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THE MODEL OF ASSESSMENT OF GOODS EXPORTS OF UKRAINE TO THE WORLD INTEGRATION ASSOCIATIONS

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Abstract. Foreign trade is an important factor of economic growth and development of open economies. At the same time, the analysis of the state of foreign trade operations is becoming methodologically more complex due to the increase in the number of indicators used and the appearance of new ones. They allow not only to examine the effectiveness of the state trade policy, the set of goods and trade partners, but also to get an idea of the structure of the economy, the level of its development and competitiveness, as well as to assess the quality of the export and import baskets from the point of view of economic growth prospects. Therefore, it is advisable to use models of commodity export valuation, which determines the relevance of the chosen topic. The subject of the study is the methods and models of commodity export evaluation. The *purpose* of the article is the formation of a model for the evaluation of Ukraine's commodity exports to the integration associations of the world and its approval. *Methodology*. The theoretical and methodological basis of the conducted research is the dialectical method of cognition, the principles of system analysis and synthesis, statistical processing of information. The methods of structural dynamics were used for the analysis of statistical indicators of commodity exports for 2016–2020; the method of constant market share – for the evaluation of changes in commodity exports of Ukraine for the period under consideration; the method of scientific abstraction is used for the generalization of the obtained results and the formation of conclusions; the graphic method – for the visual presentation of the obtained research results. *Results*. The article proposes a model for assessing Ukraine's commodity exports to the world integration associations, the main component of which is the constant market share method (CMS analysis). This model is easy to use and allows a qualitative assessment of changes in Ukraine's commodity exports. Approval of the model and assessment of changes in commodity exports of Ukraine was carried out on the international statistical database UNCTADstat for 2016–2020. The data are aggregated into groups according to the Standard International Trade Classification (SITC). The following trading partners have been selected for the CMS analysis: EU-27, ASEAN+3, CIS and REST OF THE WORLD. The obtained results make it possible to assess the state of Ukraine's commodity exports and the level of its competitiveness in foreign markets. *Practical implications.* The practical implications are related to the possibility of using the proposed model for the evaluation of commodity exports, using various options for the classification of goods and integration associations – partners of the exporting country. *Value/originality.* The originality lies in the development of a model for the assessment of Ukraine's commodity exports to the world integration associations based on the Constant Market Share (CMS) method, which allows to determine to what extent exports change with the growth of the competitiveness of the goods of the exporting country.

Key words: merchandise export valuation model, Constant Market Share – CMS, integration associations, international trade, commodity export, foreign trade activity.

JEL Classification: C81, F10, F15

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1. Introduction

Foreign trade activity is an important factor determining the economic growth and development of countries, especially those whose economy is characterized by a high degree of openness. In this regard, in recent years the analysis of the state of export and import has become methodologically more complex due to the increase in the number of indicators used and the appearance of new ones. They allow not only to examine the effectiveness of the state trade policy, the set of goods and trade partners, but also to get an idea of the structure of the economy, its level of development and competitiveness, as well as to assess how favorable the composition of export and import baskets is from the point of view of economic growth prospects. The importance of understanding the nature, consequences and determinants of the development of global export models determines the relevance of the chosen research topic.

Changes in a country's share of world exports are a useful indicator of how well an economy can generate income to pay for imports. Changes in a country's share of world exports can be influenced by many interrelated factors, such as competitiveness and specialization. On the one hand, internal and external macroeconomic features and events can affect the relative competitiveness of exports, such as input costs or exchange rate changes, markup behavior, and quality. On the other hand, structural factors, such as the availability of factors of production or technological and geographical linkages, also determine the sectoral specialization of exports and their distribution among different trading partners. Thus, if a country specializes in exporting goods to countries or groups of countries where demand is particularly high, its aggregate market share will increase even if its competitiveness does not improve. At the same time, even if a country maintains its share in individual markets, its aggregate market share may decline if it specializes in markets that grow more slowly than world exports or in goods for which demand grows more slowly than average. All these elements are relevant for the Ukrainian economy. The Ukrainian economy is faced with the task of maintaining and strengthening its export indicators in order to achieve further improvement of the balance of current operations and to bring the external debt on the path of reduction. Against this background, the application of commodity export evaluation models is an objective necessity.

The purpose of the article is the formation of a model for assessing Ukraine's commodity exports to the integration associations of the world and its approval.

The theoretical and methodological basis of the conducted research is the dialectical method of cognition, the principles of system analysis and synthesis, statistical processing of information. In the analysis of statistical indicators for 2016–2020, the methods of structural dynamics were used; the method of constant market share was used to assess the changes in the export of raw materials of Ukraine for the period under study; the method of scientific abstraction was used to generalize the obtained results and to form conclusions; the graphic method was used to visually present the obtained research results.

The research information base was formed on the basis of UNCTADstat data.

2. Literature review

In the course of theoretical and empirical researches, a set of applied tools most often used in the study of the export structure of countries was determined. Among the most widespread are the Krugman specialization index, the Herfindahl-Hirschman index and the Balassa index of revealed comparative advantages. The first two indices make it possible to determine the degree of specialization of a country's exports, but the first one measures product specialization and the second – geographical specialization. The Balassa index makes it possible to calculate the level of competitive advantages of industries in relation to a given group of countries on the basis of export volumes. Despite its ease of use, the index has theoretical (assumption that all groups of goods are traded) and conceptual (only the volume of exports is taken into account, other factors of change in trade are not taken into account) shortcomings, so the index is subject to constant improvement. Thus, Leromain E. and Orefice G. proposed a version of the Balassa index that takes into account the productivity of the industry, the effect of reciprocal trade and partially the effect of the geographical structure. (Leromain, Orefice, 2014)

Another noteworthy tool is the constant market share method, which combines the elements of the Krugman index and the Balassa index and at the same time takes into account the relationship between the commodity and geographical structure of exports. From the theoretical point of view, the method is developed on the basis of transformations of the demand elasticity function for a certain product of the exporting country in the market of the importing country.

