“GDP modelling: assessment of methodologies and peculiarities of its usage in Ukraine”

AUTHORS	Serhii Kvasha https://orcid.org/0000-0001-7448-0543 Nadiia Davydenko https://orcid.org/0000-0001-7469-5536 Yurii Pasichnyk https://orcid.org/0000-0001-9742-1378 http://www.researcherid.com/rid/I-1421-2018 Tetiana Viatkina https://orcid.org/0000-0002-2060-0818 Natalia Wasilewska https://orcid.org/0000-0001-8638-4735

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Serhii Kvasha, Doctor of Economics, Professor, Academician of the National Academy of Agrarian Sciences of Ukraine, Vice Rector for Academic Affairs, National University of Life and Environmental Sciences of Ukraine, Ukraine.

Nadiia Davydenko, Doctor of Economics, Professor, Head of Department of Finance, National University of Life and Environmental Sciences of Ukraine, Ukraine.

Yurii Pasichnyk, Doctor of Economics, Professor, Professor of the Department of Finance, National University of Life and Environmental Sciences of Ukraine, Ukraine.

Tetiana Viatkina, Doctor of Economics, Professor, Head of the International Tourism Department, Kyiv International University, Ukraine.

Natalia Wasilewska, Doctor of Economics, Professor, The Jan Kochanowski University –JKU in Kielce, Poland.

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Serhii Kvasha (Ukraine), **Nadiia Davydenko** (Ukraine), **Yurii Pasichnyk** (Ukraine), **Tetiana Viatkina** (Ukraine), **Natalia Wasilewska** (Poland)

GDP MODELLING: ASSESSMENT OF METHODOLOGIES AND PECULIARITIES OF ITS USAGE IN UKRAINE

Abstract

GDP is one of the main indicators determining the level of economic growth in countries and regions across the globe, therefore, its calculation should be based on the advanced methodology. In the present context, the existing methods of the GDP calculation do not fully meet the fineness criterion subject to certain objective and subjective reasons. Hence, the development of more perfect methodology that takes into account the disadvantages of the existing techniques and is based on economic and mathematical modeling is an urgent national task for Ukraine. The purpose of the article is to assess the GDP calculation methodology used in Ukraine. To achieve this purpose, the relevant methods of GDP calculation, which are valid in Ukraine, have been analyzed, their specifics, certain drawbacks, problems of use and application scenarios have been also revealed. According to the analysis results, an advanced methodology based on an economic and mathematical model with the use of dynamic programming is proposed. The developed methodology for calculating the GDP takes into account the peculiarities of social development in Ukraine and the tendencies of world economic processes and contributes to obtaining more reliable GDP values. It will be useful for experts in financial institutions, including international ones, and scholars working in the macroeconomic modeling area.

Keywords economic growth, alternatives to GDP, impact factors

JEL Classification C65, E28, O11

INTRODUCTION

Nowadays, GDP has been formally recognized as a key indicator of economic development, but not all experts agree with this criterion. Despite the fact that search for more complete criterion continues, this indicator is now generally accepted. It should be noted that GDP, both in a given country and in the world, plays an important role in economic development, because calculations of payments between states and international organizations are formed based on this criterion, and, at the national level, budgetary expenditures, social norms, financing of individual industries, etc. are developed.

Despite the presence of reputable international institutions involved in GDP forecasting, in particular, the World Bank, specialized financial agencies, including the International Monetary Fund, Moody's, and, at the state level, central banks, ministries, which use the services of specialists while developing their forecasts, it is now quite difficult to make a forecast even at the level of an individual country during the year. So, with regard to the GDP forecast in Ukraine in 2018, these organizations announced different values – from 3.2 to 3.5% (World Bank, 2018; IMF, 2018; Moody's Investors Service, 2018; Ministry of Economic Development and Trade of Ukraine, 2018). A similar situa-

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tion is observed in relation to other countries and regions of the world, in particular the EU. These facts indicate rather complicated national, regional and world processes that, in the context of globalization, create unforeseen consequences that are difficult to consider when calculating the GDP. Consequently, for Ukraine, GDP forecasting is an important scientific and practical issue that needs to be solved via the development of advanced methods and the use of economic and mathematical modeling.

