

10.31653/smf44.2022. 5-19

Zinchenko S.¹, Fomin O.², Bordun T.³, Zinchenko H.⁴

¹–Register of Shipping of Ukraine,

²– State University of infrastructure and technologies,

³ – Odesa National University of technologies,

⁴ – Kyiv Polytechnic Institute

ANALYSIS OF THE TRANSSHIPMENT OF GRAIN AND FEED PRODUCTS THROUGH THE SEAPORTS OF UKRAINE IN SPECIAL CONDITIONS

Statement of the problem in general. In modern conditions, the market needs changes in the logistics of food supplies (feed and grain) based on an assessment of the capabilities of producers, ports and other types of transport. In addition, the elevator capacity within the country should allow the necessary reserves to be accumulated.

If we estimate the export potential of agricultural enterprises located in a 300-kilometer zone, from where grain can be efficiently delivered by road transport to the ports of the Sea of Azov (Mariupol and Berdyansk), it amounts to 3.2...3.5 million tons [1]. For the period from July 2020 to May 2021, grain exports (excluding processed products) from Mariupol and Berdyansk amounted to 2.3 million tons through the ports of the Sea of Azov, including the Mariupol port [2].

Analysis of recent researches and publications. According to the State Statistics Service, in 2019 the production of feed (excluding premixes) in Ukraine amounted to 6348.6 thousand tons. This result is the lowest in the last six years, if in 2013 it was 6751.4 thousand tons, then by 2019 decreased by 6 % or 402.7 thousand tons. During this period, there were only 2 years (2014 – 6826.8 thousand tons and 2018 – 6632.7 thousand tons) when production showed an increase in the total volume to him (Fig. 1).

Over 6 years, the production of finished feed for pigs (20 %) and cattle (21 %) decreased by a fifth, and by 2019 it amounted to 1107.2 thousand tons and 566.1 thousand tons, respectively. The production of fodder not included in other categories decreased by almost half (by 44%) – 452.5 thousand tons in 2019. And only fodder for poultry showed a growth of 10 % over six years, and in 2019 it amounted to 4,222. 8 thousand tons. According to the Alltech Global Feed Survey, in 2020 the production of feed in the world decreased by another 1.07 %, to 1.13 billion tons [3]. African swine fever (ASF) and a reduction in pig feed in the Asia-Pacific region are cited as the main cause. The nine lead-

ing fodder producing countries are the USA, China, Brazil, India, Mexico, Spain, Japan and Germany [4-7].

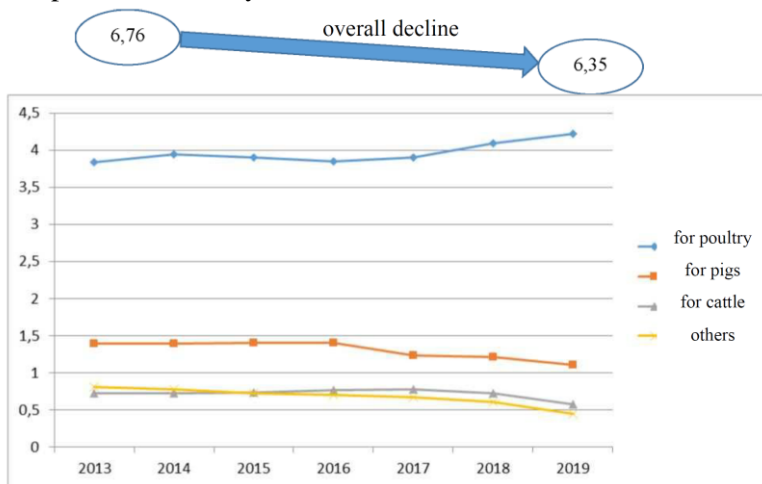


Fig. 1. Dynamics of compound feed production in Ukraine for 7 years, mln. tons

The USA is the largest fodder-producing country in the world, producing 214 million tons of products. It is mainly feed for cattle (61.09 million tons), poultry (48.53 million tons) and pigs (44.86 million tons).