The method of constant market share in connection with the analysis of international trade was first formulated and applied by the Polish economist Tyszynski H. (Tyszynski, 1951) He suggested that a country's share of world exports may depend not only on structural changes in world trade, but also on changes in the competitiveness of the

products it exports. To test his hypothesis, Tyszynski proposed to calculate a country's possible share of the world market if its market shares for each product group remained unchanged over a given interval, and then to calculate the difference between the actual observed market share and the hypothetical one. In this way, it is possible to adjust the export structure for the market effect (structural changes in world trade or the regional market) and the effect of competitiveness (the country's exports).

Important contributions to the theoretical development and improvement of this method of analysis were made by E. Limer and R. Stern, Y. Fagerberg and G. Solly, K. Jepma, A. Nissens and G. Puli, M. Dyadkova and G. Momchilom. The main applied works on the application of CMS analysis are the article devoted to the export of Portugal by J. Amador and S. Cabral (Amador, Cabral, 2008), the analysis of the effect of competitiveness on the example of ASEAN countries (Widodo, 2008), the analysis of the export of Austria by E. Skriner (Skriner, 2009), the study of the export of Spain by A. Pandiella (Pandiella, 2015), the research on the export of Ukraine (Bakaev, Bakaeva, 2020) and others.

The advantages of the method include its relative simplicity, as well as the fact that it is a tool for analyzing the structural causes that influence the characteristics and trends of countries' trade, leaving exogenous and endogenous macroeconomic factors out of the scope of consideration. In particular, the method makes it possible to determine the extent to which exports change with the growth of the competitiveness of the goods of the exporting country, due to the fact that the country supplies goods to fast or slow growing markets. (Pandiella, 2015)

A review of literary sources on methods and procedures of commodity export valuation shows that they are quite numerous. Each method has its own goals. At the same time, each method requires the development of a methodology for its application, including through the development of valuation models. This determined the choice of the research topic.

3. The main material of the research

The authors propose a model for the assessment of Ukraine's commodity exports to the world integration associations, the component of which is the constant market share method. In general, this model is presented in Figure 1.

In order to achieve the objective of the study, it is necessary to define the tasks to be solved by building a model for the evaluation of merchandise exports.

Firstly, it is necessary to determine which classification of goods (groups of goods) will be used for the assessment. Among the most common are the Standard International Trade Classification (SITC, 2022) and the Lall Classification (Lall, 2000) used by the United Nations Conference on Trade and Development (UNCTADstat, 2022). Approaches to the classification of trade flows have been considered in detail by the authors in previous studies. (Kovbatiuk, Kovbatiuk, 2021)

Secondly, it is necessary to determine the number and composition of integration associations to which export flows are directed. As a rule, this is determined on the basis of the data of a preliminary analysis based on the materials of national and international statistics.

According to the composition of the selected product groups and the list of integration associations, statistical information is grouped based on UNCTADstat data for the period under analysis. The success of the evaluation process depends primarily on the timeliness, completeness and reliability of the information support. (Hanas, Dorosh, Nodzhak, Lutsyshyn, 2019)

Direct data processing is performed using the Constant Market Share (CMS) method.

After carrying out all necessary calculations, the resulting information is analyzed, analytical conclusions about changes in the structure of commodity exports of Ukraine are drawn, on the basis of which recommendations for improving the state and structure of commodity exports are developed.

As Robert Shannon pointed out (Shannon, 1975), any model must meet certain criteria. He pointed out such criteria as simplicity and comprehensibility for the user; goal orientation, adequacy, comprehensibility and ease of use; ability to solve the main tasks; adaptability (ability to add data to the model); ability to change the model if necessary.

The proposed model for the assessment of Ukraine's commodity exports to world integration associations meets the above criteria, is easy to use, and allows for a qualitative assessment of changes in Ukraine's commodity exports.

4. Constant market share analysis methodology

The Constant Market Share (CMS) method is developed on the basis of transformations of the demand elasticity function for a certain product of the exporting country in the market of the importing country.

The essence of the method is the assumption that the country's share in world exports may depend not only on structural changes in world trade, but also on changes in the competitiveness of the products exported by the country. That is, it is necessary to calculate the possible share of the country in the world market if its market shares for each product group remained unchanged for a given interval, and then to calculate the difference between the real observed