1. LITERATURE REVIEW

Given the GDP significance for social development, in Ukraine and in other countries, this problem is constantly getting considerable attention both from scientists and relevant experts. At the same time, it should be noted that GDP, as a universal criterion, does not reflect all aspects of economic development, in particular, labor, demographic, and environmental, under current conditions. It also does not suggest comparing the qualitative changes between countries and regions of the world, especially the standard of living of the population. That is why, in 2008, the Commission on the Measurement of Economic Performance and Social Progress was created under the patronage of the then French President Nicolas Sarkozy to develop another criterion. Joseph Stiglitz headed the Commission, Amartya Sen was an Economic Advisor, and Jean-Paul Fitoussi was a Commission Coordinator. The Commission was empowered to develop a more advanced indicator that would take into account all elements of the development of a country, and not just market transactions, as it is now (Stiglitz, Sen, & Fitoussi, 2010). In addition, van den Bergh (2009), Stiglitz, Sen, and Fitoussi (2010), and Daly (2013) do not consider GDP the optimal criterion for economic development and suggest other alternative criteria that are the evidence of inefficiency and the search for alternatives to GDP.

Stiglitz (2015), while describing the global 2007–2008 financial crisis, noted that per capita GDP cannot draw conclusions about the US economy, since the enormous social stratification in the last 30 years made this indicator meaningless.

Stewart Wallis, Executive Director of the New Economy Foundation (NEF) (by December 2015), together with the United Kingdom Office of National Statistics, proposed five indicators for measuring economic development, namely Goodjobs, Wellbeing, Environment, Fairness, and Health (Wallis, 2016). Although these indicators have been developed for United Kingdom, they can also be used for other countries. At the World Economic Forum held in Davos in 2018, an alternative system for assessing the economic development of countries was proposed.

Decades of prioritizing economic growth over social equity have led to historically high levels of wealth and income inequality and caused governments to miss out on a virtuous circle in which growth is strengthened by being shared more widely and generated without unduly straining the environment or burdening future generations. These are the findings from the World Economic Forum's, which is released today (The Inclusive Development Index, 2018).

Excessive reliance of economists and policy-makers on Gross Domestic Product as the primary metric of national economic performance is a part of the problem, since GDP measures current production of goods and services rather than the extent to which it contributes to broad socio-economic progress, as manifested in median household income, employment opportunity, economic security and quality of life.

The Inclusive Development Index is an annual assessment that measures how 103 countries perform on 11 dimensions of economic progress in addition to GDP. It has three pillars: growth and development; inclusion; and intergenerational equity – sustainable stewardship of natural and financial resources (The Inclusive Development Index, 2018). Taking into account the validity of this system for calculating the main criterion of economic development, it is possible to use it in the near future, but, nowadays, GDP is used as formally recognized criterion.

Currently, in order to justify the methods of calculating the GDP within the three pillars, the scientists offer different research articles – from analytical reviews to specific proposals using the appropriate models.

1.1. Descriptive method

Kuzminov (2014) analyzed the existing methods of economic growth and suggested that today not their lack, but their negligent use is the main problem. Kravchuk (2018) investigated the sectoral structure of the Ukrainian economy with a distinction of their share in GDP, but he did not determine the reasons for changes in the GDP dynamics. The methodology proposed by Odhiambo (2014) takes into account the dynamics of FDI inflows and economic growth in six low-income SADC countries, namely, the Democratic Republic of the Congo, Madagascar, Malawi, Mozambique, Tanzania and Zimbabwe. He analyzed policies and strategies that have been introduced in these countries to attract foreign direct investment and to encourage economic growth. The study also highlights some problems and difficulties inherent in these countries in attracting foreign investment. However, the author did not specify the use of analytical techniques. Consequently, the proposed methods of this direction are based on the identification of individual components of economic growth, but without adequate analytical substantiation.

1.2. Analytical method

Kvasha (2013) substantiated the methodology that takes into account analytical decision making that promotes the growth of the agricultural sector, which is now actively developing and is about 10-12% of GDP. The peculiarity of Pasichnyk's methodology (2016) is taking into account the role of debt and borrowing in economic growth. Davydenko (2015) determined the directions of the foreign investment impact on the development of the agricultural sector of the economy. Kolot (2009), while substantiating the methodology, outlined theoretical and applied aspects of the transformation of the employment institute with the development of non-standard forms and the introduction of new time management models that have a significant effect on economic development, but, according to the purpose of the study, the level of changes in this development in the quantitative measurement was not considered. Stukalo's methodology (2010, 2013) is based on the analysis of the economic development of the world economy and individual foreign countries, but the study was not aimed at revealing the mathematical relationships between the factors of this development. Maverick (2016) proposed a methodology that takes into account the influence of the shadow economy on GDP and concluded that the US economy could be larger by 7-11% due to withdrawal from the shadow economy, and the economy of the United Kingdom – 4% larger. The author proposed ways to manage the economy, but his calculations are not based on specific models. Amadeo (2018) analyzed the economic development of Germany, the EU, China, the United States, India and Japan, and concluded that Germany had one of the best GDP growth rates in 2017 due to the Eurozone membership, mixed economy, and fight against unemployment. Also, changes in the GDP dynamics of Germany during the period 2016–2017 were analyzed and the influence of individual factors on this change was identified, but the number of these factors was limited. The research was carried out according to the purchasing power criterion and did not aim to find out the reasons for this situation. Tnani (2018) identified the relationship between economic growth, CO2 emissions, and innovation for the countries with the highest patent applications and evaluated the combination of the changes studied. The results show that, in addition to China, economic growth is largely due to electricity generation, population size, CO2 emissions, and R&D costs. Innovations have had less impact on the economic growth.

