools and at the same time an indicator of assessing the quality of life of citizens, is the key to sustainable development of Ukraine in the context of globalization. Its formation is influenced by various factors of the internal and external environment (the binary nature of such influence is defined by local and global determinants) (Strategy for the development of the agricultural..., 2013). Timely identification of existing and potential threats to food security involves assessing existing trends in its main indicators and further forecasting them. Carrying out the corresponding researches allows to form the forecast model of the development of key parameters of food safety and to establish, in what direction sources of its formation within the formed system change (Mostova, 2017). Thus, the results of regression analysis of the food security indicators in Ukraine show the lack in trend of changing the level of self-sufficiency in milk, the ratio of imports and market capacity of milk and eggs, the ratio of actual and regulatory consumption of meat and meat products, milk and dairy products, eggs. An increase in the area of agricultural land, the level of self-sufficiency in fruits and berries, the ratio of production and consumption of grain, imports and capacity of the grain market is defined (Table 4). Instead, the number of cattle and the ratio of imports to the capacity of the vegetable market tend to decrease.

Table 4. Results of Regression Analysis of the Food Security Indicators (Resource Potential, Food Production and Distribution).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Model Type</th>
<th>Trend Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of agricultural land</td>
<td>Linear</td>
<td>$y = 35000.14 + 629.12t$</td>
</tr>
<tr>
<td>Livestock of cattle</td>
<td>Growth</td>
<td>$Y = e^{8.62 - 0.4t}$</td>
</tr>
<tr>
<td>Self-sufficiency in fruits and berries</td>
<td>Degree</td>
<td>$y = 0.32t^{0.256}$</td>
</tr>
<tr>
<td>Ratio of grain production and consumption</td>
<td>Linear</td>
<td>$y = 34.731 + 60.691t$</td>
</tr>
<tr>
<td>Ratio of grain imports to market capacity</td>
<td>Degree</td>
<td>$y = 0.17t^{0.438}$</td>
</tr>
<tr>
<td>Ratio of vegetable imports to market capacity</td>
<td>Logarithmic</td>
<td>$y = 0.054 – 0.014 \ln (t)$</td>
</tr>
</tbody>
</table>

Source: calculated by the authors.

On the basis of the built models the scenario forecasts of indicators of the food security of Ukraine (resource potential, production and distribution of food) for 2022-2024 are constructed (Figure 10-15).

Fig. (10). Indicator of food security by land potential of agricultural production in Ukraine for 2022-2024
Source: calculated by the authors.

Fig. (11). Indicator of the food security for livestock of agricultural production in Ukraine for 2022-2024
Source: calculated by the authors.

Fig. (11). Indicator of the food security for livestock of agricultural production in Ukraine for 2022-2024
Source: calculated by the authors.
Fig. (12). Indicator of the food security on the level of self-sufficiency in fruits and berries of agricultural production of Ukraine for 2022-2024
Source: calculated by the authors.

Fig. (13). Indicator of the food security in the ratio of grain production and consumption in Ukraine for 2022-2024
Source: calculated by the authors.

Fig. (14). Indicator of the food security in the ratio of grain imports to market capacity in Ukraine for 2022-2024
Source: calculated by the authors.

Fig. (15). Indicator of food security in the ratio of vegetable imports to market capacity in Ukraine for 2022-2024
Source: calculated by the authors.
Ensuring Food Security of Ukraine

Among the positive forecasts, we note the maximum possible reduction in vegetable imports in the case of an optimistic scenario. Significant expected growth is characterized by the ratio of grain production to consumption (approximately 14%), which is due to the potential increase in its production. In the case of relative stability of external and internal conditions, we can expect an increase in the level of self-sufficiency of Ukraine in fruits and berries by 2.6-4.4%. Instead, a previously declining trend in livestock, all other things being equal, could lead to a reduction in livestock by 10-13% during 2022-2024.