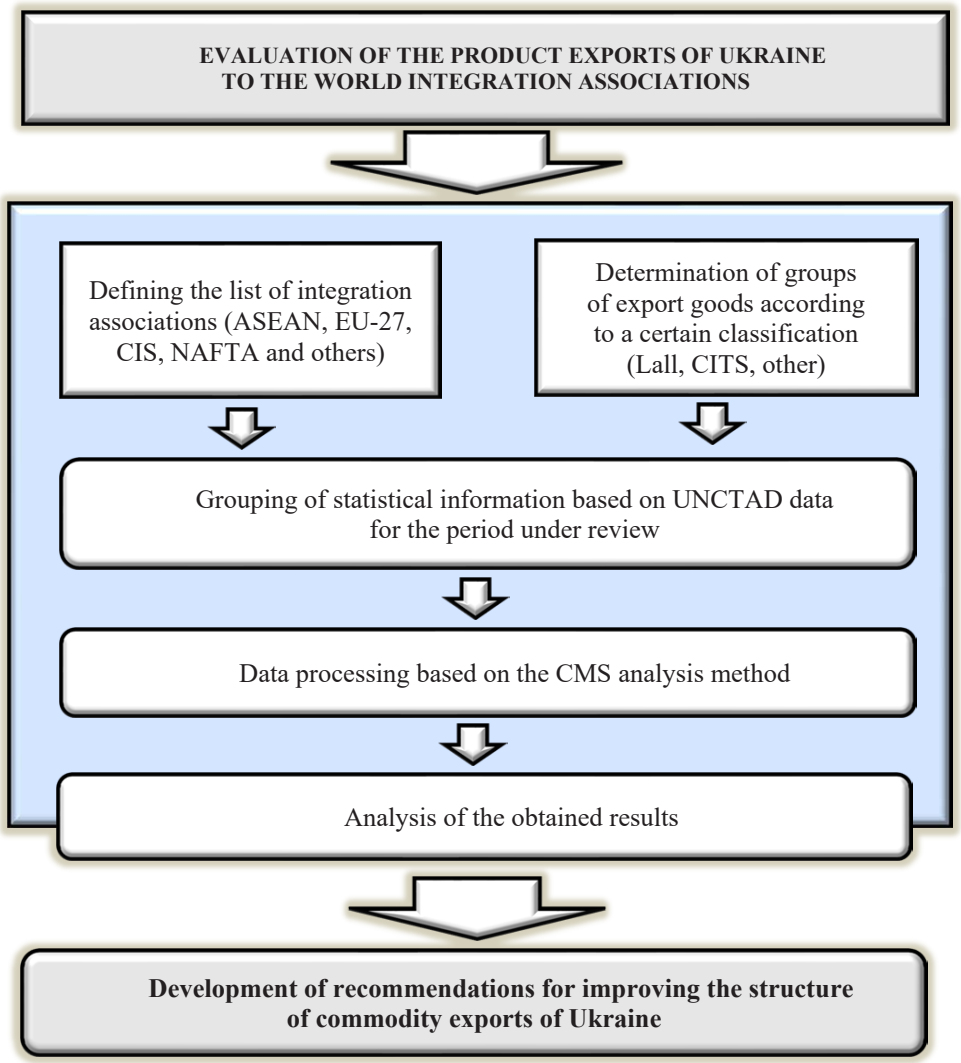

Figure 1. The model of evaluation of goods exports of Ukraine to the integration associations of the world

Source: developed by the authors

market share and the hypothetical one. In this way, it is possible to adjust the export structure for the market effect (structural changes in world trade or regional market) and the effect of competitiveness (exports of the country).

The most optimal CMS analysis is the Nissens and Poulet specification, which generally looks as follows (Pandiella, 2015):

TE=MSE+CSE=MSE+PSE+GSE+MIX

TE=MSE+CSE=MSE+PSE+GSE+MIX (1)

where:

TE – total effect;

CSE – combined structure effect;

MSE – market share effect or the effect of competitiveness;

PSE – product structure effect;

GSE – geographical structure effect;

MIX – mixed structure effect.

Each of the effects is calculated according to the following formulas:

$$TE = g - g^* = \sum_i \cdot \sum_j \theta_{ij} g_{ij} - \sum_i \cdot \sum_j \theta_{i^*j} g_{i^*j} \quad (2)$$

$$MSE = \sum_i \cdot \sum_j \theta_{ij} \left(g_{ij} - g^*_{i\,j} \right) \quad (3)$$

$$CSE = PSE + GSE + MIX \quad (4)$$

$$PSE = \sum_i \left(\theta_i - \theta_i^* \right) \left(g_i - g^* \right) \quad (5)$$

$$GSE = \sum_j \left(\theta_j - \theta_j^* \right) \left(g_j^* - g^* \right) \quad (6)$$

$$MIX = \sum_i \cdot \sum_j \left[\left(\theta_{ij} - \theta_{ij}^* \right) - \left(\theta_i - \theta_i^* \right) \frac{\theta_{ij}^*}{\theta_i^*} - \left(\theta_j - \theta_j^* \right) \frac{\theta_{ij}^*}{\theta_j^*} \right] g_{ij}^* \quad (7)$$

where "i" is the exported product,

"j" is the country to which product "i" is exported;

g_{ij} – percentage change in the export of the i-th product to the j-th country in the period t; g

θ_{ij} – the share of exports of the i-th product to the j-th country from the country's total exports in the period t – 1,

g_{ij} i θ_{ij} are calculated according to formulas (8) and (9),

$$g_{ij} = \frac{X_{ij,\,t} - X_{ij,\,t-1}}{X_{ij,\,t-1}} \quad (8)$$

$$\theta_{ij} = \frac{X_{ij,\,t-1}}{\sum_i \cdot \sum_j X_{ij,\,t-1}} \quad (9)$$

$$g^*_{ij} = \frac{X^*_{ij,\,t} - X^*_{ij,\,t-1}}{X^*_{ij,\,t-1}} \quad (10)$$

$$\theta^*_{ij} = \frac{X^*_{ij,\,t-1}}{\sum_i \cdot \sum_j X^*_{ij,\,t-1}} \quad (11)$$

where X is the volume of exports in value terms.

