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DETERMINANTS OF ENSURING FOOD SECURITY OF MANUFACTURERS OF THE GRAIN AND OIL GROUP OF UKRAINE ON THE EUROPEAN MARKET

S u m m a r y

Background. In the article, the directions of food security of Ukraine were developed, which, based on the principles of sustainable development of agricultural producers, ensure the stability of their food system, which is integrated into the synergized logistics chains of the supply of high-quality agricultural raw materials of the grain and oil group on the European market. The methods of diagnosing the state of food security of the state (rural territory or region) through the resource component of simple or extended reproduction of the food system of agricultural producers were determined.

Results and conclusions. Mathematical models of outsourcing (transportation service of commodity producers of grain and oil group) were identified in order to improve the forecasting of indicators of the technological process of production (sale) of products. The process of re-producing the potential of the food system of commodity producers of the grain and oil group in the logistics chains of the agro-raw material segment of the European market was formed. A comparative analysis of the production and sales of grain and oil group commodity producers on the Ukrainian and European markets was conducted, as well as the volume of grain stocks in the state resources of Ukraine was assessed.

Keywords: grain and oil crops market, logistics chains, agricultural production, export, import

Introduction

The strategic orientation of the successful functioning of the modern agricultural sector in the global integration processes is the expansion of the range of opportunities

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for commodity producers of the grain and oil group, which implement the latest technologies in production and achieve objective transformations on the market. However, they affect the excessive exploitation of land resources and can destabilize agricultural production in the dynamic development of the territories of those countries that are exporters of agricultural products. This makes it necessary to harmonize the national interests of Ukraine with the realities of the global economic space, to expand the sale of products of the grain and oil group on the market, which are stabilizers of the resource provision of food security not only in the country, but also in the countries of the European level of development. However, on the European market, Ukrainian producers of grain and oil products face obstacles, in particular, tough competition, external political and economic factors [29]. This was especially noticeable during Russia's military aggression against Ukraine, when the unstable political environment, the unjustified interference of the aggressor country in the national regulation of the agricultural product market led to the weakening of the socio-economic system and the leveling of the logistics infrastructure among countries of the world.

Unregulated threats to Ukraine's food security and overcoming complex challenges facing the country require transformational actions that include the principles of sustainability and the elimination of the consequences of martial law, which, since the beginning of the full-scale intervention of the aggressor country, caused a gap in the food chain between rural areas and food producers provision in the regions of the state. Producers on the grain and oil group products market are destabilized and have a low level of influence on the diversification of agricultural production development. Meanwhile, the crisis economic situation, the increase in depressed areas, their environmental and radiation pollution - all this has led to threats of food insecurity in the country, which forms the inclusion of the agricultural raw material export market of Ukraine. That is, the market for products of the grain and oil group, in the modern conditions, requires the formation of effective tools for the intensive development of agricultural production in those territories where the high standard of living of the rural population is concentrated, and, in particular, in those regions where the demographic situation has improved [5, 30].

The primary direction of the modernization of the state policy on the food security issues of agrarian production of the grain and oil group is the narrowing of the spatial destination of rural areas and the determination of priority incentives for food security in the country. The desire to revive the country's food potential in the countryside with the maximum use of the advantages of the territorial and sectoral distribution of agricultural production between the grain and oil groups, the introduction of an effective model of food security, is comprehensively implemented in the agro-raw materials segment of the market, which makes up 3.2 % of GDP and 16 % of the country's exports [24].

Issues that fully reflect the modernity of the Ukrainian countryside need to be revealed, given the temporarily occupied territories, which require both economic, social, mental and financial and investment reintegration for the restoration of the infrastructure of the agricultural sectors, and, in particular, the commodity production of the grain and oil group. The priority of our research is the development of directions for food security of Ukraine, which, based on the principles of sustainable development of agricultural producers, ensure the stability of their food system, which should be integrated into the synergized logistics chains of the supply of high-quality agricultural raw materials of the grain and oil group to the European market.

Materials and methods

The market in products of the grain and oil group as an environment for the functioning of commodity-workers of agricultural production consists of elements (social and economic components), which, in turn, are the factors influencing the sustainability of their food system. The market business environment, in particular the environment of the European market, is divided into two levels of logistics chains for the supply of quality raw materials of the grain and oil group: meso- and macro-environment (regarding the commodity producers of the agrarian production of grain and oil group products).

Any producer of agricultural production, which ensures the stability of the food system in the turnover of logistics chains while supplying high-quality agro-raw products of the grain and oil group, operates on the national market, but faces the influence of the global market business environment (in particular, due to the influence factor, imported agricultural products on the national market) [7, 32]. This provokes the displacement of domestically produced products from the national market. There is an imbalance in the situation of the agro-raw material segment, which is very dangerous for the food security of the state, since the number of influencing factors and participants of the business environment increases when agricultural producers try to enter the European market [3]. Dybska and Sergeyev [9] offer a model of food security in the environment of the functioning of agricultural producers through the logistics chains of the agricultural raw material segment on the European market, which includes the international environment; the national environment, which is divided into the macro- and micro logistics environment, the environment of supply channels and the internal environment of the logistics chain. The market business environment of commodity producers of the agrarian production of the grain and oil group, as subjects of the agro-raw material segment on the European market, is revealed in separate components of the food security model, which is presented in Figure 1.
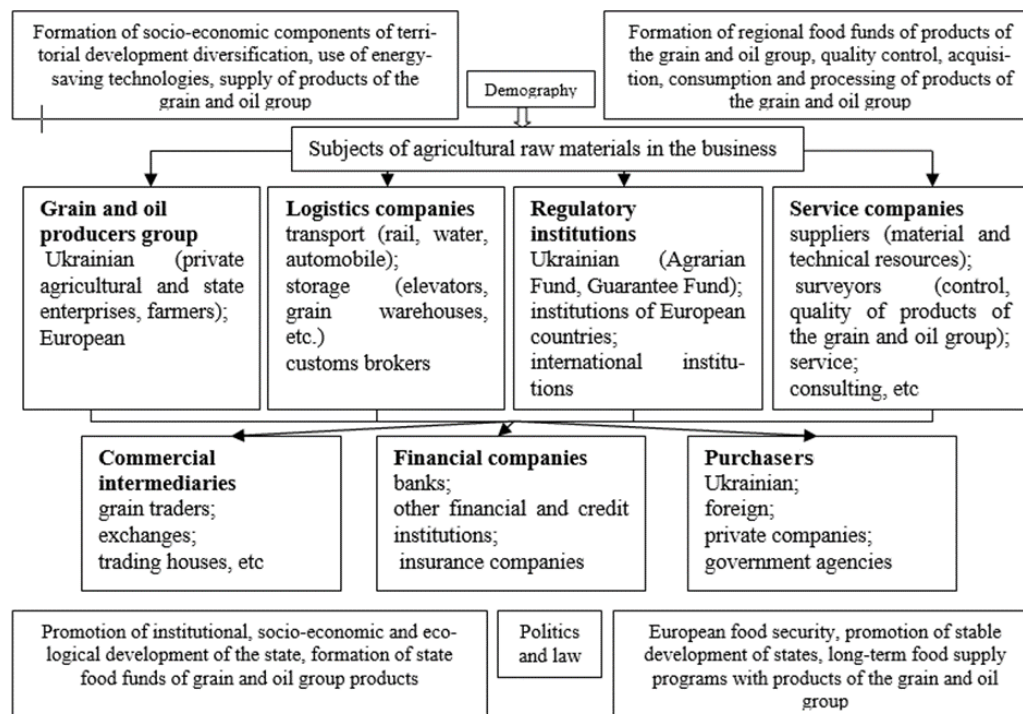
Figure 1.   Food security of the country on the world market in products of the grain and oil group

Rycina 1.   Bezpieczeństwo żywnościowe kraju na światowym rynku produktów grupy zbożowo-olejowej

Explanatory notes / Objaśnienia:

Source: compiled by the authors based on data of Khomiuk [19]; Źródło: opracowanie własne na podstawie danych Khomiuk [19].

Rapid changes and often unpredictable institutional and socio-economic fluctuations in the market business environment weaken the food system of the producers of the products of the grain and oil group and require ensuring a stable level of food security of the state, taking into account its sovereignty and the right to full resource provision in the logistics chains of the agro-raw material segment on the European market [16, 33]. Their explanatory weight is enhanced by the synergy of the four-dimensional interaction of the levels of food security:

level 1: ensuring food security (micro-, local level);

level 2: ensuring food security of the region (meso- or regional level);

level 3: ensuring food security of the state (national (nationwide) level);

level 4: ensuring European food security (mega-, global level)) [44].

A diagnosis of the state of food security of the state (rural territory or region) through the resource component of a simple or extended reproduction of the food system of agricultural producers can be carried out with the help of numerous economic

risk assessment and export assessment methods: indicator (forecast), resource-functional, program-target (complex) [20].

Savin and Karkh [35] assume that if (y-) and (y+) – are the minimum (min) and maximum (max) volumes of sales of the products of the grain and oil group on the European market, then (Ey) represents the average volume of grain and oil products groups that can be exported by producers to the European market from the total volume of production (S), and c – the price of a unit of production. Accordingly, the cost of potential costs for insurance of the average volume of products of the grain and oil group, which can potentially be exported by producers to the European market at the probable economic risk of its loss, will be equal to $y_a = \alpha Ey$, where $0 \leq \alpha \leq 1$ is the coefficient. In this case, the total sum insured will be equal to CSy_a. The producer's insurance costs in case of probable loss of products of the grain and oil group will be equal to $\pi = \delta cSy_a$, where $0 \leq \delta \leq 1$ – is the rate of the insurance intermediary in the export agreement on the European market. Parameter $0 \leq \gamma \leq 1$ – means state support for producers from the budget.