In the region of Latin America, the growth was 2.2 %, up to 167.9 million tons. Brazil remains the leader in the production of fodder in the region and ranks third among world producers. The main types of production are fodder for poultry (32.1 million tons) and pigs (17.0 million tons). The top three, Brazil, Mexico and Argentina, continue to produce the majority of feed in Latin America and account for 76 % of regional production.

Europe remains a relatively sluggish region with a slight increase of 0.2 % compared to 2019. The top three feed producers in Europe include Russia (40.5 million tons), Spain (34.8 million tons) and Germany (25.0 million tons). At the same time, the production of fodder for pigs leads in all three countries.

In 2019, feed production in the Asia-Pacific region fell by 5.5 %, mainly due to African swine fever and a significant reduction in pig feed production. In China, fodder production decreased by almost 20 million tons, to 167.9 million tons.

Africa continues its strong growth with a 7.5 % increase in production, with all major species showing positive growth. The top five feed producing countries in the region account for 75 % of feed production in Africa and are South Africa, Egypt, Nigeria, Morocco and Algeria.

Poultry feed remains the number one product on the Ukrainian market. In 2019, its share is 67 %, which is explained by both the development of the Ukrainian poultry market and the growth of poultry meat consumption. Fodder for pigs occupies 17 %, cattle – only 9 %. Mostly, the main producers of compound feed in Ukraine are large agro-industrial vertically integrated holdings. The TOP-10 companies produce almost 60 % of all compound feed in the country [8].

It is impossible to save all the harvest in the country. Almost half of the agricultural products produced in Ukraine are export potential, which must now be realized in order to prevent hunger in the world and ensure the inflow of foreign currency to Ukraine. Therefore, with the help of the UN and Turkey, "grain corridors" through the Black Sea ports are open and functioning.

The main domestic manufacturers of compound feed are presented in Fig. 2.

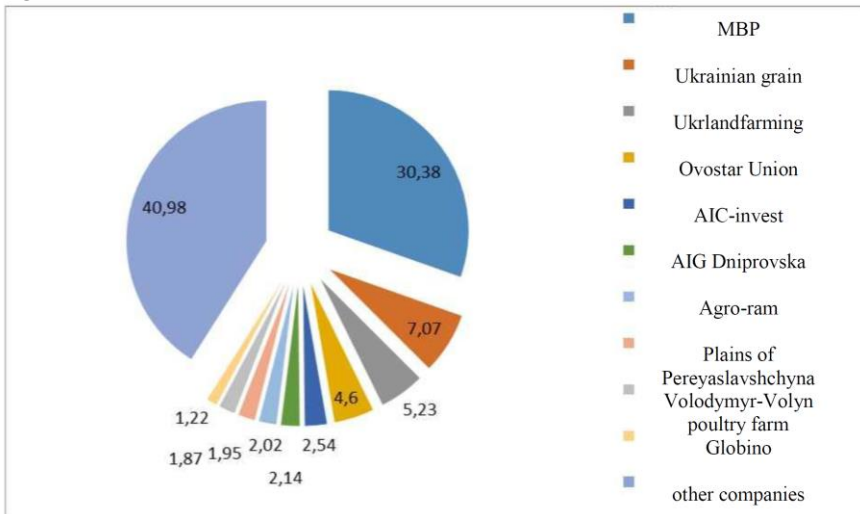


Fig. 2. Distribution of the feed market among companies in Ukraine, %

The top 10 feed producing countries in the world in 2020 according to the Alltech version [3] look like this (Fig. 3):