Parameters g^*_{ij} i θ^*_{ij} express the same relations as g_{ij}, θ_{ij}, but for world exports, and the country that is the object of analysis is not included in the volume of global exports.

In formulas (2) – (7):

$\theta_i = \Sigma_i\theta_{ij}$ – the share of product "i" in the country's exports;

$\theta^*_i = \Sigma_j\theta^*_{ij}$ – the share of product "i" in world exports;

$\theta_j = \Sigma_i\theta_{ij}$ – market share "j" in the country's exports;

$\theta^*_j = \Sigma_i\theta^*_{ij}$ – market share of "j" in world exports;

$g^*_i = \frac{\sum_j \theta^*_{ij}\, g^*_{ij}}{\theta^*_i}$ – growth of world exports of goods "i";

$g^*_j = \frac{\sum_j \theta^*_{ij}\, g^*_{ij}}{\theta^*_j}$ – growth of global exports to the market "j".

This method allows to consider four effects that can be unambiguously interpreted at a given level of data aggregation.

5. Results

Approval of the model and assessment of changes in Ukraine's commodity exports were carried out on the international statistical database UNCTADstat for 2016–2020. UNCTADstat provides detailed annual data on nominal imports and exports of goods by commodity, partner country or group of countries, expressed in US dollars. The advantage of using annual data is that it avoids the variability found in high-frequency trade data.

Data are aggregated into groups according to the Standard International Trade Classification (SITC, 2022).

Consider the structure of world exports and Ukrainian exports according to this classification.

As shown in Table 1, the structure of Ukraine's exports differs significantly from that of the world. The largest share of world exports is occupied by machinery and transport equipment – SITC 7 (36.81% and 36.80% in 2016 and 2020, respectively), fuels and lubricants – SITC 3, chemicals and related products – SITC. 5, manufactured goods – SITC 6, miscellaneous manufactured articles – SITC 8. The share of these goods ranges from 8.5 to 12.63%. The export structure of Ukraine is dominated by manufactured goods – SITC 6 (27.25% and 22.44%), food and live animals – SITC 0 (25.6% and 28.32%) and raw materials – SITC 2 (13.67% and 16.02%). In the dynamics over five years, it is food and live animals that have the greatest tendency to grow, while the share of manufactured goods is decreasing. The structure of world exports and exports of Ukraine in 2016 and 2020 is shown more clearly in Figure 2.

Table 1

The structure of world exports of goods and exports of Ukraine

Group of goods	World				Ukraine			
	2016		2020		2016		2020	
	mln $	%	mln $	%	mln $	%	mln $	%
Total all	**15 886 802**	**100**	**17 463 039**	**100**	**36 357**	**100**	**49 219**	**100**
SITC 0	1 077 075	6,78	1 237 098	7,08	9 308	25,60	13 937	28,32
SITC 1	139 855	0,88	149 328	0,86	484	1,33	648	1,32
SITC 2	566 927	3,57	709 519	4,06	4 969	13,67	7 883	16,02
SITC 3	1 509 492	9,50	1 496 044	8,57	446	1,23	555	1,13
SITC 4	90 120	0,57	104 718	0,60	3 922	10,79	5 703	11,59
SITC 5	1 783 592	11,23	2 172 470	12,44	1 373	3,78	1 934	3,93
SITC 6	1 986 275	12,50	2 136 560	12,23	9 907	27,25	11 043	22,44
SITC 7	5 847 890	36,81	6 426 194	36,80	4 175	11,48	5 292	10,75
SITC 8	2 005 955	12,63	2 105 314	12,06	1 556	4,28	2 028	4,12
SITC 9	879 621	5,54	925 794	5,30	217	0,60	196	0,40

Source: formed by the authors on the basis of (UNCTADstat, 2022)