Therefore, the producer must pay the insurance intermediaries the amount $(1 - \gamma)^{\pi}$; insurance compensation in the event of an economic risk will be equal to $r = cS(y - y_a)_+$. The subscript (+) is the Heavy side function. If the value (y_a) is the insurance rate of the average volume of products of the grain and oil group that can be exported by the producer to the European market with the probability of occurrence $(P(y \leq y_a) = p_a)$, then the value$(1 - p_a)$ is the potential income of the producer of the grain and oil group from the export agreement on the European market; the probable value (p_a) is the income that will be compensated by the insurance intermediary.

Thus, commodity producers of agricultural production have two criteria for assessing stability: the average income received and the level of stability from the sale of products of the grain and oil group, which is set by the corresponding level of probability. At the same time, the application of the logistics system as a criterion for assessing the level of food security of producers of the grain and oil group allows to shorten the terms of cargo transportation, reduce the amount of crop loss, increase the economic effect and speed up resource provision for loss-free development in the current and future period [35]. The functioning of the logistics system for assessing the level of the food security of agricultural producers is presented in Figure 2.

A mathematical model of outsourcing (transportation service of the producers of the grain and oil group) is determined in order to improve the forecasting of indicators of the technological process of production (sale) of products. To build a mathematical model, the theory of mass service with certain limitations is used, transport service of the technological process of harvesting grain and oil group products by vehicles is
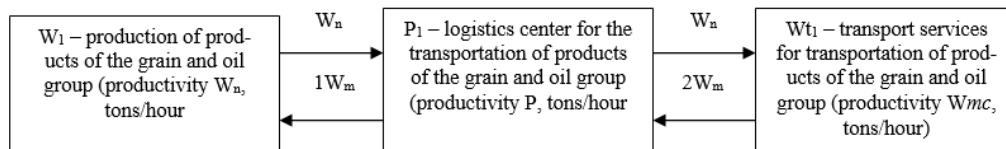
W_1 – production of products of the grain and oil group (productivity W_n, tons/hour	W_n $\to$ / $1W_m$ $\leftarrow$	P_1 – logistics center for the transportation of products of the grain and oil group (productivity P, tons/hour	W_n $\to$ / $2W_m$ $\leftarrow$	Wt_1 – transport services for transportation of products of the grain and oil group (productivity Wmc, tons/hour)

Figure 2.   Functional scheme of the logistics system of the food security of commodity producers of the grain and oil group

Rycina 2.   Schemat funkcjonalny systemu logistycznego bezpieczeństwa żywności producentów towarów z grupy zbóż i olejów

Explanatory notes / Objaśnienia:

developed by the authors based on data of Dybska & Sergeyev [9]; Savin & Karkh [35]; opracowane przez autorów na postawie danych Dybska & Sergeyev [9]; Savin & Karkh [35].

considered as an unstable (random) process with fluctuations in productivity over time. The flow of requests for cargo transportation considered as the time interval between orders for transportation is a random variable, which is represented by formula (1):

$$f(t) = \lambda^{-\lambda t}, \tag{1}$$

where: λ – the intensity of the flow of requests for cargo transportation, request/hour;

t – the current time in which the freight transportation process is simulated.

The service system of the logistics center is a single-channel mass service system, but the transport service system is a multi-channel system consisting of N channels of cargo transportation by n-cars. As a criterion for the intensive flow of applications for harvesting, transportation by means of vehicles of products of the grain and oil group, the total productivity of grain harvesting complexes is determined – Wп, tons/hour (Fig. 2). The structural system of transport service for simple and extended reproduction of resources (stocks) of production (transportation) of commodity producers of the grain and oil group in the raw material segment of the market is multi-channel, consisting of n-cars (Fig. 3).

The presented structures of the models of the logistics center (Fig. 2) and the multi-channel transport service system (Fig. 3), according to the theory of operations research, are considered as graphs of states. At the initial stage, the state of the transport service system of the logistics center is determined (Fig. 2). Status W1 – the system is waiting for the cargo; logistics center P1 and vehicles 1Wmc are free. State P1 – the logistics center forecasts the volume of transportation, routes, calculates the number of vehicles. State 1Wmc – all elements of the system, including vehicles, participate in the production and transportation of products.
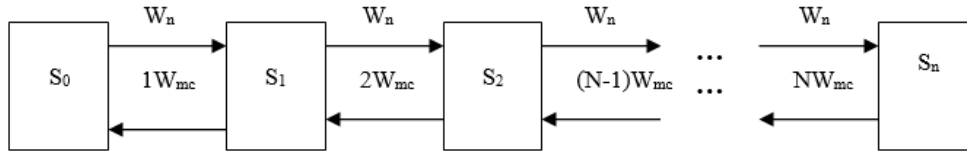
Note. S_0, S_1, S_2, S_n – system status; Wmc – unit vehicle performance.

Figure 3. The structure of the multi-channel transport service system of commodity producers of the grain and oil group in the flow of simple and extended reproduction of production resources (stocks)

Rycina 3. Struktura wielokanałowego systemu usług transportowych producentów towarowych z grupy zbóż i olejów w przepływie reprodukcji prostej i rozszerzonej zasobów produkcyjnych (zapasów)

Explanatory notes / Objaśnienia:

developed by the authors based on data of Dybska & Sergeyev [9]; Savin & Karkh [35]; opracowane przez autorów na postawie danych Dybska & Sergeyev [9]; Savin & Karkh [35].

Arrows from left to right show the intensity of requests for cargo transportation, Wn; arrows from right to left – the intensity of transport and logistics services. Based on the graph of the states of the logistics chain (Fig. 2), a system of differential equations is formed, which makes it possible to determine the probability of the system being in any of the states of the logistics chain.

The derivative of the probability of the state of the logistics chain is located on the left side of the equation; the right side contains the number of derivatives of the logistics chain, which are equal to the number of arrows in a given state. If the arrow is directed from the state of the logistics chain, then the corresponding derivative of the logistics chain has a "minus" sign, and if the arrow is directed to the state of the logistics chain – a "plus" sign is placed. Each derivative is equal to the product of the intensity by the probability of the state of the logistics chain from which the arrow originates [9, 35].

A system of differential equations is determined, according to Figure 2:

$$\frac{dp(W_1)}{dt} = -W_{np}(W_1) + W_{tp_{(p_1)}}, \tag{2}$$

$$\frac{dp(p_1)}{dt} = W_{np}(W_1) + W_{tp}(1W_m) - W_{tp}(p1) - W_{np}(p1),$$

$$\frac{dp(1W_m)}{dt} = -W_{tp}(W_1) + W_{np}(p1), \tag{3}$$

Provided that at the initial time t = 0, then the derivatives on the left side of the equation of the system (3) will be equal to zero. Shifting the value with a minus sign to the left allows for obtaining a system of linear equations:

$$W_{np}(W1) = W_{mp}(p_1),$$

$$(W_m + W_n) \times p(p1) = W_{np}(W1) + W_{tp}(1W_m)$$

$$W_{tp(1W_m)=W_{np}(p1)}, \tag{4}$$

The equation (4) allows for the determination of the state probability through the derivative p (W1).

From the first equation we obtain:

$$p(p1) = \frac{W_n}{W_m} \times p(1W), \tag{5}$$

From the third equation we obtain:

$$p(1W_m) = \frac{W_n{}^2}{W_{m^2}} \times p(1W), \tag{6}$$

Taking into account the condition that the sum of all probabilities is equal to one, then the equation (7) will be as follows:

$$p(1W_m) + \frac{W_n}{W_m} \times p(W_1) + \frac{W_n{}^2}{W_{m^2}} \times p(W_1) = 1, \tag{7}$$

The equation (7) allows for the determination of the state probability through the derivative $p(W_1)$.

$$p(W_1) = \frac{1}{1+\frac{W_n}{W_m}+\frac{W_{n^2}}{W_{m^2}}}, \tag{8}$$

The equations (5), (6) and (7) make it possible to model the services of a logistics center for the transport service of commodity producers of the grain and oil group, with the determination of the probabilities of being in one of the states of the logistics chain directed to the agro-raw market segment. In the above formulas, the Wmc parameter is used, which characterizes the intensity of the fulfillment of requests for transportation, which depends on the number of vehicles, their carrying capacity and the distance of cargo transportation. To develop a mathematical model of the functioning of vehicles, one has to consider the structure of a multi-channel transport service system (Fig. 3).

The state of the multi-channel system of transport service for commodity producers of the grain and oil group in the logistics chain of the simple and advanced reproduction of production resources (stocks) is determined by the following derivatives. Where: S_0 – all n-cars are free and waiting for cargo; S_1 – one car is running the remaining n-cars are free; S_2 – two cars are running, n-cars are free; S_n – all n-cars are running, there are no free vehicles.

From state to state by arrows from left to right, the system transfers the intensity of the flow of requests for cargo transportation. Accordingly, the intensity of the flow of applications (W_n) is defined as the total productivity of collection complexes and is calculated in tons per hour. Arrows from right to left indicate the intensity of the service of collection complexes by cars.