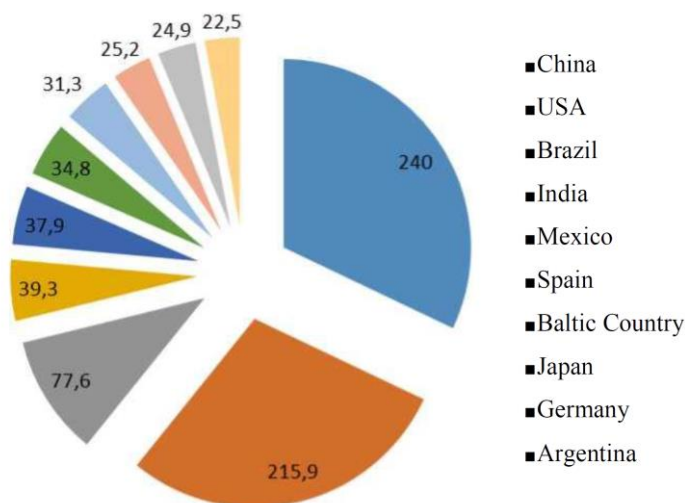


Fig. 3. Distribution of the world compound feed market in 2020, million tons

In the modern conditions of socio-economic development of the agro-industrial complex of Ukraine, the feed industry occupies a special place. The production of compound feed is an intermediate link in the production chain: supplier of raw materials (agricultural enterprises, farms) – processor (compound feed enterprises) – consumer (poultry and livestock complexes). Therefore, the compound feed industry is one of the foundations of providing the population with meat products. The underestimation of the importance of the compound feed industry and the decline of the entire agro-industrial complex of Ukraine for 90 years of XX century had a negative impact on the economic efficiency of the compound feed industry, the destruction of the industry's capacities, a decrease in production volumes, reorientation to other types of activities, bankruptcy and the closure of most enterprises.

Therefore, research and the search for ways to increase the economic efficiency of the functioning of feed industry enterprises are particularly relevant today. There is a growing need to apply a comprehensive approach to the formation of new mobile small and efficient enterprises engaged in the production of compound feed. During the last ten years, the agro-industrial complex was engulfed by crisis phenomena. They were the most destructive in animal husbandry and the industries that provide it, fodder production and in the production of compound feed. Low-quality compound feed: grain components make up more than 70 % on average, which is much higher than the recommendations of EU standards.

The development of the compound feed industry is an integral condition for raising domestic animal husbandry to the level of competitiveness of economically developed countries. Increasing production efficiency is an economic consequence of the process of continuous improvement of production factors, the source of which can be both intensive and extensive factors of the reproduction process. Based on the fact that the combination and interrelationship of the main components, reserves, directions and factors of increasing the efficiency of the development of the feed industry can be considered as ways of its growth, we note that the growth of the final production results should be achieved by increasing its main factors and increasing their return. The compound feed market has changed significantly: many new companies have appeared recently. Fierce competition in the market has a positive effect. The main stimulating factor today is "price-quality" [9].

According to experts, the growth of fodder production will be adequate to the growth of animal husbandry needs. And their deficiency will still be covered by the import of feed components. In modern conditions, fodder producers need to find any form of integration with livestock complexes. This is explained by the fact that the mass share of compound feed consumed in the country falls on agricultural complexes. Feeding with compound feed is economically beneficial for them. Speaking about the prospects of domestic fodder production, it is worth noting that in many respects the industry depends on state support: effective subsidies, effective lending rates, and risk insurance in animal husbandry.

The development of the enterprise development strategy should be based on the economic assessment of the production activity of business entities. In the conditions of an ever-increasing shortage of resources (especially energy) and an incredible increase in their cost, it is necessary to take into account the effect of the release of resources. In addition, it is advisable to use the level of risk based on the estimate of the break-even volume of sales as the main evaluation criterion for the formation of a favourable ratio of the cost to the sale price. The economic mechanism of enterprises must develop continuously, smoothly and without sudden changes.

There is considerable competition in the regional market for transshipment of grain and oil cargo, some of whose players use not always honest methods in their work. In Ukraine, Mykolaiv ports, elevators of the Nibulon company in the Zaporizhia region, and river terminals in the

Dnipropetrovsk and Zaporizhia regions take on large volumes of grain cargo [10].

As for the European compound feed market, it should be noted that the share of grain crops in the total amount of raw materials is about 50 % (in Ukraine, 65...70 %). Thus, according to Toepfer International, about 80 million tons of European fodder grain were used for the production of compound feed. The main producers of compound feed products on the European market are: France – 15 % of the total output, Germany – 14.5 %, Spain – 13.2 % [11].

Europe is the second largest compound feed market in the world. The total volume of feed production in Europe in 2019, according to the Al-etch global survey, amounted to 249.4 million tons, and in the Asia-Pacific region – 367.6 million tons. In total, the countries of the European Union (EU) produced 153.4 million tons of fodder, and the rest (96 million) by countries that are not part of the EU-28, including Baltic Country (29 million) and Turkey (19 million) [3].

