“Modeling of diversification of foreign economic interactions”

AUTHORS	Ihor Hroznyi https://orcid.org/0000-0001-8083-3050 Oleh Kuzmak https://orcid.org/0000-0002-1950-8416 Olena Kuzmak https://orcid.org/0000-0003-0394-0981 Olha Rusinova https://orcid.org/0000-0001-9702-2289

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Ihor Hroznyi (Ukraine), **Oleh Kuzmak** (Ukraine), **Olena Kuzmak** (Ukraine), **Olha Rusinova** (Ukraine)

MODELING OF DIVERSIFICATION OF FOREIGN ECONOMIC INTERACTIONS

Abstract

The article developed a basic simulation model of diversification of foreign economic interactions, which makes it possible to assess the mutual influence of key economic indicators and their reaction to changes in the equilibrium in world markets. The peculiarity of the developed model of diversification of foreign economic interactions is its functioning as a complex dynamic system in which many factors are interrelated, and the connections are dynamic. This makes it possible to calculate a simulation model that takes into account hidden and subtle connections. While modeling foreign economic interactions and evaluating the influence of various regulators on them, in addition to the stage of model development itself, mandatory parameterization of this model is proposed, that is, the determination of specific types of dependence between the factors included in the model and the parameters of these dependencies.

The implementation of this model can be carried out in any simulation package.

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Keywords diversification, foreign economic interactions, modeling, information technologies, simulation model, dynamic system, factors, regulators

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Ihor Hroznyi, Doctor of Economics, Professor, Head of the Department of Management, European University, Ukraine.

Oleh Kuzmak, Doctor of Economics, Associate Professor, Director of the Rivne branch, European University, Ukraine.

Olena Kuzmak, Doctor of Finance, Associate Professor, Head of the Department of Economics and Entrepreneurship, European University, Ukraine.

Olha Rusinova, Ph.D., Associate Professor of the Department of Management, European University, Ukraine.

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INTRODUCTION

Foreign economic activity of the country is one of the main directions of development of many modern states, a source of goods, production of which is impossible within the country, as well as revenues from export-import operations.

Foreign economic activity of the country should not only follow world trends, but also anticipate them.

It is necessary to regard all countries without exception as potential partners, trade interests should be evenly dispersed in different parts of the world, especially in rapidly growing markets.

The impact of unforeseen circumstances that affect the management processes and lead to the modification of the elaborated plans and already developed solutions, beyond the stereotypical vision and the need to consider unlikely alternative solutions, makes new research relevant to modeling the diversification of foreign economic interactions.

In research on this subject, two main areas for analysis can be identified: approaches to modeling the external economic development of countries; universal approaches to modeling of macroeconomic systems.

1. LITERATURE REVIEW

The political and economic changes that have occurred over the past 2-3 years put most of the states in front of the need to maximize the use of both viable links and the search for promising areas of economic interaction, with the aim of maximizing the economy in modern conditions. This caused interest in the development of effective models for diversifying foreign economic interactions, oriented toward implementation through information technology.

In McMillan (2012), Uk Heo (2014), Stankovsky (1990), Reeves (2016), Feng (2013), OECD (2011) models of foreign economic interactions of different countries are analyzed, features and reasons for their diversification are highlighted. These models are not universal, the main reasons that do not allow the use of the experience of these researchers in the field of modeling of foreign economic development are:

- narrow specialization of models built for the particular country or region;
- impossibility or excessive difficulty in practical implementation of models due to lack of required statistics;
- specific prerequisites, which are the basis for models that cannot be adopted in a crisis;
- orientation of models on the solution of particular issues of foreign economic interactions, for example, only investment or only cross-border interaction.

The possibilities of diversification at the national level and in the region, due to the creation of a stable economic environment and a good business climate, are considered in works of OECD (2011), Asche, Neuerburg, and Menegatti (2012), but for real diversification of foreign economic interactions, it is necessary to increase the scale of efforts at the level of governments to support the economic growth of new areas of the economy. The papers examined did not have formalized decision-making models.

In Tu and Zhou (2011), the rules of a combination of diversification strategies require more observations, which make the authors' approach rather cumbersome and time-consuming.