The forecast results show a positive dynamics of growth in the level of self-sufficiency in meat (growth by 1.3-1.6% annually). However, even with an optimistic forecast, Ukraine is unable to ensure full independence in meat products and meet the physiological needs of the population. Therefore, it is strategically important not to support the existing trend, but to create conditions for its change in the direction of acceleration. The ratio of milk production to consumption will remain virtually unchanged. In particular, it is expected that Ukrainian agricultural producers will continue to cover the domestic demand for milk, but will not create reserves in the case of force majeure and a basis for increasing exports of agricultural products of this type.

It is established that according to the coordinated time series, the dynamics of most food security indicators is described by increasing degree functions (Table 5 and Figure 16-19).

### Table 5. Results of Regression Analysis of the Food Security Indicators of Ukraine (Smoothed Time Series)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Model type</th>
<th>Trend Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-sufficiency in vegetables</td>
<td>Degree</td>
<td>$y = 0.982t^{0.185}$</td>
</tr>
<tr>
<td>Self-sufficiency in meat</td>
<td>Degree</td>
<td>$y = 0.450t^{0.194}$</td>
</tr>
<tr>
<td>The ratio of production of fruits, berries, grapes to</td>
<td>Growth</td>
<td>$y = e^{-0.78+0.1}$</td>
</tr>
<tr>
<td>consumption</td>
<td>Degree</td>
<td>$y = 1.217t^{0.55}$</td>
</tr>
</tbody>
</table>

Source: calculated by the authors.
The largest increase in food security is in terms of production and consumption of fruits, berries and grapes – by 4.8-7.2% for 2022-2024. However, given that the demand for these products is met by more than a half, such growth is also insufficient. The best situation is with the ratio of production and consumption of vegetables, which will gradually increase. It is expected that the needs of the population of Ukraine in vegetables will also be fully met.

We summarize the trends of changes in the food security indicators of Ukraine. In the context of its strengthening, it is necessary to note such dynamics. First, we expect a rapid reduction in cattle by 10-13% during 2022-2024. Second, the ratio of grain production to consumption is expected to increase (by 14% for 2022-2024). Third, the level of self-sufficiency in fruits and berries is projected to increase by 4-6% at a moderate level of risk of reduced yields of fruits and berries. Fourth, the level of self-sufficiency in vegetables is expected to increase by 3-4%.

Given the increasing openness of the national economy, expanding domestic and foreign agri-food markets, as well as European integration intentions of Ukraine, the level of food security should be carried out in the context of simultaneous assessment of economic and social indicators and effective governance. Prompt response to changes and restructuring of the state food policy is the result of systematic monitoring of the formative resource potential during changes in the food basket and the definition of strategic priorities of socio-economic growth.

4. CONCLUSIONS

Thus, a more rational use of world food and agricultural resources is possible only if the food security system of the country is created at the national and local levels. Certain risks of the developing regions in specific territorial and sectoral conditions encourages the state to implement a set of international standards and requirements of other countries and actively address urgent issues at the national and local levels to minimize threats to the economy of agriculture and other spheres. It will ensure the food security and economic interests of economic entities, taking into account the needs of citizens. Ukrainian producers of food products and raw materials directly have to compete in the markets with representatives of this business, which have more developed resource potential and a sufficient amount of state support, better technological security and so on. That is why it is necessary to form a balance of domestic food supply, in the presence of modern doctrine of food security and ensure the effectiveness of the mechanism of public management of its implementation.

In the field of food security of Ukraine, state support policy should provide a platform to increase opportunities to overcome threats to the development of agro-industrial complex,
which should be based on regional and local public-private partnership programs, combined with national health policy and key national priorities of security in the international arena. At the same time, the systematization of key provisions of world practices, in the context of food security regulation policy, will identify a number of effective tools for state regulation of market pricing and product quality, support for social policy and meet the needs of the population. At the same time, the formation of an appropriate legal and institutional platform to ensure the balance of the “production – consumption” of food products should encourage agrilibusiness in the regions to clearly and effectively implement the functions of food security institutions, with clear steps to determine the imperatives of the growth and enhancing the independence of the food continuum (production, processing, storage, transportation, marketing and consumption) in the food infrastructure.

**CONFLICT OF INTEREST**

There is no conflict of interest.

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