Considering the size of the livestock and animal feed sector, the EU is the second largest feed consumer after China and far ahead of the US and Brazil. Grains make up the majority of feed in the EU, accounting for around 70 %, followed by oilseeds around 25 %. The EU accounts for 18 % of all feed grain used worldwide, and although the volume of feed grain in the EU has slightly increased over the past 10 years, other regions have shown higher growth rates [12].

According to Strategyie Grains estimates, about 60 % (166 million tons) of grain was used for feed in the EU in 2019/20. The rest was fed directly on farms.

Over the past four years, the amount of wheat used in feed has increased from 45 million tonnes in 2016/17 to 54 million tonnes in 2019/20, with the majority of wheat grown in the EU.

In addition to cereals, 56 million tons of oilseeds are used for feed in the EU, which makes the EU the second largest consumer of oilseeds in the world after China.

The amount of oilseed meal and meal consumed in the EU increased by 1 % per year during the last five years. However, other countries such as China (+3 %) and the US (+2 %) showed stronger growth.

Soy flour, cake and meal make up 58 % of all oil products used in the EU. Soybean production in the EU has doubled over the past four years to 2.4 million tonnes, but this is enough to meet only 5 % of soybean meal needs. In 2019/20, the EU imported 21 million tonnes of soybean meal, of

which 60 % came from Argentina, 33 % from Brazil, 5 % from Paraguay, and the rest from the USA, India and China.

In addition, almost 13.5 million tonnes of soybeans are imported and processed in the EU, with around 50 % coming from Brazil and almost 30 % from the US.

The production of rapeseed in the EU decreased, therefore the import of agricultural products increased, exceeding 4 million tons in 2016/17 (+20 %). At the same time, in 2019/20, the total consumption of rapeseed decreased in favour of rapeseed meal – 13 million tons.

The European animal feed industry also buys 2.5 million tons of palm oil from Malaysia, less than 500 thousand tons of fish, flax and cotton meal, as well as 3 million tons of gluten, a by-product from the wet grinding of corn for the starch industry, and another 3.5 million tons of distiller's dry grains from the ethanol industry.

In recent years, the volume of purchases of protein mixtures by the EU has increased and is increasing its share. In 2019/20, about 2.2 million tons of them were used, which is 1.8 million tons more than the year before [11, 12].

The Guardian notes that according to the Food and Agriculture Organization of the United Nations (FAO), wheat production in the European Union is expected to fall by millions of tonnes compared to last year, with far greater losses in the south of Europe than the north. Agricultural production in France has been severely affected – losses of more than 20 % of the grain harvest are expected. Italy could lose 13 % of wheat, and Great Britain – 12 %. Across the EU, wheat production is forecast to decrease by 10 million tons, or about 10 %. In 2022, Ukraine will lose its crops by 30...50 % due to the war [13].

"Everything that is raw material costs two or three times more than it did a year and a half ago," warned Rafael Neves, administrator of Ovopor, a Milagres company in the municipality of Leiria, which, in addition to egg production, produces animal feed. The administrator of the company since its foundation in 1984, Rafael Neves, watches with some disbelief the "crazy expenses" that are fixed from 2021.

If at the end of 2020 the price of grain, namely corn, was about 180 euros per ton, then a year later it was already at the level of "200 and many, almost 300 €", the increase is explained by the increase in demand for due to the easing of restrictions, imposed by the pandemic, the increase in logistics costs, Russia's military aggression in Ukraine, the energy crisis, climate problems affecting grain production in South America,

as well as the supply of a large amount of grain from China on the way to self-sufficiency in meat production [14].

"With this crazy war we are living in, we had an increase of 200 and a lot to be now at 400 euros per ton," he told the Lusa Rafael Neves agency. According to the head of Ovopor, the animal feed sector in Portugal is "very dependent on corn and wheat from Ukraine", and for many months of the year "a large part of the corn consumed" is Ukrainian corn.

Jaime Pizarra, Secretary General of the Portuguese Association of Compound Feed Producers (IASA), said that the war in Ukraine only exacerbated the "crisis" that the sector was already experiencing. He mentioned that 30...40 % of grain produced in Ukraine is in Portugal.