At the same time, Figure 3 shows that when one car is working, the maintenance intensity is equal to the car's productivity (W_{mc_i}); in the presence of n-cars, the service intensity will be equal to ($N \times W_{mc_i}$). That is,

$$\frac{dp_0}{dt} = -W_{np_0} + W_{mc}p_1$$

$$\frac{dp_1}{dt} = -(W_n + W_{mc}) \times p_1 + W_{np_0} + 2W_{mc}p_2,$$

$$\frac{dp_2}{dt} = -(W_n + 2W_{mc}) \times p2 + W_{np_1} + 3W_{mc}p_3,$$

$$\dots \dots \dots \dots$$

$$\frac{dp_n}{dt} = -NW_{mc}p_n + W_{np_{N-1}}, \tag{9}$$

Applying the condition that at the initial moment of time at t = 0, all probable derivatives are equal to zero, we rewrite the system of equations in the form of a system of linear equations:

$$W_{np_0} = W_{mc}p_1$$

$$(W_n + W_{mc}) \times p_1 = W_{np_0} + 2W_{mc}p_2,$$

$$(W_n + 2W_{mc}) \times p_2 = W_{np_1} + 3W_{mc}p_3,$$

$$NW_{mc}p_n = W_{np_{N-1}}, \tag{10}$$

The derivative (p_1) is through the derivative (p_1) of the first equation.

$$p_1 = \frac{W_n}{W_{mc}} \times p_0, \tag{11}$$

Substituting successively into other equations, we obtain:

$$p_2 = \frac{W_n^2}{W_{mc} \times W_{mc}} \times p_0, \tag{12}$$

$$p_3 = \frac{W_n^2}{W_{mc} \times 2W_{mc} \times 3W_{mc}} \times p_0, \tag{13}$$

$$p_n = \frac{W_n^2}{W_{mc} \times 2W_{mc} \times NW_{mc}} \times p_0, \tag{14}$$

Or, in general, the expression for determining the probability of events in the system can be written as follows:

$$p_n = \frac{(W_n/W_{mc})^N}{N_i} \times p_0, \tag{15}$$

Applying the condition that at t > 0 the sum of all probabilities of the system is equal to one:

$$p_0 + p_1 + p_2 + \dots + p_{n=1}, \tag{16}$$

Given the equation (16) value of the probability of system events, we obtain an expression for p_0:

$$p_0 = \frac{1}{1 + \frac{(Wn/Wmc)}{1} + \frac{(Wn/Wmc)^2}{2} + \ldots + \frac{(Wn/Wmc)^n}{N_i}}, \tag{17}$$

Applying the obtained expressions $(11) \div (17)$, it is possible to determine the required performance of the transport service system:

$$W_m = W_n(1 - p_n), \tag{18}$$

The required number of vehicles for the operation of the transport service system can be determined by the expression:

$$N = \frac{W_n}{W_{mc}}(1 - p_n), \tag{19}$$

On the basis of the equation (18), the productivity of the transport service system is determined and the logistics chains of the flow of agricultural raw materials to the market are modeled using the equations (5), (6) and (8). That is, the power of logistics chains is equal to the productivity of the transport service system. At the same time, the transport service system, consisting of n-cars, is outsourced during the current period and is formed by the logistics center. All formulas and equations provided above are based on research by Dybska and Sergeyev [9] and Savin and Karkh [35].

Results

The change in the processes of agricultural production and in the logistics chains of the supply of agricultural raw materials of the grain and oil group from Ukraine to the European market was caused by the full-scale military invasion of the aggressor country on the territory of the state [25]. This provoked a threatening downward trend in the level of food security in the country on the domestic market, which in 2022 became critical in relation to the level of 2021. According to the data provided by Mo-EDT [28], FAO [11] and SSSU [37], the total amount of agricultural products produced in the country for $2019 \div 2021$ increased three times, the yield two-and-a-half times. Before the war period $(2019 \div 2021)$, the area of agricultural land in Ukraine, including the area of leased land plots, which had been cultivated by agricultural raw material entities and which ensured the country's food security, had increased by 2.6 %. However, due to the occupation of certain regions of Ukraine by the aggressor country, in 2022 their share decreased in relation to the level of 2021 by 29 % (Fig. 4).

A significant share (more than 40 %) of the production of crops of the grain group in Ukraine is formed by winter crops of wheat, barley and rye. Taking into account the fact that the sowing of these crops had taken place before the beginning of the war in the country, it is advisable to start with the prospects of the winter wedge. In $2020 \div 2022$, in the total structure of crops, winter grain crops accounted for 51 % on average and ranged from 7.6 to 8.2 million hectares. For the 2022 harvest, 7.6 million

hectares of winter grain crops were sown, which is 7 % lower than in 2021 (8.2 million hectares), and practically the same as the area in 2020. Including the area under winter wheat under the harvest in 2022, which was 6.5 million hectares (-5 % compared to the 2021 figure), under winter barley – 969.0 thousand hectares (-15 %) and under rye – 108.5 thousand hectares (-39 %) [25].
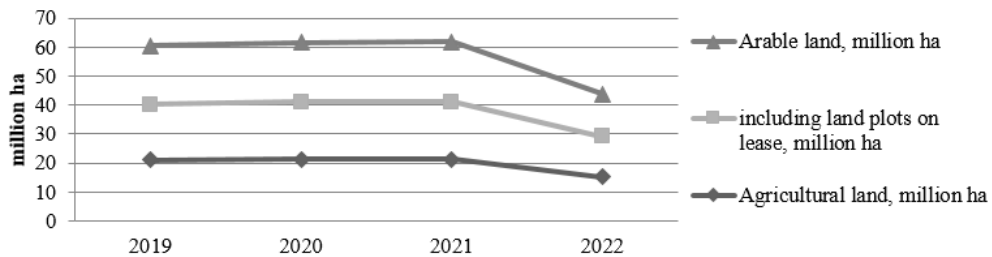

Figure 4.   Area of agricultural land cultivated by agricultural raw material entities of Ukraine for 2017 ÷ 2022 [million hectares]

Rycina 4.   Powierzchnia gruntów rolnych uprawianych przez podmioty surowcowe Ukrainy w latach 2017 ÷ 2022 [mln ha]

Explanatory notes / Objaśnienia:

developed by the authors based on the data of MoEDT [28], FAO [11], SSSU [37]; opracowane przez autorów na podstawie danych MoEDT [28], FAO [11], SSSU [37]

Unfortunately, the military actions in Ukraine led to a significant reduction in the area of commodity producers of the grain group, which were potentially available for the collection and transportation of agricultural raw materials by logistics centers on the territory of the country.

A large part of the land was beyond the limit of the physical possibility of its cultivation. First of all, these are the territories of the Kherson, Donetsk, Luhansk, Zaporizhzhya, Mykolaiv, Kharkiv, Sumy, Chernihiv and Kyiv regions. Losses of crops of winter grain crops reached 41 %, which corresponds to 3.1 million hectares (Fig. 5). For these reasons, subjects of agro-raw materials did not receive 78.5 % of the harvest of winter grain crops. In 2019 ÷ 2021, the area of spring grain crops in Ukraine ranged from 7.5 to 7.8 million hectares. However, the beginning of the war and its consequences led to a significant adjustment in the structure of cultivated areas in 2022.

Increased demand from processing enterprises to ensure Ukraine's food security, commodity producers of the grain agro-raw materials group replanned the structure of crops in 2022. First of all, this concerned wheat, barley and cereal crops, such as buckwheat, millet, oats, etc. Due to military operations, the country lacked the opportunity to fully export corn (a key product of the grain group for Ukraine), with a record harvest of 41.9 million tons. However, even with high losses, the reserves of this agricultural raw material are estimated at 13.5 million tons, which is 6.6 times more than in

2021 [25]. At the same time, with low exports, it was quite difficult to implement such a volume of supply, which led to a decrease prices on the domestic market. External demand for corn can return to a high level only if sea ports are restored and safe access to them provided, which, taking into account the risks for ship-owners and the damage to the transport infrastructure in Ukraine, is not a fast enough prospect.
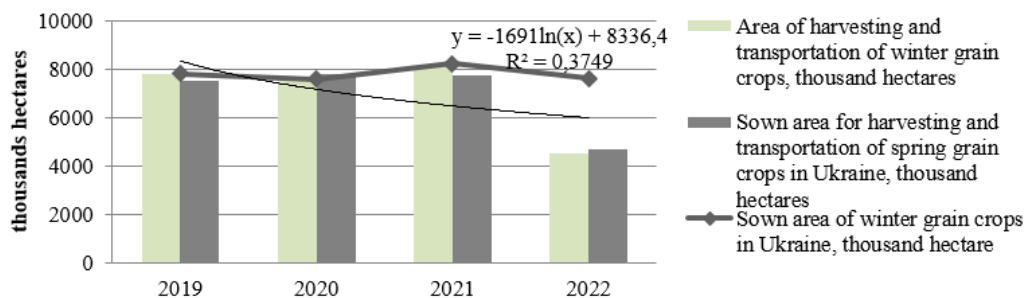