According to Miebs (2012), De Miguel, Garlappi, and Uppal (2009), the increase in productivity is due to the constant diversification effect between the portfolio strategies under consideration, as well as the empirical characteristics in the portfolio. However, the application of the averaging rules in their works is limited to portfolios with minimal deviations.

According to Derunova, Ustinova, Derunov, Semenov (2016), the model of diversifying foreign economic interactions should be based on the dependence of key macroeconomic indicators on the dynamics of energy prices, the implementation is proposed through a model of simultaneous equations whose endogenous variables include structural values reflecting the structure of national production systems. These models are described by systems of interdependent regression equations whose parameter values are unknown and are subject to estimation, which is difficult to do with qualitative indicators.

Also on the basis of the regression model of foreign trade analysis with trading partners, the proposals of Rose (2004) based on the impact of the accession of a particular country to the WTO on its foreign trade. The regression model includes the factors of the economic potential of the trading partners, the distance between Kiev and the partner country, as well as the dummy variables responsible for the foreign trade policy regimes between trading partners – mutual participation in the free trade zone, WTO, Generalized System of Preferences, which is granted only to the acceding country, some developed countries. However, the proposed models are applicable only for calculations within the WTO member countries; in addition, there are doubts about the possibility of collecting all the data required for parameterization for a sufficiently long period.

In Khrawish (2014), Chena, Zhongb, and Chenc (2014), models for assessing the risks of foreign economic interactions, allowing to identify the patterns of the evolution of a situation in which diversification is inevitable, are considered. The works examined had no practical implementation

in the form of experimental calculations of foreign trade activity in the simulation package.

Pace (2012), Roza (2004) analyzed the methodology of simulation modeling, on the basis of which they determined the potential magnitude of uncertainties for modeling results in various fields. An integrated approach to modeling uncertainty not only reduces the likelihood of incorrect conclusions from modeling results, but also provides information that can help determine where it is most appropriate to make efforts to reduce the uncertainty of simulation results to improve the accuracy of simulation results. Studies are not brought to the software implementation, and in fact a comprehensive assessment of the uncertainty of modeling has serious shortcomings.

Some studies that are universal in terms of the region for foreign trade have a number of other shortcomings, in particular, do not allow for practical calculations on available statistical data.

The main drawback of most approaches is the limitation of the region, for which the effect of foreign trade activity is estimated. Also, the difference in the level of neo-industrial development, which causes the low competitiveness of Ukrainian goods in the markets of developed countries, is practically not taken into account. Among other common drawbacks, one should note the use of regressions without taking into account the high probability of changing existing trends.

Thus, taking into account the controversy in the papers considered (McMillan, 2012; Uk Heo, 2014; Stankovsky, 1990; Reeves, 2016; Feng, 2013; OECD, 2011; Derunova, Ustinova, Derunov, Semenov, 2016), it is obvious that it is necessary to continue research on the further development of models and algorithms for diversifying foreign economic interactions. At the same time, it is necessary to focus attention on their implementation with the help of information technology.

The aim of the work is to develop a basic simulation model for diversifying foreign economic interactions of a conditional state, on the basis of which it would be possible to develop a set of models for assessing the influence of various regulators on foreign economic activity with the help of information technology.

2. METHODS

To date, we can identify the following areas of modeling of foreign economic development:

- assessment of the consequences of accession to various economic unions;
- evaluation of foreign trade cooperation between the two countries;
- evaluation of external economic development of individual regions, clusters, free economic zones, etc.

The model of diversification of foreign economic interactions is based on the following assumptions.

As economic agents in the model are considered:

- population, as a labor force and consumer of goods, which can be either of domestic production or imported;
- enterprises that convert labor and capital into gross domestic product;
- state A (conditional state), which affects the economic environment through economic regulators;
- partner states A, which purchase and sell goods and services;
- international organizations that provide loans and financial assistance.

Enterprises in the manufacturing of products interact with the public. The main indicator characterizing this interaction is the aggregate amount of wages. The cost of enterprises for wages determines domestic demand in the country for products of both domestic production and imported, which, in turn, spins the production cycle in terms of domestic consumption. External consumption is determined by partner countries.

A schematic diagram of the interaction of economic agents described by the model is shown in Figure 1.