"It was a time when we imported a lot of corn from Ukraine and were waiting for corn from Brazil, which arrives in June. We have an obligation – and we do – to contact suppliers to find alternatives to this corn and other raw materials," such as canola or sunflower.

"Since we have raw materials as the main cost item, it affects the entire food chain. If we don't have viable businesses with profitability that can survive, they will collapse," he warned [15].

In the case of Avenal, a pet food (dog and cat) company based in Aroeira, in the municipality of Leiria, the increased costs are already felt in the final product.

If in January 2022 the prices for animal fodder were already revised, then this month they increased by about 20 %, company administrator Ulisses Mota said. The company, which is estimated to make €30 million this year, is growing by "double digits" annually, and is recording ever-shrinking margins in the face of rising costs [16].

Formulation of the problem. Mobilization and use of significant available reserves for improving the efficiency and development of the feed and elevator industry of the south-eastern region of Ukraine, as confirmed by analytical calculations, make it possible to increase the production of high-quality and cheap basic types of food by 2.5...3 times, to form the necessary fund of food products for further meeting the needs of the domestic market and creating their powerful export potential.

Presentation of the main research material. Today, the feed industry of Ukraine has the opportunity to produce high-quality products that would meet the requirements of modern foreign breeding. However, negative factors restrain the development of the industry. The way to solve this problem is the development, adoption and introduction of the Law of Ukraine "About Feed", which should become the basis for the further

development of the regulatory and technical base and the compound feed industry, this law will open unlimited horizons for the production of highly profitable poultry and livestock products.

In the eastern regions of Ukraine, the total gross harvest of grain and leguminous crops is 30...35 % of the total volume of production in the country and has increased by 21 % over the past few years. The expansion of the acreage under grain crops and the increase in their yield contribute to the increase in the production of grain crops in the region. In 2020/21, 5 regions of eastern Ukraine – Donetsk, Zaporizhzhya, Luhansk, Dnipropetrovsk, Kharkiv – collected a total of 15.2 million tons of grain: wheat, barley, corn and peas. About a third of this figure will be used for domestic consumption, the rest – the export potential of the region, which is up to 10 million tons. That is, a total of about 10 million tons per year can be exported only from these 5 regions.

A fifth of all elevator capacities of Ukraine is located in the east. Of the 25 granaries built in the country last year, 9 new elevators and one river terminal appeared in the eastern region. Most of them are in the Dnipropetrovsk and Kharkiv regions, many companies are building elevators and production facilities in the Ukrainian-controlled territories of the Donetsk and Luhansk regions [17].

The mobilization of reserves for increasing the efficiency and development of elevator capacities of Ukraine will ensure the delivery of high-quality food. Last season, 2020/21, Ukraine exported 48.8 million tons of grain and oil crops. In the current 2021/22 season, as of February 23, Ukraine exported 43 million tons of grain and legumes. Such data are provided by the Ministry of Agricultural Policy. Overload volumes are in Table 1.

Before Russia's attack on our country, the main volumes of grain exports in Ukraine were sent to buyers through the ports of Mykolaiv and through the ports of Southern Odesa and Chornomorsk. In total, this is 95 % of grain cargoes exported by sea. Mariupol and Berdyansk accounted for another 5 %. For the most part, grain was transported to seaports by rail. Export of grain to the EU, which takes place by rail and road transport, according to USA, accounts for 5 % of all Ukrainian grain exports (by land and sea). Since the beginning of hostilities on the territory of Ukraine, the export of grain through port terminals has been stopped. Despite the fact that ports in these conditions are inferior in logistics to rail and road transport, sea transportation is in demand due to its low cost and connection between continents.