Figure 5.   Winter grain crop cultivation and logistics review (2019 ÷ 2022)
Rycina 5.   Przegląd uprawy zbóż ozimych i logistyki (2019 ÷ 2022)
Explanatory notes / Objaśnienia:
developed by the authors based on the data of MoEDT [28], FAO [11], SSSU [37]; opracowane przez autorów na podstawie danych MoEDT [28], FAO [11], SSSU [37]
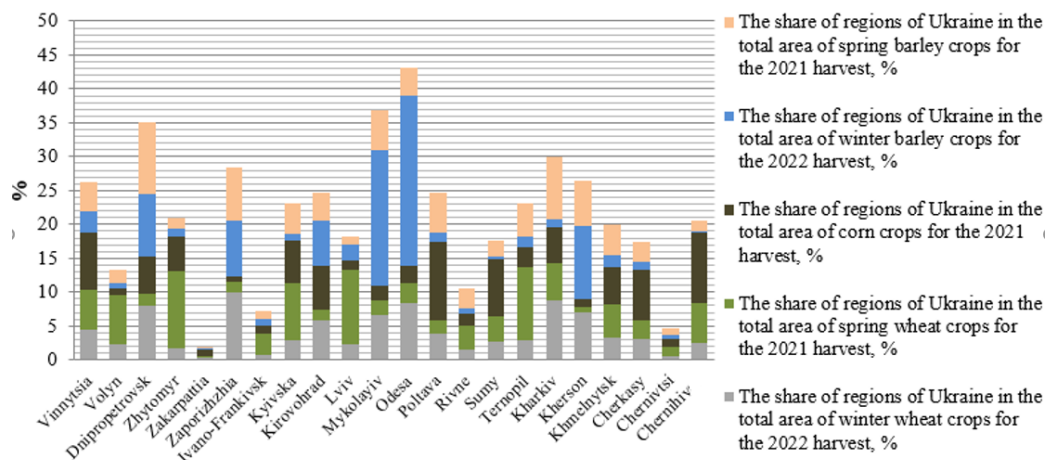

Figure 6.   The share of regions of Ukraine in the total area of crops of the grain group for the 2021 ÷ 2022 harvest
Rycina 6.   Udział obwodów Ukrainy w ogólnej powierzchni upraw grupy zbożowej na zbiory 2021 ÷ 2022)
Explanatory notes / Objaśnienia:
developed by the authors based on the data of MoEDT [28], FAO [11], SSSU [37]; opracowane przez autorów na podstawie danych MoEDT [28], FAO [11], SSSU [37]

The regional distribution of sown areas under the main crops shows that almost 51 % of the total sown area of the crop was sown with winter wheat for the 2022 harvest in the most dangerous areas. Therefore, the projected losses of areas under winter crops are so significant (Fig. 6).

In the regions of Ukraine in 2021, the share of spring wheat acreage was concentrated in dangerous areas, hence the loss of agricultural raw materials of this group is estimated at 30 %. However, there are prospects for expanding the area under spring wheat in relatively safe regions (Zhytomyr, Ternopil and Vinnytsia regions are among the TOP-6 regions of Ukraine in terms of the area planted with spring varieties with established production technology), where its average yield is traditionally observed.

In 2021, the area of corn crops between the regions of Ukraine was concentrated in dangerous areas (more than 36 % of the total area of crops of the grain group was sown). The Chernihiv, Sumy and Kyiv regions were the most important, where more than 25 % of corn crops were planted. In 2022, these leading regions left the logistics chain of corn supply to the European market. In addition, taking into account the low market incentives and the high energy intensity of the production of this crop in the relatively safe regions of Ukraine [1], there was no expansion of crops for this export agro-raw material, with the aim of compensating the areas unavailable for cultivation (Fig. 7).
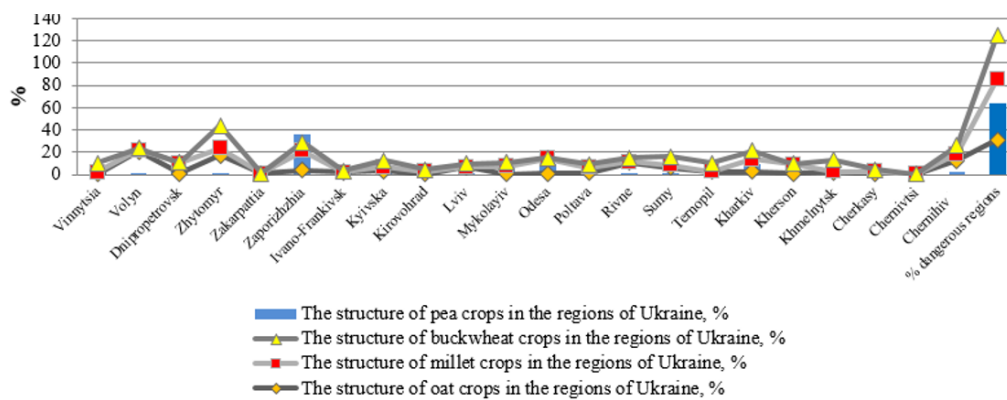

Figure 7.   The structure of grain crops and their total share in dangerous regions of Ukraine in 2022
Rycina 7.   Struktura upraw zbóż i ich łączny udział w niebezpiecznych rejonach Ukrainy w 2022 roku
Explanatory notes / Objaśnienia:
developed by the authors based on the data of MoEDT [28], FAO [11], SSSU [37]; opracowane przez autorów na podstawie danych MoEDT [28], FAO [11], SSSU [37]

In the agro-raw materials segment of both the domestic and European markets, a rather difficult situation with the supply of barley was observed. First, the distribution between winter and summer crops was formed in the ratio of 45 % to 55 %, respective-

ly; secondly, a significant share of winter and spring crops is located in dangerous regions. Thus, the total share of winter barley crops for the 2022 harvest in dangerous regions equaled almost 44 % of the total area. The share of spring crops in 2021 in these regions was almost 49 %. Moreover, crops are highly consolidated. It should be noted that from 2022, five of the TOP-6 regions of Ukraine for spring barley crops are currently unsafe, which is a significant limitation for ensuring the country's food security. The Poltava, Ternopil, Vinnytsia and Khmelnytskyi regions are potential regions of Ukraine where the expansion of this crop of the grain group is possible, in which a sufficiently high yield of spring barley is traditionally formed (Fig. 6).

In the agro-raw materials segment of both the domestic and European markets, cereal crops should be singled out, the increase in the sown areas of which can to some extent compensate for the expected reduction in crops such as corn and sunflower. However, in this agro-raw material segment of the market, a significant share of the area was also formed in dangerous regions of Ukraine, which cannot be used due to the military conflict with the aggressor country (Fig. 7).

It should be noted that in dangerous regions of Ukraine, 31.2 % of the agricultural land area was concentrated under oats, 51.1 % under millet, 39.6 % under buckwheat, and 63.9 % under peas. The largest part of oat production in $2019 \div 2021$ was concentrated in the North of Ukraine - in the Zhytomyr, Volyn, Chernihiv, Rivne and Sumy regions. In 2022, the loss of the harvest of this crop in the Sumy and Chernihiv regions, as a result of active hostilities, was compensated by the producers of agricultural production, due to the expansion of the sown areas under grain crops in the Khmelnytskyi, Poltava, Ternopil and Vinnytsia regions, where high yields were recorded in the past oats. The production of millet in Ukraine was increased due to the increase in its sown areas in the Khmelnytskyi, Vinnytsia, Cherkasy and Poltava regions, in which in $2019 \div 2021$ the highest yield was recorded – in the range of $32 \div 25$ quintals per hectare - with the average yield in Ukraine being equal to 19 quintals per hectare.

The losses of areas under buckwheat due to the impossibility of its production in the Sumy, Kyiv and Chernihiv regions were compensated by producers of agricultural production due to an increase in the area under this crop in the Khmelnytskyi, Rivne and Vinnytsia regions, in which high indicators were recorded in $2019 \div 2021$ productivity – at the level of $13.6 \div 16.4$ quintals per hectare. In general, in 2022, the sown area under dry crops was only 4.7 million hectares, which is 39 % less than in 2021 (7.7 million hectares) [25]. Compared to 2021, corn planting decreased by 43 % to 3.1 million hectares, spring barley by 27 % to 972.1 thousand hectares, spring wheat by 23 % to 147.3 thousand hectares. There was a significant reduction in the area sown under grain crops: oats – by 28 % (to 127.4 thousand hectares), buckwheat – by 41 % (to 49.4 thousand hectares), millet – by 24 % (to 59.4 thousand hectares), peas – by 51 % (up to 119.2 thousand hectares) [18].

Considering the new realities for Ukrainian producers in 2022, due to military actions, sunflower, like corn, will lose its strategic logistics chain on the European market. This is, first of all, due to a significant reduction in sunflower oil export volumes and the suspension of oil production enterprises. Thus, about 93 % of the total production volume of sunflower oil was exported to the European and world markets. At the moment, Ukrainian ports remain blocked, the export potential of this product has significantly decreased and, as a result, processing enterprises, adapting to new volumes of demand for oil, reduce processing volumes or "look closely" at the market for the feasibility of resuming work. Unfortunately, there is a high probability that the prices of one of the most high-margin crops of the last decade – sunflower – in 2023 may "drown" in the volume of supply that may be formed due to large residues and new crops.

Sunflower oil is an important product both for the Ukrainian market and for many countries on different continents. After the disruption of the logistics chain of sales of these products from Ukraine, the booming demand in the world will stimulate the expansion of areas under sunflower in key (after Ukraine) regions [22]. However, it will not be possible to completely replace Ukrainian sunflower oil since the volume of product deliveries from Ukraine is about half of all world exports for the season; it is physically impossible to compensate for such volumes in such a short period of time, therefore the demand for Ukrainian oil and sunflower will also be present on the European market, but with significant limited logistical difficulties.