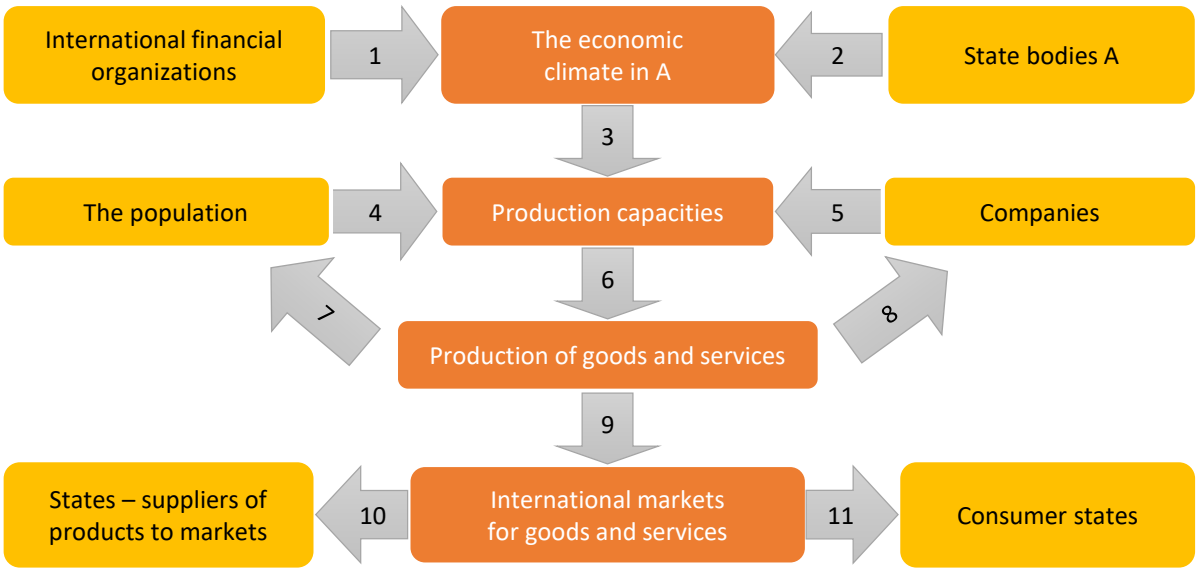


Figure 1. Schematic diagram of the interaction of economic agents

Let's assume that international financial organizations have a significant impact on the economic climate in A (conditional state). In view of the imbalance in budget A and the financial and economic crisis, it depends on external borrowing. A low credit rating does not allow to borrow from private creditors, so keeping the country from default entirely depends on international financial organizations (stream 1).

State bodies A are the main agents influencing the economic climate (stream 2). They affect many indicators that determine the ease of doing business, the purchasing power of the population, the level of inflation, the availability of financial resources, and so on. In the basic model of diversification of foreign economic interactions A of the set of regulators that characterize the economic climate, the indicator of the investment climate assessed by the European Business Association is chosen.

Also, various synthetic integrated indicators can be used, for example. Ease of Doing Business Index and the index of tax burden (Total tax rate). These indicators are estimated by the World Bank and are fairly objective, unlike many other indicators that are calculated by government A and carry a distortion. If the necessity and the accuracy of the model are increased, in addition to these indicators characterizing the economic climate in A, others can be added.

The economic climate in A determines the production capacity (stream 3), the main characteristics of which are labor costs and capital investments. At the same time, it is assumed that the capital that has been invested in the previous period has no more significant value to production capacity. This is explained by the fact that estimates of the residual value of fixed capital do not reflect its real capabilities. Some of the main capacities are obsolete and cannot be used with the same efficiency as the more modern ones. In addition, during periods of crisis, a significant part of the capacity is idle and their availability does not affect the results of the production function. Also, the most modern production facilities in the neo-industrial economy are sufficiently mobile and can be moved to other countries with more favorable investment and economic climate.

In accordance with the forecasts of demand for products and services, production facilities consume labor or labor (stream 4). It is provided by population A, and the measurement of labor consumption is realized in value terms. Such a measurement makes it possible to better establish the relationship between production volumes and labor costs than the measurement of labor in hours or the number of employed people. Also, the measurement of labor costs in the form of the amount of wages received by the population makes it possible to take into account the ad-

aptation of production to the change in demand for products. In case of an insignificant drop in demand, production declines, but in this case, employees are not usually dismissed, but transferred to a shorter working day, which affects the amount of wages.