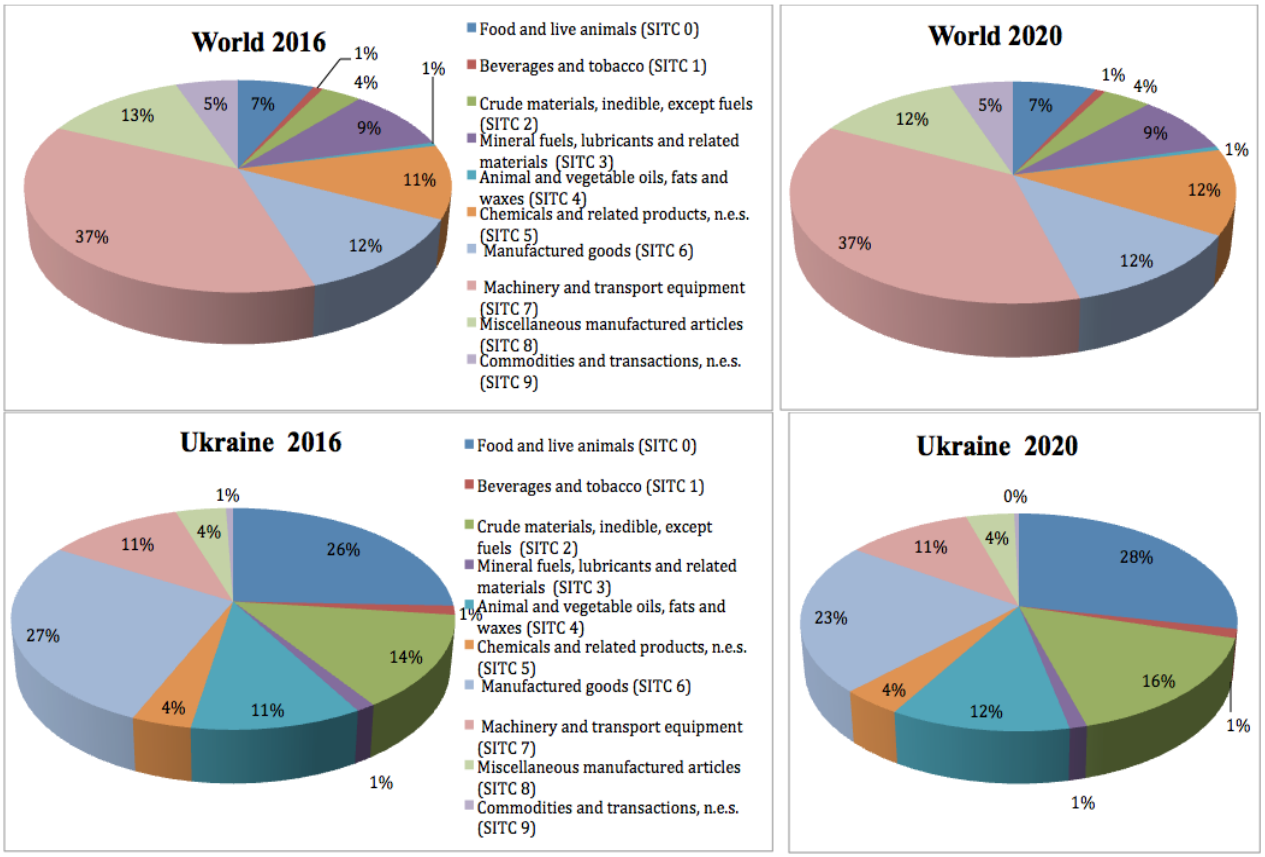

Figure 2. Structure of world exports and exports of Ukraine by groups of goods

Source: formed by the authors on the basis of (UNCTADstat, 2022)

The analysis of these indicators in dynamics indicates that the trends of changes of indicators in relation to product groups in the world and in Ukraine are approximately the same. This is confirmed by the data shown in Figure 3.

Although the growth of Ukrainian exports in 2016–2020 is similar to the growth of global exports, it is lower than the global growth for certain groups of goods due to negative competitiveness (measured by the effect of market share) and structural effects.

For the analysis of the CMS, the trade partner associations – EU-27, ASEAN+3, CIS and all others – were selected. The total share of Ukrainian exports to EU-27, ASEAN+3 and CIS countries in 2020 is 69%. During the analyzed period it increased by 6% (Figure 4).

However, it can be noted that within five years there have been some changes in the distribution of exports to the EU-27, ASEAN+3 and CIS countries. The share of exports to the countries of the European Union increased from 37% to 38%, while the share of exports to the countries of the former Soviet Union decreased from 16% to 12%. The largest changes occurred in the volume of exports to the ASEAN+3 countries, which increased from 10 to 19%. First of all, it is connected with political factors, deterioration of economic and political relations with some CIS countries.

In the process of applying the CMS analysis method to the structure of Ukrainian commodity exports, estimates of the effects of the model were obtained, which are shown in the Table 2.

The obtained results indicate that in 2017, the growth rate of exports in Ukraine was almost twice as high as the growth rate of world exports. This was caused both by the activation of manufacturers in foreign markets and by the improvement of the product structure. In 2018, there was a decline in the indicators, and in 2019–2020, the dynamics of Ukrainian exports also improved, the deviations of export growth exceeded the global ones, which indicates an improvement in the structure and volume of commodity exports of Ukraine.

Table 3 shows more detailed data in the section of individual commodity groups regarding their contributions to the increase of the total market share (MSE) of commodity exports of Ukraine to each association (market) in 2020 by 0.02%, and the positive change in the total effect of the change in export (TE) by 5.5%.