At the same time, it is worth noting that there will be no significant change in the plans of commodity producers regarding sunflower cultivation. Most of the commodity producers bought the seed they needed even before the start of the war or paid and are waiting for delivery and do not intend to change their plans due to financial possibilities and other factors (crop rotation, proximity to the sales market, etc.). In addition, in the conditions of a shortage of seed material, the supply of sunflower seeds is the most widespread among the oil group, so real deliveries will be expected during the first decade of April 2023.

The situation in the temporarily occupied regions is different and even worse – where almost continuous hostilities are taking place. The situation changes every day and it is very difficult to predict where sunflower sowing can go through at least partially, and where it is completely dangerous to go into the field. As of the end of March 2023, a significant part of the hostilities in the country is concentrated in the Southern regions of cultivation of crops of the oil group (Mykolaiv, Kherson, Zaporizhzhya regions) and Eastern regions (Kharkiv, Donetsk and Luhansk regions).

The sown area under sunflower in Ukraine for the 2022 harvest will decrease to the minimum level and is about 4.2 million hectares (-38% by 2021) [25]. The cultivation of this culture in the Central and Western parts of the country is also at risk due to

logistical gaps following from the lack of economically active labor resources, as the significant number of people joined the Armed Forces of Ukraine. In 2022, sunflower production in Ukraine reached 9 million tons. This is enough to ensure food security and satisfy domestic needs for oil, as well as export products through current logistics routes to European countries. A significant decrease in the production of this agricultural raw material was partially compensated by significant residues of oil products from 2021, due to the closure of many factories and a decrease in processing volumes in 2022.

Given the above-mentioned factors, the total area of crops of the oil group was expected to decrease to about 6.8 ÷ 6.9 million hectares in 2022, taking into account the areas already sown under winter rapeseed (1.4 million hectares), equal to the level of 2010. The main share remained for sunflower – 61 % (73 % in 2021), while around 21 % and 17 % were occupied by rapeseed and soybeans, respectively (12 % and 15 % in 2021) (Fig. 8).
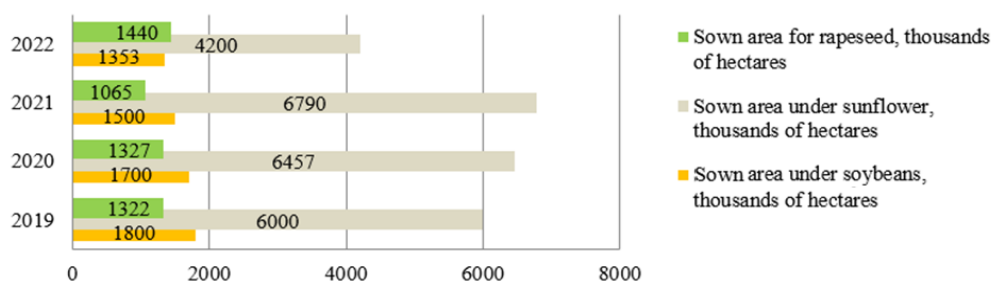

Figure 8. Area of oil crops in Ukraine for 2019 ÷ 2022 [thousand hectares]
Rycina 8. Powierzchnia upraw oleistych na Ukrainie w latach 2019 ÷ 2022 [tys. ha]
Explanatory notes / Objaśnienia:
developed by the authors based on the data of MoEDT [28], FAO [11], SSSU [37]; opracowane przez autorów na podstawie danych MoEDT [28], FAO [11], SSSU [37].

Soybean sowing area has slightly decreased, since the main areas for growing this crop are the Central and Western regions. It is impossible to use 20 % of the area for this culture in the occupied regions of Ukraine. From the point of view of the state's food security strategy, soy provides the livestock industry with protein feed, which in a critical situation can be replaced by sunflower meal or forage group of cereals, but only partially and not in all directions [26]. In 2022, the total area under soybean cultivation decreased by 11 % compared to 2021, and was equal to 1.2 million hectares.

In 2022, Ukrainian commodity producers sowed only 1.4 million hectares due to military measures; about 37 % of this area is located in regions with active hostilities, as a result of which a significant share of crops has been lost due to mines or other factors influencing military operations. Only 2 ÷ 3 % of the total area is sown with

spring varieties of rape, and this is 20 thousand hectares. Due to the reduction of the cultivation area, the yield of rapeseed in the overall production structure of the oil group in 2022 amounted to no more than 2.5 million tons, which is 21 % less than in 2021 and is the minimum level for the last four years (Fig. 9).
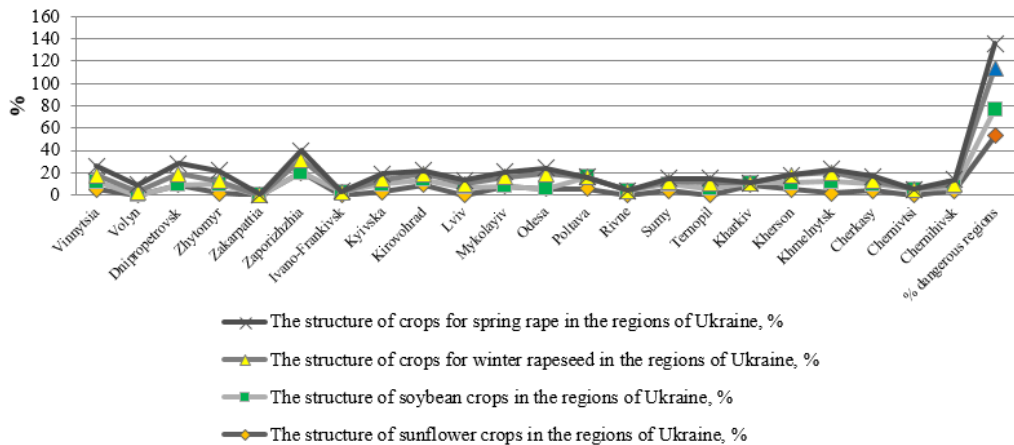

Figure 9.   The structure of oil crops and their total share in dangerous regions of Ukraine in 2022
Rycina 9.   Struktura upraw roślin oleistych i ich łączny udział w niebezpiecznych rejonach Ukrainy w 2022 roku

Explanatory notes / Objaśnienia:
developed by the authors based on the data of MoEDT [28], FAO [11], SSSU [37]; opracowane przez autorów na podstawie danych MoEDT [28], FAO [11], SSSU [37].

The modern degree of the development of food security of agricultural production and logistics of commodity producers of the grain and oil group is determined by innovativeness (use of innovative developments); self-organization (formation of organizational structures adequate to market dynamics); competence (development of those areas of activity in which subjects of agricultural raw materials have the greatest competitive advantages); virtuality and interaction (participation in various network structures, logistics chains, use of digital technologies).The ability to produce and deliver value to consumers, as a condition for achieving food security, is the basis of the model of four levels of value for the customer. The model of the structure of value for the client is built on the basis of the classical concept of the structure of the product (service), as well as the concept of four levels of the brand.

According to the concept of this model, it is possible to determine four levels of the cost of logistics center services in the process of ensuring the food security of commodity producers of the grain and oil group in modern markets (Fig. 10). These are: the core value level, the incremental value level, the customer service-enhanced value level and the relationship-based value level.

Level – 1	Level – 2	Level – 3	Level – 4
			The value of relationships in the market
		Extended cost of service (related services)	Extended cost of service (related services)
	The cost is additional	The cost is additional	The cost is additional
The price is basic	The price is basic	The price is basic	The price is basic

Figure 10. The levels of the cost of services of logistics intermediaries to ensure food security of producers of grain and oil products on the market

Rycina 10. Poziomy kosztów usług pośredników logistycznych zapewniających bezpieczeństwo żywnościowe producentów zbóż i produktów olejowych na rynku

Explanatory notes / Objaśnienia:

developed by the authors based on the data of Krykavskyi et al. [23]; opracowane przez autorów na podstawie danych Krykavskyi et al. [23].

The first level of food security cost of grain and oil group producers on the market is provided to logistics intermediaries when concluding contracts for the provision of services, at the current tariff rate (grain storage, unloading and loading of grain onto vehicles, weighing, conducting analyzes to determine grain characteristics). The second level of the cost of food security of commodity producers of the grain and oil group on the market is formed from additional value (additional services). Additional value is formed by services (drying, cleaning, threshing and calibration of raw materials of the grain and oil group), as well as service costs (advance payment, monthly, deferred payments, etc.), other costs (loss of time, inconvenience, negative emotions, irritation and inconvenience when receiving services).

The third level of the cost of food security of producers of grain and oil products on the market (related services) consists of services that accompany the sale – market monitoring of agro-raw materials of the grain and oil group, consulting, transportation, service, equipment rental, commodity lending (fuel and lubricant materials, fertilizers, etc.). These services are a source of additional values, as well as additional costs of commodity producers of the grain and oil group on the market. The fourth level of food security of commodity producers of the grain and oil group in the market is the costs associated between the commodity producers of the grain and oil group and logistics intermediaries in the distribution channels [23].

Examining the cost structure of the food security of producers of grain and oil products on the market through the prism of the differentiation of logistics chains with growing needs for resource provision allows us to single out high competitive advantages of the commercialization of innovative ideas in the integrated models of strategic networks, which simultaneously focus on the internal characteristics of the reproduc-

tion process in the agro-raw material segment of the state market and its connection with the European market [41].