In addition to the labor input in production, capital expenditures are used (stream 5). Capital is provided by enterprises, and the basic version of the model does not address sources of capital and does not involve economic agents such as financial intermediaries and banks. It is assumed that the capital investment, made in the previous one, has a major impact on production this year, that is, the average time for the development of capital investments is one year. Testing the hypothesis of a link between gross domestic product and capital investment in the previous year on statistical data confirmed this assumption.

Production capacity determines the maximum possible production of goods and services in A (stream 6). The description of the dependence of the gross domestic product on the outlays of labor and capital is carried out in the form of a production function with a constant elasticity of substitution. The measurement of the gross domestic product is proposed to be carried out at actual prices, with a view to harmonizing with the measurement of labor and capital costs. At the same time a transition can be made to the valuation in real prices for the purpose of further analysis of the influence of the economic policy of the authorities on the economic environment.

In turn, in addition to production capacity, the volume of production is determined by the demand for finished products and services. Consumers are the population (stream 7), enterprises (stream 8) and foreign markets. Consumption of the population is determined by its consumer sentiment and income. In turn, consumer sentiment is determined by wages in the previous period. Consumption by enterprises is determined by the multiplier of production activity.

The most important part of the model of diversification of foreign economic interactions A is the interaction of production of goods and services in A with external markets (steam 9). At the same time, interaction is carried out with suppliers of goods and services to the Ukrainian market (stream 10) and consumers of Ukrainian products (stream 11). Suppliers can have a negative impact on domestic production A in case of high exchange rate of its own currency and non-competitiveness of products manufactured in A. Consumers are more important economic agents, since A is an export-oriented country. The aggregate demand for its goods and services is determined on the basis of forecasts of GDP growth rates of consumer countries. In the basic model of diversification of foreign economic interactions A, demand is determined collectively for the seven types of goods and services. In the future, the model can be complicated by the allocation of foreign markets for the most important industries in individual sub-models. Let us assume that the key industries for A are metallurgy and agriculture.

The basic interrelations between the indicators of the model of diversification of foreign economic interactions A are shown in Figure 2.

Among the indicators that are described in the model of diversification of foreign economic interactions A, we can distinguish the following groups.

Regulators: investment attractiveness and, according to the assessment of the European Business Association, the minimum wage. The list of regulators can be expanded depending on the features of the analysis.

Basic external factors: price of steel (USD per ton); price of grain (Cereals Price Index); price of oil (USD per barrel); price of gas for A (USD per thousand cubic meters); GDP growth rates of partner countries (%); share of partner countries in Ukrainian exports (%).

Basic internal factors: costs of labor remuneration (million); capital investments (million); exchange rates of A against the dollar (USD); the exchange rate of A against the euro (EUR); domestic consumption (million); number of able-bodied population (thousand people); number of unemployed (thousand people); foreign trade balance (million USD).