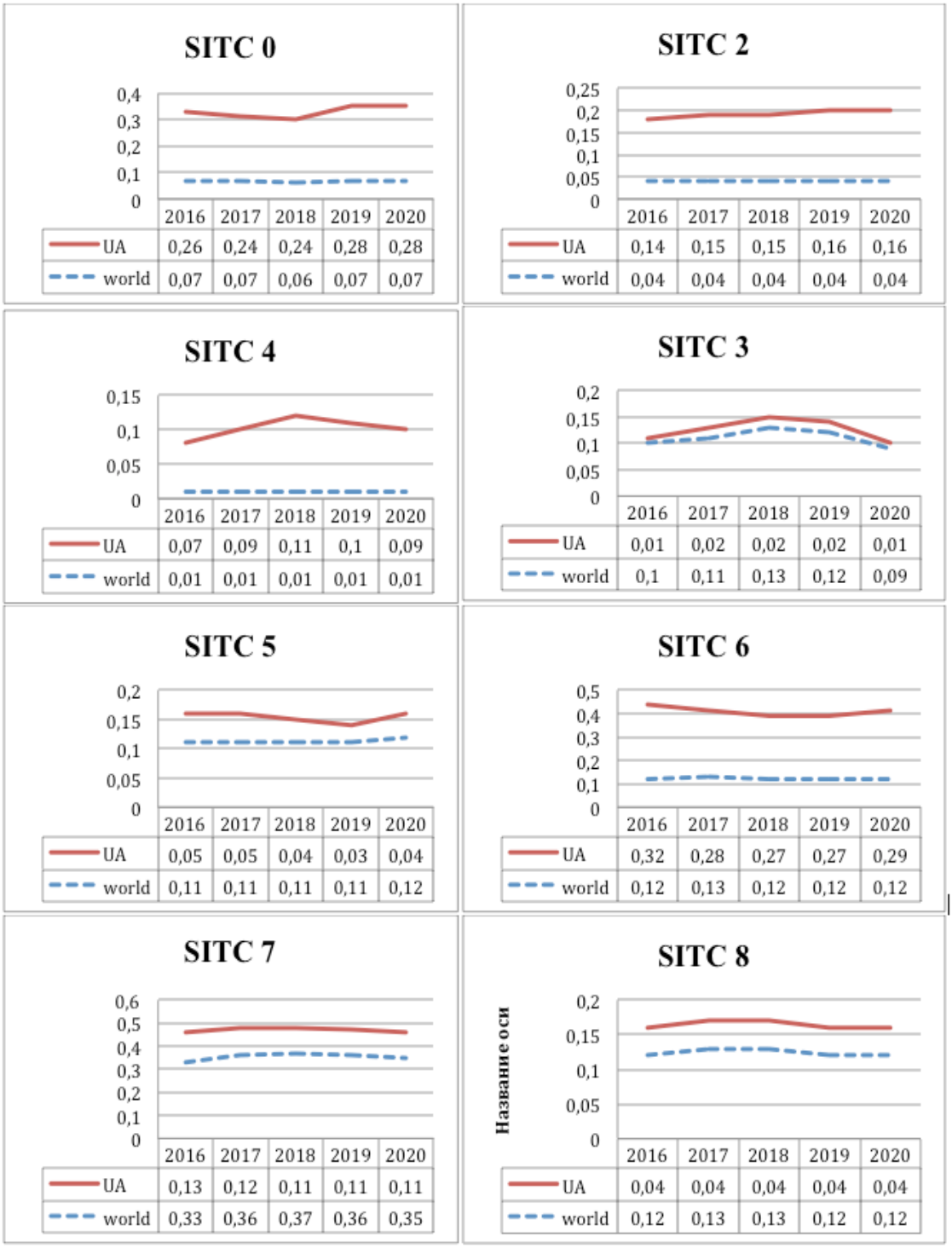

Figure 3. Dynamics of the structure of world exports and exports of Ukraine according to the SITC classification

Source: formed by the authors on the basis of (UNCTADstat, 2022)

The general effect is the difference between the growth rates of Ukrainian exports and world exports. The market share effect aggregates market share fluctuations in individual export markets. The combined structural effect, in turn, is divided into three components: the product structure effect, the geographical structure effect, and the mixed structural effect. The product structure effect and the geographical structure effect of exports are positive when a country's specialization in markets that grow faster than world trade as a whole is above average. Conversely, high specialization in slow-growing markets leads to negative structural effects (Figures 5-6).

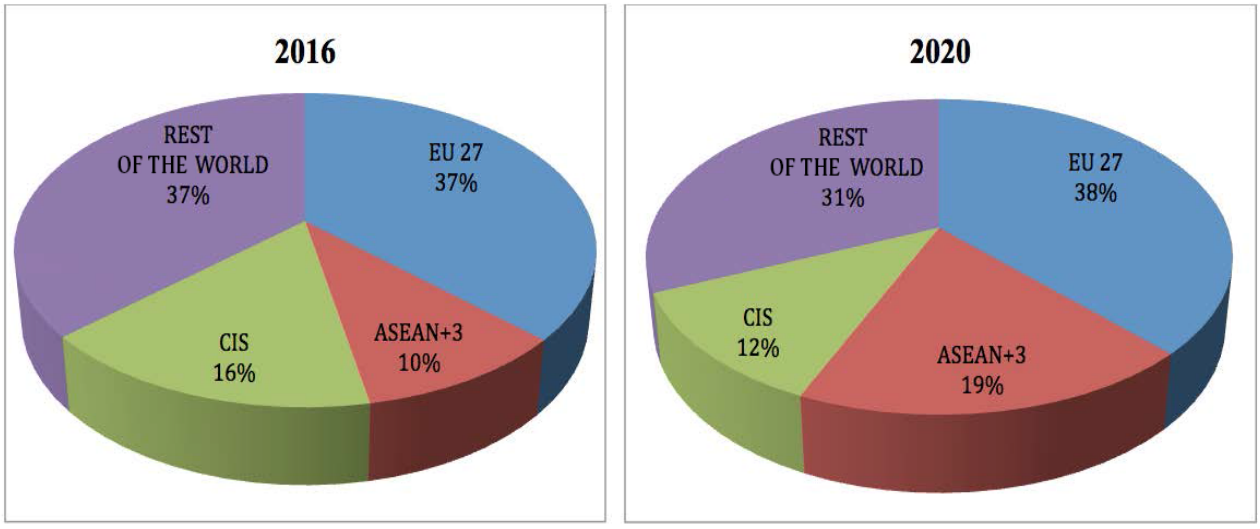

Figure 4. Structure of Ukraine's exports by trading partners

Source: formed by the authors on the basis of (UNCTADstat, 2022)