The reproductive process of logistics chains in the agro-raw materials segment of the European market should be carried out through the potential of the food system (PPS) of agricultural producers, which ensures the stability of the food security of the state (region or rural areas), and which, by its very nature, has a dynamic-cyclical nature, the duration of which is at least a year [39]. Depending on strategic programs for the development of agriculture, the process of long-term (continuous) reproduction of logistics chains in the agro-raw material segment of the world market is foreseen. At the same time, PPP restoration depends not only on the quantitative and qualitative properties of the resource component of food security, but also on its level in space and time. Taking into account the above, the process of the reproduction of the PPS of commodity producers of the grain and oil group is presented in the logistics chains of the agro-raw material segment of the European market, presented in Figure 11.

Thus, from the position of the past period, the potential of the food system of commodity producers of the grain and oil group is determined by the totality of resources mobilized by the subjects of the agro-raw material segment on the European market and is characterized as achieved (PFS1). Depending on the areas of potential use, namely: simple or extended reproduction of the food system of commodity producers, logistics chains in the agro-raw material segment of the world market enable the distribution, exchange and use of resources; resources used in the past activate reserves to determine the current level of the potential of the food system (PFS2). According to the specific characteristics, it is the available (actual) potential of the food system of commodity producers of the grain and oil group. At the same time, the current potential of the food system can be reproduced both at the already achieved level, or below it (PFS2 ≤ PFS1), and at a higher level (PFS2 > PFS1).

The state regulation of the potential of the food system of commodity producers of the grain and oil group allows for ensuring the guarantees of the budgetary financing of economic activities with time limits to determine their potential state of economic growth and break-even development in order to eliminate the shortcomings of the current procedure for the selection of alternative innovative developments of agricultural production, for the cultivation of products of the grain and oil group , the implementation of which is carried out through logistics centers according to the norms and rules of the customs policy of various countries of the world. This allows forpredicting the expected effect from the sale of products, without losing interested parties in the reproduction of agricultural production.

Therefore, it is advisable to define the future state of the potential of the food system of commodity producers of the grain and oil group as prospective (PFS3 > PFS2 > PFS1), that is, one that is oriented towards achieving a higher level. However, as alrea-

dy noted, depending on the conditions and results of the logistics chains in the agro-raw materials segment of the world market, the functioning of commodity producers of the grain and oil group in the previous periods may lead to a change in the state of the potential of the food system in the future and characterize this process as a simple reproduction of resource provision (PFS3 $\leq$ PFS1).
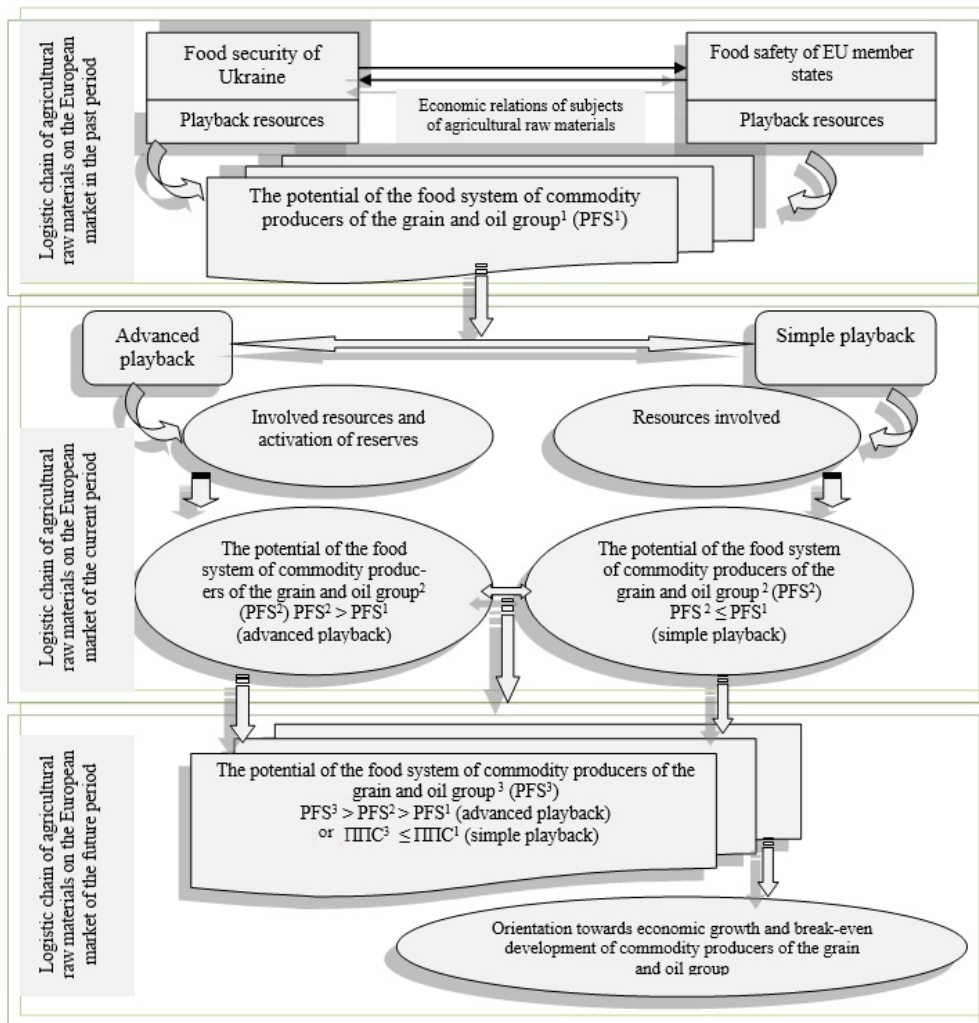

Figure 11. The restoration of agricultural and raw material potential: logistics chains of grain and oil producers in the European food system

Rycina 11. Odbudowa potencjału rolno-surowcowego: łańcuchy logistyczne producentów zbóż i oleju w europejskim systemie żywnościowym

Explanatory notes / Objaśnienia:

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Summarizing the above, we note that the resource component of the state's food security implies the presence of potential reserves, the use of which is impossible without an optimal combination of the forms of attracting resources into the food system of commodity producers of the grain and oil group (self-financing, lending and budget financing). This makes it necessary to carry out a study on the methodology of assessing the sustainability of the potential of break-even development, determining its optimal level for stabilizing the functioning and economic growth of commodity producers.

The logistics chain of agricultural raw materials of Ukraine on the European market in 2022 depended on the following factors: the development of the situation in the country due to the deployment of terrorist and military aggression by Russia; the intensification of hostilities in the Southern, Eastern and Northern regions and constant change of front lines; the mining of a large part of territories, including agricultural land; logistical gaps in the transportation of agricultural raw materials (destroyed roads and a shortage of fuel and drivers, as a result of which the delivery of seeds to commodity producers was significantly complicated; financing – many commodity producers of the grain and oil group expected to sell stocks of grain or oil crops in the spring before sowing to replenish circulating resources. This issue is particularly acute in the regions which are close to the front line, where trade is very weak; the availability of resources – not being able to prepare properly and taking into account logistical problems, commodity producers use resources available in their region [40].

The analysis of the supply of resources showed that there is a shortage of seed supply in the regions. This issue is the most critical for the production of corn and sunflower, where the share of imported seeds in the total seed fund was formed at the level of $15 \div 20$ % for corn and at the level of $50 \div 60$ % for sunflower seeds. At the same time, active import is carried out every year between October and April, and mainly from EU countries. According to the data of the customs service, in the third quarter of 2022, 20.6 thousand tons of corn seeds were imported into Ukraine, which is 85 % more than the volume of imports in 2021 (11.2 thousand tons). That is, the corn seeds imported in 2021 accounted for more than 12 % of the projected volume of the seed fund.

Taking into account the expected reduction in the area of corn for the 2022 harvest, the share of imported seeds only from October to February reached 28 % of the total volume of the seed fund. Thus, this trend demonstrates a high level of supply of imported seeds, but the issue of logistical delivery of ordered batches of corn seeds to Ukrainian producers, which are under constant fire from the terrorist country, remains open. The volume of sunflower seed imports between October and February 2022 amounted to 14.1 thousand tons, which almost corresponds to the level of 2021 (14.3

thousand tons). Given the reduction of areas under sunflower, even these volumes already cover more than 67 % of the need for seeds of this crop.

In addition, it should be noted once again that both corn and sunflower seeds are supplied mainly from EU countries, and, in the presence of a stable land connection, the volume of logistics deliveries can be increased until the end of the sowing season. Moreover, European companies have announced the possibility of assistance in obtaining seed material for Ukrainian producers. At the same time, only 18 % of commodity producers have not fully formed their seed fund and need help with providing this resource [19]. Thus, more than 80 % of farmers in relatively safe regions are provided with seeds, and the existing problems are mostly caused by complicated internal logistics.