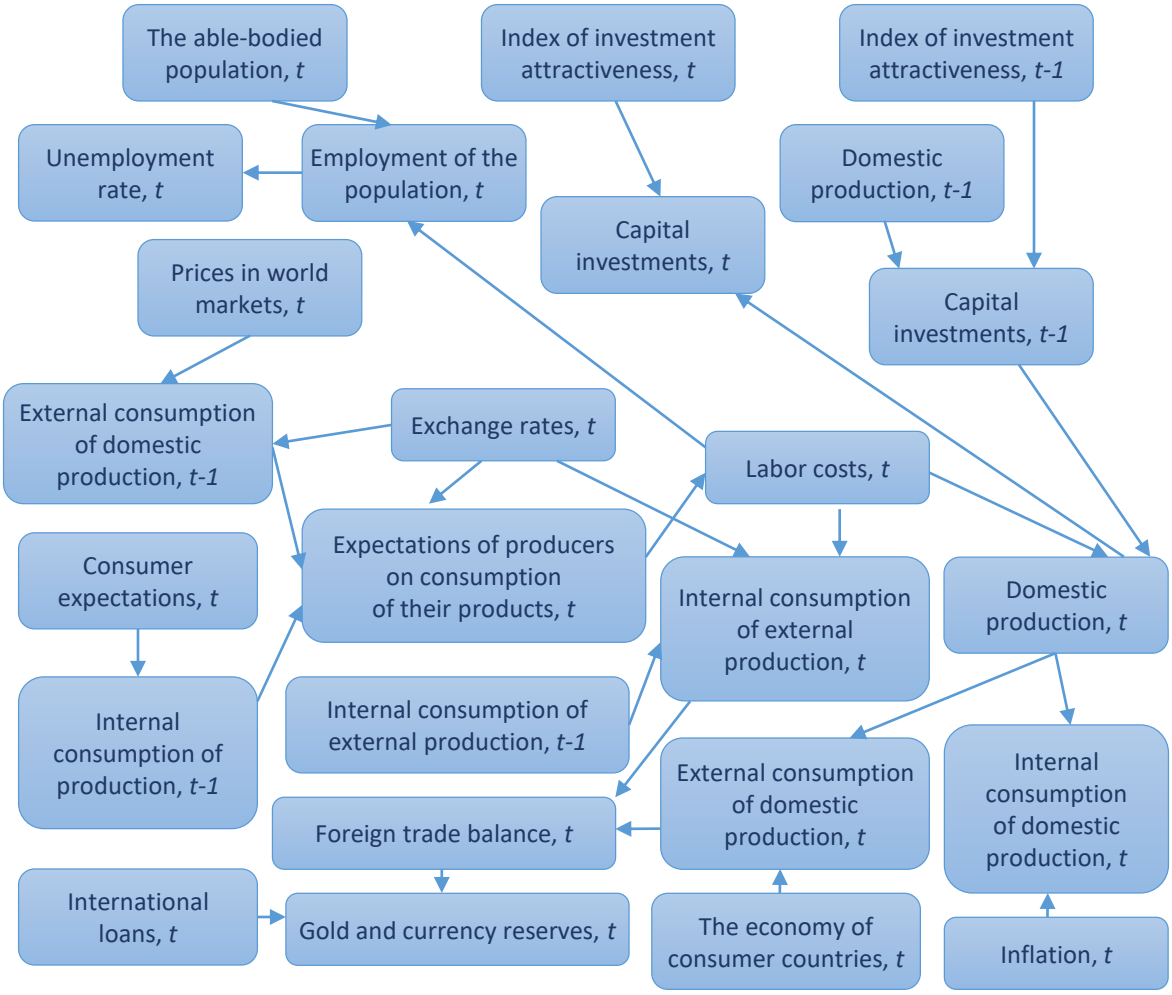


Figure 2. Scheme of the main interrelations between the indicators of the model of diversification of foreign economic interactions A

3. RESULTS

The model identifies three main groups of consumed products and services. The first is the internal consumption of products and services produced in A. And by internal consumption, we mean not only the final consumption by the population, non-profit organizations and state bodies, but also gross accumulation.

The second group – external consumption of products and services produced in A – is equal to the volume of exports from A to other countries.

The third group is the domestic consumption of products and services produced abroad, in fact, coincides with the volume of imports in Ukraine. In aggregate, the sum of the first and second groups, minus the third, is equal to the gross domestic product.

The production function, which determines the possibilities for the internal production of products and services, depending on the outlays of labor and capital, is a generalized non-uniform function with a permanent elasticity of substitution and has the form (Figures 3-4):

$$V_t = A\left(a\left(W_t\right)^{\alpha} + b\left(K_{t-1}\right)^{\alpha}\right)^{\frac{\lambda}{\alpha}}, \qquad (1)$$

where V_t – production of products and services in the A in the t-th period; W_t – expenses for payment of labor of the population in the t-th period; K_{t-1} – capital investments $t-1$-th period; A – parameter of neutral production efficiency; α – parameter characterizing the elasticity of substitution of production factors; a – indicator of the capital intensity of the production function; b – indicator of labor intensity of the production function; λ – parameter of the degree of homogeneity.