Table 2

The main results of the CMS analysis

Years	Export growth		TE	MSE	CSE	Components of the combined structural effect		
	Ukraine	World				PSE	GSE	MIX
	1	2	3=1-2 =4+5	4	5= 6+7+8	6	7	8
2017	0.1944	0.1059	0.0885	0.0730	0.0155	0.0015	0.0096	0.0044
2018	0.0899	0.1029	-0.0130	0.0239	-0.0369	0.0054	-0.0024	-0.0399
2019	0.0575	-0.0298	0.0873	0.0870	0.0003	-0.0075	0.0078	0.0000
2020	-0.0166	-0.0715	0.0550	0.0002	0.0548	-0.0043	-0.0032	0.0623
Average	0.0813	0.0269	0.0270	0.0460	0.0084	-0.0012	0.0030	0.0067

Source: developed by the authors

Table 3

Contributions to the overall change in the market share of Ukraine's commodity exports according to the Standard International Trade Classification for 2020

Merchandise groups	Integration associations			
	EU-27	ASEAN+3	CIS	Rest World
SITC 0	-0,0166	0,0231	-0,0020	-0,0118
SITC 1	0,0004	0,0007	-0,0001	0,0003
SITC 2	-0,0129	0,0229	-0,0022	-0,0085
SITC 3	-0,0004	0,0000	-0,0002	0,0002
SITC 4	0,0023	0,0053	0,0000	0,0015
SITC 5	-0,0005	0,0007	-0,0006	0,0030
SITC 6	-0,0075	0,0052	-0,0051	-0,0036
SITC 7	0,0043	0,0011	-0,0009	0,0016
SITC 8	0,0018	-0,0003	0,0002	0,0001
SITC 9	0,0003	0,0000	0,0004	-0,0019
MSE	**-0,0289**	**0,0587**	**-0,0105**	**-0,0191**
	0,0002			

Source: developed by the authors

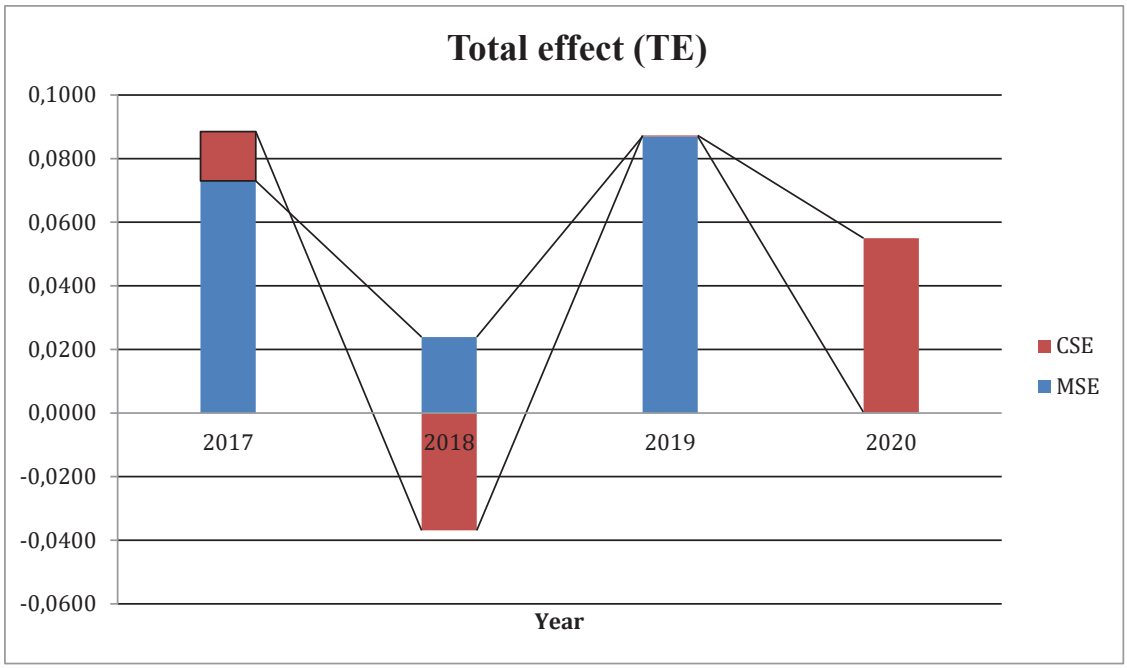

Figure 5. The general results of the CMS analysis (TE)