The sufficiency of grain stocks in state resources (the ratio between the amount of food grain in the state food reserve and the amount of domestic consumption of bread and bread products by the population in terms of grain) has a threshold criterion of 17 % (Fig. 12).
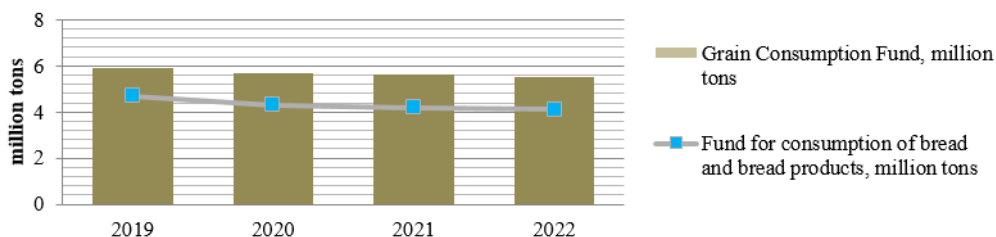

Figure 12. The volume of grain reserves in state resources of Ukraine for 2019 ÷ 2022
Rycina 12. Wielkość zapasów zbóż w zasobach państwowych Ukrainy na lata 2019 ÷ 2022
Explanatory notes / Objaśnienia:
developed by the authors based on the data of MoEDT [28], FAO [11], SSSU [37]; opracowane przez autorów na podstawie danych MoEDT [28], FAO [11], SSSU [37].

The deepening of the free trade zone of Ukraine with EU countries has a duration from 2016 to 2026 and is based on mandatory processes of convergence of the international business environment with different levels of state stimulation of the export-oriented domestic market with products of the grain and oil group in accordance with current rules and regulations [42]. This is manifested by access to markets without customs restrictions within the framework of tariff quotas when importing Ukrainian products of the grain and oil group to EU member states. The tariff quota for trade with EU countries is calculated by canceling 83.1 % of tariff lines in the process of export to their territory and 35.2 % of tariff lines when importing European products to the territory of Ukraine. That is, Ukrainian agricultural producers have been given the opportunity to adapt to highly competitive European markets [27]. Thus, according to the

agreement with the EU, Ukrainian exporters can import products of the grain and oil group to Community countries within the established tariff quotas without paying import duties. The dynamics of permissible volumes of duty-free exports and their possible increase are presented in Figure 13.

Despite the critical situation provoked by the aggressor country in the food security of the country, Ukrainian producers fulfill their obligations to ensure the sustainable potential of the food system, which is integrated into the synergized logistics supply chains of high-quality agro-raw materials of the grain and oil group on the European market.
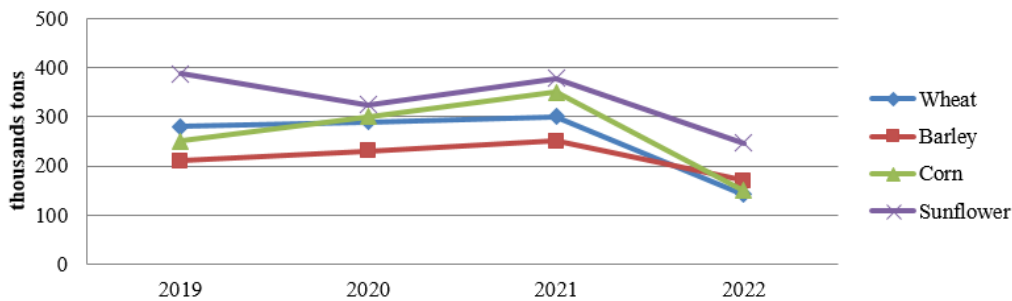

Figure 13. The dynamics of permissible volumes of duty-free exports and their possible increase
Rycina 13. Dynamika dopuszczalnych wolumenów bezcłowego eksportu i ich możliwy wzrost
Explanatory notes / Objaśnienia:
developed by the authors based on the data of the Committee on World Food Security [8], Global Survey Hub [12], International Fund for Agricultural Development [18], MoEDT [28], SSSU [37]; opracowane przez autorów na podstawie danych Committee on World Food Security [8], Global Survey Hub [12], International Fund for Agricultural Development [18], MoEDT [28], SSSU [37].

Foreign trade in Ukrainian agricultural raw materials of the grain and oil group in 2022 made it possible to partially balance the supply of strategic products and increase exports by 9.5 %, imports by 20.5 % due to the convergence of the international business environment, with an equal partnership with an export-oriented direction, such as the European market, and to the domestic market (Fig. 14).

The majority of the export of agricultural raw materials comprises the volume of production of wheat – 40.5 %, corn – 52.8 %, sunflower – 40.4 %, soybean – 36.4 %. The Top 5 European countries in terms of exports of Ukrainian agricultural raw materials include: Poland – EUR 3.99 billion, Italy – EUR 2.49 billion, Germany – EUR 2.03 billion, Romania and the Czech Republic – EUR 1.13 billion. The largest share of the import of agricultural raw materials to Ukraine was sent from Germany – for EUR 4.52 billion, from Poland – for EUR 3.54 billion, from Italy – for EUR 1.78 billion, from France – for EUR 1.28 billion, from Hungary – for EUR 1.22 billion and from the Czech Republic – for EUR 1.01 billion.
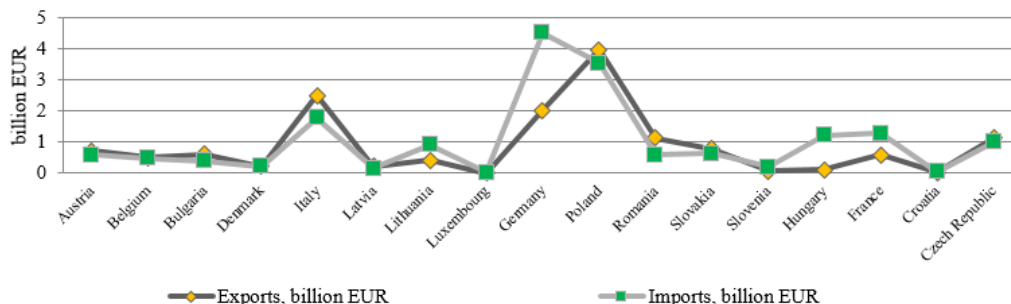
Figure 14. The tariff quotas of Ukraine on the volume of duty-free export of products of the grain and oil group in 2022

Rycina 14. Kontyngenty taryfowe Ukrainy dotyczące wielkości bezcłowego eksportu produktów grupy zbożowo-olejowej w 2022 r.

Explanatory notes / Objaśnienia:

developed by the authors based on the data Committee on World Food Security [8], Global Survey Hub [12], International Fund for Agricultural Development [18], MoEDT [28], SSSU [37]; opracowane przez autorów na podstawie danych Committee on World Food Security [8], Global Survey Hub [12], International Fund for Agricultural Development [18], MoEDT [28], SSSU [37].
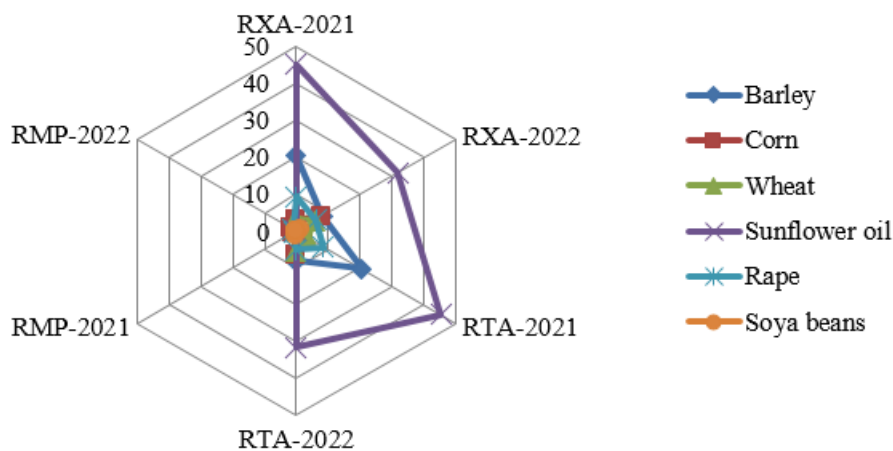

Figure 15. The sustainability assessment of Ukrainian agricultural producers' food system in logistics supply chains for grain and oil exports to the European market

Rycina 15. Ocena zrównoważonego rozwoju systemu żywnościowego ukraińskich producentów rolnych w logistycznych łańcuchach dostaw eksportu zbóż i oleju na rynek europejski

Explanatory notes / Objaśnienia:

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Using the index of export competitiveness (RXA), the index of dependence of the country's food security on imports (RMP) and the index of relative trade advantages (RTA), the level of sustainability of the food system of commodity producers in the

logistics supply chains of export-oriented types of products of the grain and oil group (wheat, barley, corn) was determined , sunflower oil, rapeseed, soybeans) on the European market [6, 10]. Preference indices for 2021 ÷ 2022 are presented in Figure 15.

Thus, during the studied period, the RTA index shows that the most competitive types of products are: sunflower oil, which in 2022 had a relative trade advantage of 31.6, barley – 8.0, and corn – 6.4. However, for the period of 2021 ÷ 2022, a downward trend of the RTA index is observed, in particular for barley – a decrease by two-and-a-half times, for rapeseed – by 40.6 %, for sunflower oil – by almost one-and-a-half times.

Discussion

The key characteristic of food security is the availability, possibility, stability and use of the food system, which largely depends not only on the growth of agricultural production, but also on trade policy, the development of trade relations in the agricultural raw material markets, which can strengthen these characteristics, ensuring they reach positive levels. Food security includes the production aspect (due to the development of own production, and only then – the necessary volume of import of agricultural products and food [34]. The food security of the state should be focused on ensuring its own agro-economic capacities, without resorting to the import of food from other countries. It is a criterion for the quality of strategic products of agricultural production, a guarantee of completeness, nutrition and availability of products of the grain and oil group in sufficient quantity at the level of justified medical standards.