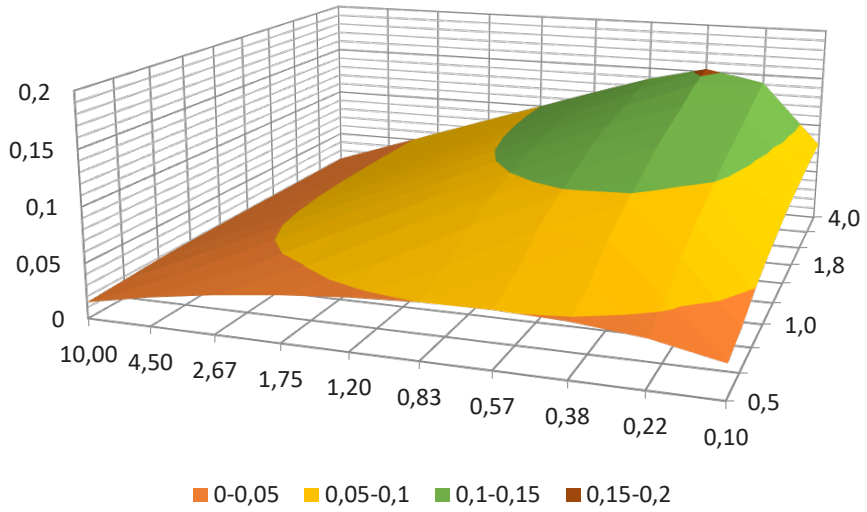


Figure 3. Dependence on elasticity (alpha) and the ratio of labor costs and capital W/K with the equality of labor and capital intensity

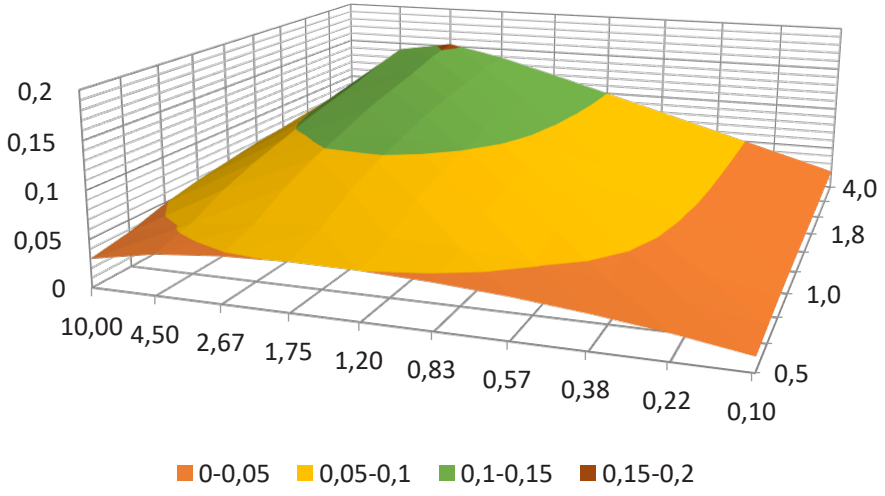
The distribution of domestic production for domestic and external consumption is based on the priority of exports. It is assumed that, first of all, the export demand is satisfied, and then the domestic one.

$$D_t^{EF} = D_t^E, \tag{2}$$

$$D_t^{MF} = min\left(D_t^M, V_t - D_t^{EF}\right), \tag{3}$$

where D_t^{EF} – estimate of the volume of satisfied demand for exports from A in the t-th period; D_t^E – the volume of demand for exports from the t-th period; D_t^{MF} – estimate of the volume of demand for consumption of domestic products in the A in the t-th period; D_t^M – the volume of satisfied demand for consumption of domestic products in the A in the t-th period; V_t – production of products and services in the A in the t-th period.

The aggregate demand in world markets for products manufactured in A (external consumption of products and services produced in A) is assumed to be inertial and proportionally dependent on the growth rates of the economies of consuming countries. That is, the aggregate demand in the current period depends on the demand in the past,



Note: if $w = k$, an even surface is obtained.

Figure 4. Dependence on elasticity and labor/capital intensity a/b for cases when $w = 3k$ and $w = 1/3k$

adjusted for the change in the real gross product of the countries that are consumers of Ukrainian goods and services. In addition, non-economic regulators are used for individual countries, which reflect the deterioration of political relations and trade wars.

$$D_t^E = L \cdot D_{t-1}^E \cdot T_t^E, \quad (4)$$

$$T_t^E = \sum_s e_t^s \cdot P_t^s \cdot R_{t-1}^s, \quad (5)$$

where L – the linear export growth factor; D_t^E – the volume of demand for exports from A t-th period; D_{t-1}^E – the volume of demand for exports from A t-th period; T_t^E – the growth rate of world markets in the t-th period; e_t^s – expert coefficient reflecting the change in the t-th period of economic interaction with the s-th country due to political factors; P_t^s – the growth rate of the gross domestic product of the s-th country in the t-th period; R_{t-1}^s – the share of the s-th country in the export of products produced in the A in $t-1$-th period.