Tabl. 1. Transshipment of grain cargoes in seaports of Ukraine for 2015-2021, thousand tons

Sea port	YEAR							IN SUM for 7 years
	2015	2016	2017	2018	2019	2020	2021	
Berdiansk	1001	1020,9	1077,8	952,2	1527,8	1787,7	1409,8	8777,2
Belgorod-Dnistrovsk	0	5,98	27,44	0	2,95	0	0	36,37
Izmail	156,66	217,64	183,83	111,39	11,38	11,72	27,61	720,23
Mariupol	433,45	807,22	770,97	552,23	1134,35	1225,25	968,88	5892,35
Mykolaiv	8766,79	9107,89	9121,21	13175,86	16255,5	13237,44	12951,31	82616
Odesa	8615,44	8203,29	7650,43	6890,78	8892,48	6491	5827,77	52571,19
Pyvdenny	9763,3	8203,84	8684,12	8061,68	10998,2	9046,43	9701,33	64458,9
Reni	245,98	469,9	552,72	712,86	765,34	367,35	862,58	3976,73
Skadovsk	9,5	3	2,5	0	0	0	0	15
Olviya	2445,32	3045,67	3316,47	884,79	1232,16	1829,78	2873,72	15627,91
Ust-Dunaysk	16,3	13,6	33	29,3	51,2	21,3	60,5	225,2
Kherson	956,29	1262,12	1108,8	789,64	1083,11	722,3	795,47	6717,73
Chornomorsk	5088,49	7985,99	8121,91	9219,38	12664,14	13333,78	14553,93	70967,62
EVERYTHING per year	37498,52	40347,04	40651,2	41380,11	54618,61	48074,05	50032,9	312602,43

In Ukraine, according to Elevatorist.com Map of Elevators [1], the total elevator capacity before the start of the Russian aggressor's attack on our country amounted to more than 57 million tons. And the grain and oil crop harvest in 2021, according to the State Statistics of Ukraine, reached 107.38 million tons (as of December 1, 2021) and it still needs to be delivered from the field to various consumers. That is, even if you use all these capacities plus the possibility of storage "in sleeves", it is impossible to save the entire harvest in the country without export. Now, due to the war, the storage capacity will be significantly reduced. The map of military operations is constantly changing, so it is difficult to predict which elevators may be in the "gray zone".

As of March 22 of this year, the elevators of Sumy region, parts of Kharkiv region, Chernihiv region, Zaporizhzhia, Donetsk regions, Luhansk region, and parts of Kyiv region can be excluded from the logistics chain. All the capacities located in the war zone are estimated to be more than 22 million tons. Competition among agricultural producers within Ukraine also has a negative impact.

The elevators of the western regions will be the most interesting for storage, if the existing situation on the fronts is maintained. As of March 22, they have the following capacities: Transcarpathian region – 111.45 thousand tons; Chernivtsi region – 234 thousand tons; Volynsk region – 887 thousand tons; Lviv region – 1,050 thousand tons; Rivne region – 1,054 thousand tons; Ivano-Frankivsk region – 527 thousand tons; Ternopil region – 1,837,000 tons; Khmelnytsk region – 3,000 thousand tons.

That is, the total storage capacity of the western regions is about 9 million tons. Now, regardless of the war, elevators are being built in these regions, but this will not significantly change the situation.

According to the Ministry of Agricultural Policy, the remaining amount of grain to be exported is 17 million tons. Of these, approximately 10 million tons are corn, and about 6.7 million tons are sunflower and its processing products (oil, meal, husks). 730,000 tons of soybeans remain, these are residues that, in addition to the necessary consumption, can be processed into meal and oil. That is, if we talk about agricultural goods, 17 million tons should be exported, mainly through sea ports.

To export all this grain, there are several challenges to overcome. First, it is necessary to distribute cargo transportation from three to 12 border points. Secondly, to solve the problem of transshipment of grain and oil from Ukrainian broad-gauge wagons to European narrow-gauge

wagons. Separately, the Ministry of Agricultural Policy together with the Ministry of Infrastructure are working on simplifying the procedure for the export of grain by motor vehicles [1].

According to the website Elevatorist.com [1], the certified elevator capacity in Ukraine is about 45...50 million tons. Currently, 65...70% of elevators are morally and physically outdated and do not meet modern requirements for grain storage, efficiency of receiving and shipment, etc. In recent ten years, Ukraine has confidently entered the top five world grain exporters, which allows our country to steadily replenish its gold and currency revenues [18].

A modified exponential equation [19] can be used as time trend models:

$$\tilde{y} = k + a \exp(-bx), \quad (1)$$

where \tilde{y} – estimated (forecasted) value of grain transshipment volume, thousand tons;

k , a , b – empirical coefficients determined by the method of the smallest squares;

x – time factor (year).