The state's position on ensuring food security is focused on the ability of producers to independently provide themselves with the necessary volume and range of agricultural products. Accordingly, the achievement of food security involves taking the following main directions:
1) maintenance of food supply at a level sufficient for healthy nutrition;
2) ensuring the appropriate level of the population's supporting demand;
3) eliminating dependence on imports and protecting the interests of domestic producers of agricultural raw materials [43].

The problem of food security of the state in theagricultural raw material market is complex, hence its solution should be considered from the point of view of different hierarchical levels [2]. The basis for distinguishing and classifying such levels can be considered the specific interests of a separate group of subjects of each specific level. The national level of food security of the agrarian sector and the decision to achieve it are presented by the governments of the countries that create the sustainable potential of the country's food system and determine the directions for improving the quality of products of the grain and oil group [4]. The specifics of ensuring food security at the

national level are determined by the difference in economic and political interests of countries.

Thus, countries with the most developed agricultural production have natural advantages in the production of agricultural products. However, countries with less favorable natural conditions for agricultural production are limited by agricultural production resources or emerging markets. The concept of food security at the national level does not mean self-sufficiency in food. It assumes that a country should produce enough products for its own needs, but if comparative advantages do not contribute to this, then it should be able to import the necessary amount of food to meet the needs of the population [38].

The main characteristics of the food system at the national level should be considered to be the following [36]:

1) the ability to produce, import, provide storage and promote to the final consumer of the food product in the volumes necessary to meet the regulatory needs of all social groups of the population;

2) the equality of population groups in the possibility of purchasing balanced food products of high quality;

3) the adaptability of the national food system to fluctuations in the global market situation;

4) stable supply of food to the population of all regions of the country regardless of the influence of natural conditions;

5) the balanced development of the national market in the mode of extended reproduction.

Ensuring food security by commodity producers at the regional level is a necessary, but not sufficient, condition for ensuring a sustainable food system. It includes the ability of countries in general and individual households to obtain or produce the necessary food products. Maintaining food security depends on a macroeconomic policy and is aimed at ensuring effective demand for food products, reducing population stratification by an income level [31].

In our opinion, the division of food security by levels is an important component of the effective functioning of the food system as a whole: ensuring global food security requires the efforts of the entire world community, the national level – a balanced state policy, the regional level is ensured by local authorities and local food producers. Therefore, if at the national and regional level a person is the object of food security, then at the local level it requires the use of various tools and mechanisms to achieve the desired state of food security [13].

Balancing the quantitative and qualitative parameters of the production of agricultural products, determining the criteria of the domestic market situation at the local level allows for ensuring the food security of the territories where the producers of

grain and oil products are located. The growth of consumer demand leads to an increase in the potential of the food system, which determines the favorable cycle of the logistics chain of grain and oil products. It is worth noting that in the food system, agricultural producers ensure the reproductive process of the territories and support the food security of the region (country) as a whole. This approach expands the range of products of the grain and oil group according to the scale of its consumption, while differentiating the price policy and within the regional market, stimulating international trade and the export of agricultural products. This is confirmed by Kotykova et al. [21], who emphasize that for the highest guarantee of the food security of the state, with a stable potential of the food system, agricultural producers in the logistics chain organize, plan and forecast services for the transportation of products of the grain and oil group to the market at affordable prices. This contributes to long-term agreements for the supply of agricultural raw materials to the countries of the world on mutually beneficial terms.

As Grigriev [14] notes, the process of reproducing the potential of the food system of commodity producers of agricultural production in the logistics chain covers all stages of distribution, exchange and use of resource provision and is a complex form of economic circulation of resources between industries. The material, value and monetary forms of the produced products of the grain and oil group intertwine, change from one form to another and are inextricably interconnected. The rate of increase in the production of grain and oil group products with the improvement of the quality of their range, in the general reproductive turnover of logistics chains, is determined by the economic determinant in the food security strategy of the state, which is formed by producers of agricultural production under the influence of a complex of regulatory factors of resource provision.

The latter is a more important methodological principle, which does not lose its relevance even now, because in modern conditions, as noted by Grishova and Kryukova [15], the main task of the food security of the state is the fundamental reorientation of agriculture to the accelerated rate of economic and break-even growth of commodity producers in the logistics chains of the agro-raw material segment on the European market. Only under this condition can one count on the process of reproducing the potential of the food system of commodity producers in logistics chains based on the quantitative and qualitative resource component of the simple or extended reproduction of the break-even development cycles of agricultural raw material entities. They are caused by innovations in the production technology of grain and oil products, the acceleration of the financial cycle in certain stages of expanded reproduction of resources, both on the national and European markets.

The restoration of the quantitative and qualitative resource component of the state's food security on the basis of the implementation of the amplitude of the possibili-

ties of the food system of commodity producers of the grain and oil group activates the available reserves of logistics chains in order to take strategic directions for the loss-free development of agro-raw materials subjects in the international business environment. This process makes it possible to have a stimulating effect on the growth of capital investments, the accumulation of productive capital in objects of technological innovation with the aim of obtaining profit and (or) achieving a positive effect [20].

Conclusions

1. Thus, in order to expand the agricultural production capacities of commodity producers to ensure the food security of Ukraine on the European market of grain and oil group, it is necessary to improve the system of ensuring the foreign economic activity of subjects of agricultural raw materials on the basis of the integration of logistics chains into the international integrated network of the food system, which creates competitive advantages and is oriented towards foreign consumers, taking into account that the results of the sale of agricultural raw materials can be appropriated not by agricultural producers, but by subjects of the sphere of circulation, exporting enterprises, intermediaries. The development of Ukrainian food and logistics chains in the European market of the grain and oil group should be based on the strategy of increasing the export capabilities of agricultural producers and be carried out in systematic interaction with the economic interests of the subjects of the supply of agricultural raw materials in the circulation of export products.

2. Along with the possibilities of agricultural producers' foreign economic activity on the European market, there is a need for the ensured liberalization of foreign trade between countries in the international business environment. This may increase competition between European and Ukrainian producers of grain and oil products. Therefore, it is necessary to develop a strategic model for ensuring food security between regions, taking into account their inability to fully restore the food system due to military operations in a large area of the country. The state regulation of the potential of the food system in the regions should be carried out in the following directions:

    − in the field of international trade in agricultural raw materials – ensuring the protection of the economic interests of producers of agricultural products through the implementation of a complex of customs-tariff and non-tariff measures in line with Ukraine's international obligations; the development of import substitution measures to guarantee the food independence of the region;

    − in the economic sphere – to introduce a guaranteed policy of financial support for the producers of agricultural products; to develop the regional food market with improved logistical and infrastructural support and establishment of inter-

regional trade relations; the implementation of the price policy for agro-raw products and having control over its implementation.

3. At the same time, the intensification of foreign economic processes in the state should move to a new doctrine of the innovation of production and technological standards of regional development, with the strengthening of food security in the agrarian sphere, subject to the introduction of an integrated regional system of agriculture. This will have a positive effect on the sustainability of the potential of the food system in the state, will ensure the greening of agricultural raw materials, and will also allow for shaping a new behavior of commodity producers to ensure their own food security, by stimulating cooperation with other consumers, with the aim of finding a reliable supplier of seeds of the grain and oil group and careful planning of diversification of production. In addition, an effective state food policy should determine the safety parameters of agricultural raw materials, their economic availability, reliability and resistance to external barriers and restrictions, both according to national and European standards for ensuring food security; coordinate them with the main macroeconomic parameters of the country's development and be responsible for the implementation of the state agrarian policy.

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UWARUNKOWANIA ZAPEWNIENIA BEZPIECZEŃSTWA ŻYWNOŚCIOWEGO PRZEZ PRODUCENTÓW GRUPY ZBOŻOWO-OLEJOWEJ UKRAINY NA RYNKU EUROPEJSKIM

S t r e s z c z e n i e

Wprowadzenie. W artykule opracowano kierunki bezpieczeństwa żywnościowego Ukrainy, które w oparciu o zasady zrównoważonego rozwoju producentów rolnych zapewniają stabilność ich systemu żywnościowego, który jest zintegrowany w synergiczne łańcuchy logistyczne dostaw wysokiej jakości surowców rolnych grupy zbóż i olejów na rynku europejskim. Wyróżniono metody diagnozowania stanu bezpieczeństwa żywnościowego państwa (obszaru lub regionu wiejskiego) poprzez komponent zasobowy reprodukcji prostej lub rozszerzonej systemu żywnościowego producentów rolnych.

Wyniki i wnioski. W celu usprawnienia prognozowania wskaźników procesu technologicznego wytwarzania (sprzedaży) produktów zidentyfikowano modele matematyczne outsourcingu (usług transportowych producentów towarów z grupy zbóż i olejów). Ukształtował się proces odtwarzania potencjału systemu żywnościowego producentów towarowych grupy zbóż i olejów w łańcuchach logistycznych segmentu rolno-surowcowego rynku europejskiego. Dokonano analizy porównawczej produkcji i sprzeda-

ży producentów surowców z grupy zbóż i oleju na rynku ukraińskim i europejskim, a także oszacowano wielkość zapasów zbóż znajdujących się w zasobach państwowych Ukrainy.

Słowa kluczowe: rynek zbóż i roślin oleistych, łańcuchy logistyczne, produkcja rolna, eksport, import ◙