Internal consumption of products and services produced in A directly depends on changes in consumer expectations and consumption in the previous period.

$$D_t^M = \mu_0 + \mu_1 \cdot ln\left(CP_t\right) + \mu_2 \cdot D_{t-1}^M, \quad (6)$$

where D_t^M – internal consumption of products and services produced in A in the t-th period; CP_t –consumer preferences in the t-th period; D_{t-1}^M – internal consumption of products and services produced in the A in the $t-1$-th period; μ_0, μ_1, μ_2 – function parameters.

Domestic consumption of products and services produced abroad (imports in A) depends on the current income of the population, and is also affected by the UAH exchange rate.

$$D_t^I = f^I\left(D_{t-1}^I \cdot EC_t \cdot W_t\right), \quad (7)$$

where D_t^I – the volume of imports in the A t-th period; D_{t-1}^I – volume of imports in the A $t-1$-th period; EC_t – change in the exchange rate of the currency of the A t-th period; W_t – costs of labor remuneration of the population in the t-th period.

The labor costs that enterprises are willing to incur in order to achieve the required volume of domestic production are determined on the basis of producers' expectations of consumption of their products. And these expectations are made up of the expectations of domestic consumption of Ukrainian production of the past period, taking into account changes in consumer expectations in the current period, as well as external consumption of Ukrainian production of the past period, taking into account changes in prices on world markets and the exchange rates in the current period.

$$W_t = f^{WM}\left(D_{t-1}^M, CP_t\right) + f^{WE}\left(D_{t-1}^E, EC_t, WP_t\right), \quad (8)$$

where W_t – the planned amount of labor costs for enterprises in the t-th period; f^{WM} – a function that reflects the dependence of producers' expectations on the demand for their products on the domestic market from consumption in the $t-1$-th period and changes in consumer preferences during the t-th period; D_{t-1}^M – internal consumption of production in A in the $t-1$-th period; CP_t – evaluation of consumer expectations in the t-th period; f^{WE} – a function that reflects the dependence of manufacturers expectations on the demand for their products on foreign markets from consumption in the $t-1$-th period and changes in prices of world markets and the exchange rate of the t-th period; D_{t-1}^E – internal consumption of production in A in the $t-1$-th period; EC_t – change in the exchange rate of the currency of the A t-th period; WP_t – index of changes in world prices for exported A products.

Capital investments are formed by enterprises based on the prospects for the next year. In turn, the prospects are determined by the results of production in A and the values of regulators of the economic climate in the current year. As a regulator of the economic climate, the index of investment attractiveness A from the European Business Association is used.

$$K_t = a_0^K \cdot \left(D_t^{MF} + D_t^{EF}\right)^{a_1^K} \cdot \left(IP_t\right)^{a_2^K}, \quad (9)$$

where K_t – capital investments in the t-th period; D_t^{MF} – internal consumption of products and services produced in the A in the t-th period; D_t^{EF} – export from A in the t-th period; IP_t – index of

investment attractiveness A according to the surveys of the European Business Association; a_0^K, a_1^K, a_2^K – function parameters.

Demand for export products abroad depends on aggregate demand in world markets and on changes in world prices. And it is assumed that the share of the world market is inertial and within one year there cannot be a significant change in the proportions between countries due to price changes. That is, the proportions of the physical volume of sales are preserved. With further development of the model, this element can be refined by developing a separate sub-model that takes into account the impact of changes in exchange rates and world prices on the redistribution of world markets for various types of goods and services.

$$T_t^E = P_t \cdot \sum_s e_t^s \cdot P_{t-1}^s \cdot T_t^s, \quad (10)$$

where T_t^E – is the growth rate of world markets in the t-th period; P_t – the index of changes in demand due to changes in prices in world markets the t-th period; e_t^s – expert coefficient reflecting the change in the t-th period of economic interaction with the t-th country due to non-economic factors; P_{t-1}^s – the share of the s-th country in the export of products produced in A in the $t-1$-th period; T_t^s – the forecast of the growth rates of the s-th country in the t-th period estimated by the World Bank.