Source: developed by the authors

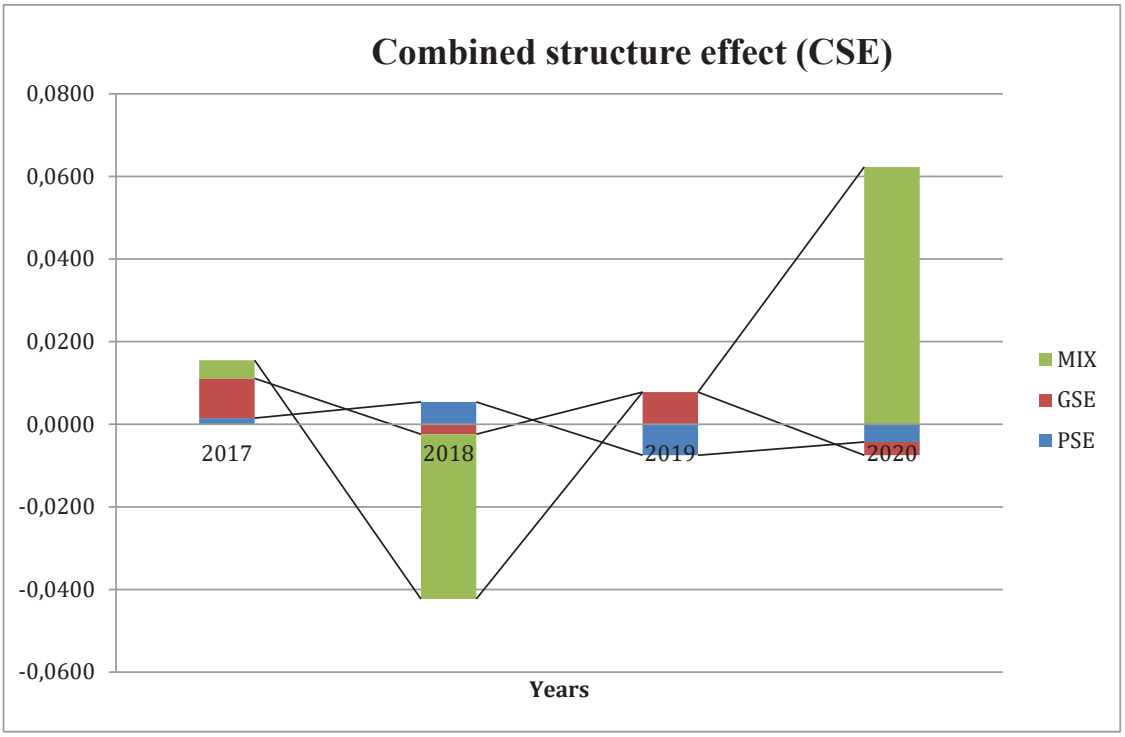

Figure 6. The main results of the CMS analysis (CSE)

Source: developed by the authors

Market Share Effect (MSE). The MSE provides information on the development of market shares independent of structural changes in trade patterns. The results indicate the stabilization of the competitiveness of Ukrainian goods for the period 2016–2020.

The indicator has positive values throughout the analyzed period and indicates that Ukraine's market share in world exports has been constantly increasing.

The increase in market share was due to its increase in the ASEAN+3 countries. In terms of product groups, the growth was due to an increase in the market share of SITC group 0 "Foodstuffs and live animals", SITC group 2 "Raw materials", SITC group 4 "Animal and vegetable oils, fats and waxes", SITC group 6 "Industrial products", SITC group 7 "Machinery and transport equipment".

As for the analysis of geographical directions in the period 2016–2020, it can be noted that Ukraine gained market share in the countries of the European Union and the Association of Southeast Asian Nations, China, South Korea and Japan, as well as in other countries of the world. At the same time, the largest losses of market share were in the CIS countries.

The Combined Structure Effect (CSE) consists of three effects: product structure effect, geographic structure effect, and mixed structure effect.

Product structure effect (PSE). On average, during 2016–2020, the relative specialization of Ukraine's export products has a negative impact on export indicators. The contribution to the product structure was positive in 2017–2018 and became negative in 2019–2020. In 2016–2017, the most negative effect was caused by the relatively low specialization of Ukrainian exports of products of the following commodity groups: SITC 5 "Chemicals and related products", SITC 7 "Machinery and transport equipment", SITC 8 "Miscellaneous manufactured goods", SITC 9 "Other goods".

This was partially offset by the positive market impact of the following product groups: SITC 0 "Foodstuffs and live animals", SITC 3 "Fuels and lubricants", SITC 4 "Animal and vegetable oils, fats and waxes", SITC 6 "Industrial products".

The data in Table 4 illustrate the product structural effect according to the 2020 data and testify to the impact of relative specialization on the evolution of total market share.

Geographical structure effect (GSE). The geographical specialization of Ukrainian exports had a negative impact on the overall evolution of market shares. This reflects the high relative specialization of Ukrainian exports in some European markets and the lower average growth rates of world exports to these countries. In contrast, the non-specialization of Ukrainian exports to China and other Asian economies made an important negative contribution, given the high growth of world exports to developing Asian countries.

It is worth noting the spread of specialization of Ukrainian exports to other countries of the world.

6. Conclusions

In the process of applying the CMS analysis method to the structure of Ukraine's commodity exports, estimates of the effects of the model were obtained, which indicate that Ukraine is experiencing strong competitive pressure from other countries, which has led to a loss of world market share. However, the structure of the geographical markets to which Ukraine exports, with a large share for relatively slow-growing areas such as the Eurozone and a small share for fast-growing countries such as China and other Asian economies, has had a negative impact on Ukrainian exports. The product structure, focused on relatively slow-growing product lines, also did not contribute to better export performance.

The obtained results indicate the expediency of applying the proposed model of evaluation of commodity exports of Ukraine to the integration associations of the world for the analysis of foreign trade relations and determination of the country's place in the international environment. Moreover, this model has signs of universality and can be used for the analysis of commodity exports of any country.

Table 4

Distribution of the product structure effect of commodity exports of Ukraine, 2020

SITC 0	SITC 1	SITC 2	SITC 3	SITC 4	SITC 5	SITC 6	SITC 7	SITC 8	SITC 9
0,018	0,000	0,010	0,027	0,017	-0,006	0,003	-0,005	-0,001	-0,002

Source: developed by the authors

Table 5

Distribution of the geographical structure effect of commodity exports of Ukraine, 2020

Integration associations	EU-27	ASEAN+3	CIS	Rest World
Change %	-0,05	-0,25	-0,10	0,07

Source: developed by the authors

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