The basis of structural analysis and synthesis to increase the accuracy of data processing is based on a typical equation of numerical values, for example, of the form [20], which is an equation of excess dimensions with a linear function of the transformation of dimensions:

$$\{x_{i1}\} = \{x_0\} \left\{ \frac{U'_3(x_1 + x_0)}{U'_3(x_1 + x_0)} - \frac{U'_1(x_0)}{U'_2(x_0)} \right\}, \quad (2)$$

where x_1 , x_2 , x_3 , – physical values of measurements with dimensions: $\{x_1\} = \{x_0\}$,

$\{x_2\} = \{x_i\}$ and $\{x_3\} = \{x_i\} + \{x_0\}$; $\{x_{i1}\}$ – шукана фізична величина;

U_1 , U_2 , U_3 – встановлені об'єднані (перетворені змінні) величини вимірів.

At the same time, structures of the implicit form are equations of excess dimensions, represented by independent variables x_i , x_0 , x_i+x_0 , ... and functions U_1 , U_2 , U_3 , ..., which are connected by an equation of the form $F(x_i, x_0, x_i+x_0, \dots, U_1, U_2, U_3, \dots) = 0$.

Ukraine is traditionally the leader in food supplies in the world. It is necessary to end the military conflict in Donbas region as soon as possible, to return to control all captured territories of Donetsk, Luhansk regions, and Crimea, and then carry out humanitarian demining of these

territories. The return of the temporarily occupied territories to the control of Ukraine will add 1...2 million tons to the existing export potential and will improve the entire supply chain from the field up to the seas in the region and in the whole country [8].

Conclusions and prospects for further researches.

1. According to experts, the export potential of agricultural enterprises of the Sea of Azov region alone is 3.2...3.5 million tons of cargo.

2. According to the State Statistics Service, for 2019, the production of fodder in Ukraine amounted to 6,348.6 thousand tons. It is impossible to preserve all this product in the country, it is necessary to export it to consumers all over the world, primarily to Africa and Asia.

3. The Top 10 companies – leaders in the production of compound feed in Ukraine were demonstrated. The top three includes: MBP, Ukrainian grain, Ukrlandfarming.

4. The world market of grain and fodder production is analyzed. It is expected that in 2022, production in Europe will decrease by millions of tons, primarily in Ukraine by 30...50% due to the war, in the EU countries, wheat production is predicted to decrease by 10 million tons, or by about 10 %.

5. Companies are forced to look for other ways of supply and other suppliers of food raw materials to meet the demand for agricultural products.

6. About 20 % of all elevator capacities of Ukraine are located in the East of Ukraine. Of the 25 granaries built in the country in 2021, 9 new elevators and one river terminal appeared in the eastern region.

7. Analyzed volumes of transshipment of grain cargoes through the sea ports of Ukraine over the past seven years. In total, more than 90 % of these cargoes were exported by sea.

8. The total elevator capacity of Ukraine before the start of hostilities amounted to 57 million tons, and all capacities located in the war zone are estimated to be more than 22 million tons, that is, more than a third.

9. According to the Ministry of Agricultural Policy, the remaining amount of grain to be exported is 17 million tons, however such of problems must be overcome.

10. The return of the temporarily occupied territories to the control of Ukraine will add 1...2 million tons of grain to the existing export potential.

References:

1. The official website of the Elevatorist company. Map of elevators. URL: <https://elevatorist.com/karta-elevatorov-ukrainy> (accessed 01.02.2022).
2. The official website of the state enterprise "Administration of Sea Ports of Ukraine". Section "Performance Indicators". URL: <http://uspa.gov.ua/ru/pokazateli-raboty> (accessed 21.08.2022).
3. The top 10 feed producing countries in the world in 2020 according to the Alltech version. URL: http://soyanews.info/news/proizvodstvo_kombikormov_v_mire_vyroslo_m_1_-_antech.html (accessed 21.08.2022).
4. Oleksij Fomin, Alyona Lovska, Vaclav Pistek, Pavel Kucera Research of stability of containers in the combined trains during transportation by railroad ferry // *MM Science Journal* March 2020. – P. 3728-3733 DOI : 10.17973/MMSJ.2020_03_2019043
<https://www.mmscience.eu/journal/issues/March%202020/articles/research-of-stability-of-containers-in-the-combined-trains-during-transportation-by-railroad-ferry>
5. Okorokov, A. M. Research into a possibility to prolong the time of operation of universal semi-wagon bodies that have exhausted their standard resource [Text] / A. M. Okorokov, O. V. Fomin, A. O. Lovska, R. V. Vernigora, I. L. Zhuravel, V. V. Fomin// *Eastern-European journal of enterprise technologies. 2018. – 3/7(93). – P. 20-26 (DOI: 10.15587/1729-4061.2018.131309)*
<http://journals.uran.ua/eejet/article/view/131309>
6. Oleksij Fomin, Alyona Lovska, Václav Pištěk, Pavel Kučera Dynamic load computational modelling of containers placed on a flat wagon at railroad ferry transportation // *Vibroengineering Procedia*. November 2019, Volume 29. – P. 118-123 DOI: <https://doi.org/10.21595/vp.2019.21132>
<https://www.jvejournals.com/article/21060>
7. Lovska A, Fomin O, Pištěk V, Kučera P. Dynamic Load Modelling within Combined Transport Trains during Transportation on a Railway Ferry. *Applied Sciences*. 2020; 10(16):5710. <https://doi.org/10.3390/app10165710> <https://www.mdpi.com/2076-3417/10/16/5710>
8. TOP-10 feed manufacturers in Ukraine 2019. URL: <https://latifundist.com/rating/top-10-proizvoditelej-kombikormov-v-ukraine-2019> (accessed 21.08.2022).

9. Goychuk O. I. Food safety [Prodovol'cha bezpeka]. Monograph. Zhytomyr: Polissya, 2004. P. 348-359.
10. The port of Mariupol intends to resume work as soon as possible after the release. URL: <https://gmk.center/ua/news/mariupolskyj-port-pisliavzvilnennia-maie-namir-vidnovyty-robotu-v-najkorotshi-terminy/> (acceded 13.07.2022).
11. Raw materials for the production of animal feed. Quality control of raw materials for the production of animal feed. URL: <https://90zavod.ua/raznoe/syre-dlya-proizvodstva-kombikormov-kontrol-kachestva-syrya-dlya-proizvodstva-kombikormov.html#52> (acceded 08.08.2022).
12. The European feed market began to stagnate. URL: <https://app.agro-online.com/57661/details/> (acceded 08.06.2022).
13. Why is feed more expensive and what to do about it? URL: <https://kurkul.com/spetsproekty/918-chomu-dorojchayut-kormi-i-scho-z-tsim-roboti> (acceded 08.06.2022).
14. Economy. A lot of grain. URL: <https://www.dsnews.ua/economics/zerna-navalom-31052022-460179> (acceded 08.06.2022).
15. Window of opportunity: why in a crisis it is important not to cut costs, but to conquer new markets. URL: <https://uga.ua/meanings/okno-vozmozhnostej-pochemu-v-krizis-vazhno-ne-sokrashhat-rashodya-zavoevyvat-novye-rynki/> (acceded 08.06.2022).
16. Market of extruded compound feed, compound feed, animal feed. URL: <http://kormoproizvodstvo.su/the-market-for-extruded-feed> (acceded 08.06.2022).
17. The Mariupol sea trade port has good prospects for increasing transshipment of grain cargoes. URL: <https://www.apk-inform.com/uk/exclusive/topic/1520899> (acceded 15.09.2022).
18. Burlaka N.I. Ukraine as a world grain exporter. [*Ukrayina yak svi-tovyy eksporter zerna*]. Collection of scientific works VNAU. Ser: Economic sciences № 3 (69) 2012. P. 37-42.
19. Boldanova O.V. Economic and mathematical methods and models [*Ekonomiko-matematicheskiye metody i modeli*]: study guide. – Irkutsk: BGUEP, 2015. – 139 p.
20. Kondratov V.T. The theory of structural analysis of redundant dimension equations [*Teoriya strukturnogo analiza uravneniy izbytochnykh izmereniy*]. Monograph / V.T. Kondratov. – K.: Steel, Kharkov: Machulin, 2020. – 318 p.