In the basic model, only those countries with which A had the most developed foreign trade or groups of countries united by geography were identified as countries. Such countries and groups, for example, are:

- European Union;
- the countries of South and North America;
- countries of Africa;
- countries of Asia;
- other.

With further development of the model, additional allocation of countries that are major partners of A.

The index of changes in world prices for exported A products is determined on the basis of the share that the main groups of exported A products have in the total export volume.

$$WP_t = \sum_n \frac{GP_{n,t}}{GP_{n,t-1}} \cdot GC_{n,t}, \quad (11)$$

$$GC_{n,t} = \frac{GV_{n,t}}{\sum_n GV_{n,t}}, \quad (12)$$

where WP_t – index of changes in world prices for exported A products; $GC_{n,t}$ – the average price in the t-th period for n-th the group of goods or the price for a sample product from the n-th group (steel of a certain brand, grain of a certain class, etc.); $GP_{n,t}$ – the share that the n-th group in the price dimension is in A's exports; $GV_{n,t}$ – volume of the n-th group in the price measurement; n – index of a group of products.

The indicator of the change in the exchange rate during the t-th period allows us to take into account the structure of the export of A. At the same time, the countries of the Eurozone are selected (by default, they include the countries of the European Union, distortions made by EU countries that have not moved to the Eurozone are insignificant). Foreign trade with other countries is considered in US dollars. The proportions of exports between groups of countries are estimated at the last known actual value.

$$EC_t = \frac{K_t^{USD}}{K_{t-1}^{USD}} \cdot \frac{1 - CV_{t-1}^{EU}}{CV_{t-1}} + \frac{K_t^{EUR}}{K_{t-1}^{EUR}} \cdot \frac{CV_{t-1}^{EU}}{CV_{t-1}}, \quad (13)$$

where EC_t – the change in the currency exchange rate of the A t-th period; K_t^{USD} – forecast of the exchange rate of A against the US dollar in the t-th period; K_{t-1}^{USD} – the actual value of the exchange rate of A against the US dollar in the $t-1$-th period; CV_{t-1}^{EU} – the volume of exports from A to the countries of the European Union in the $t-1$-th period; CV_{t-1} – the volume of exports from A in the $t-1$-th period; K_t^{EUR} – the actual value of the exchange rate of A against the Euro in the $t-1$-th period.

In the future, the model can be refined by entering into it other currencies, in particular, the Chinese Yuan, which will improve the accuracy of forecasting and take into account the change in purchasing power as a result of devaluation or strengthening the currencies of other countries.

The peculiarity of the developed model of diversification of foreign economic interactions is its functioning as a complex dynamic system in which many factors are interrelated, and the connections are dynamic. This allows to calculate an imitation model that takes into account hidden and subtle connections. At the same time, the parameterization of the model is carried out for each parameter separately, by the methods of correlation regression and cluster analysis. Therefore, when assembling a model from a set of private links into a single dynamic simulation model, it is necessary to perform its additional tuning. This will allow to check the relevance and adequacy of the identified links, in addition, the hidden and unobvious connections between factors. The development of this model can be increased in the number of regulators considered.

CONCLUSION

Thus, the developed basic imitational model of diversification of foreign economic transactions allowed us to assess the mutual influence of key economic indicators and their responses to changes in the equilibrium in the world markets.

For our purpose there was developed a model of diversification of foreign economic interactions, the feature of which is its functioning as a complex dynamic system, in which many factors are interconnected, and the links are dynamic. This makes it possible to calculate a simulation model that takes into account hidden and subtle connections.

The implementation of this model can be carried out in any simulation package, in particular, experimental calculations of foreign trade activity (conditional state) in 2016 implemented in a package PowerSim Studio, it is proof that the model is ready to solve real practical problems.

Effective diversification of foreign economic interactions is impossible without a scientifically substantiated and supported by the calculations scenario, which reflects the most likely trends of the target economic indicators under given conditions. At the same time, the correspondence of the theoretical model to the trends actually existing in the economy should be carried out before the practical operation begins, with minimal subsequent adjustments.

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