These papers analyze the dynamics of the development of individual economic sectors, the role of investments, in particular foreign ones, in economic growth, as well as approaches to the GDP growth rates. Representatives of this direction apply the methods for GDP calculation using comparison, table-graph technique, analysis, etc. It is possible to use a mathematical apparatus technique, but without simulating the formation and forecasting of the GDP.

1.3. Methods based on GDP forecasting using economic and mathematical modeling

Novikova (2014) proposed a method of forecasting the GDP based on artificial neural networks, which include structural modeling taking into account four impact factors, but projection data are not calculated. This method allows for ap-

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propriate calculations, but does not take into account future events that have a significant impact on GDP in Ukraine. Semenenko, Boiko, Vodchyts, Dobrovolskyi, and Kremeshnyi (2014) tried to forecast the GDP of Ukraine by 2030, using four impact factors, but this proved to be insufficient, and ignoring the factor of the hryvnia exchange rate against the dollar has led to the fact that from 2015 onwards, the forecast values differed from the actual ones substantially. Dritsaki (2015) modeled and projected the real GDP figure of Greece using Box-Jenkins method for the years 1980–2013. Using this method, the real GDP indicator for the period 2015–2017 has been determined and real GDP of Greece is concluded to be constantly improving.

In practice, central statistical authorities and international financial organizations calculate the GDP according to specific methods.

State Statistics Service of Ukraine (2018) calculates the GDP in nominal and real terms. The specifics of these calculations is that the nominal GDP is calculated at the actual prices of the current year, and the real one is determined at previous or another year values adjusted for inflation. Nominal and real GDP can be measured in national or other currencies, in particular USD. To calculate the GDP, three methods are used: production-based (by value added); distributive or profit-related (by distribution); and cost-based (by end use). In the final analysis, all three methods should yield the same result. State Statistics Service of Ukraine also discloses the GDP according to the Purchasing Power Parity (PPP), which is calculated taking into account the value of all final goods and services that have actually been sold in the country for the past year and are recalculated according to PPP. It is measured in percentage to the previous year. However, these methods are not perfect because of the complexity of obtaining reliable data on enterprises, especially those registered in Ukraine, but located in the temporarily occupied territories of Donetsk and Luhansk regions, seasonal fluctuations in inflation and the UAH exchange rate, etc. Given the importance of defining the GDP and the lack of practical and scientific substantiation of the calculation methods, it is expedient to analyze this problem.

2. METHODS

The study of GDP modeling processes should be based on methods that are implemented using the analysis of the social system of Ukraine, in the structure of which the corresponding components of GDP are formed, and on the development of an optimal methodology for calculating this indicator. The systemic method, which allows to investigate how things unfold in complex unbalanced systems, which is currently the Ukrainian economy, meets these requirements. To analyze the main macroeconomic indicators of Ukraine in dynamics, benchmark method, synthesis and comparisons are used. In order to identify the impact of individual components of the social system on GDP, the correlation method has been applied. The development of a methodology that improves the existing one, involves the GDP calculation and is carried out using economic and mathematical methods, in particular, dynamic programming. The dynamic method has been selected as allowing one to predict the state of the selected research object, taking into account changes in the parameters of this object under the influence of various factors over a certain period of time. Given that usually GDP indicators in the future are formed ranging from the maximum value to the minimum one, the tools of dynamic programming allow to obtain optimal results.

3. RESULTS

GDP is formed in the environment of a country, group of countries, or regions of the world. In the case of a certain country, under the influence of external and internal processes, which form impact factors, the social production process is realized, as a result of which the appropriate economic climate is determined. This situation is characterized by specific indicators, in particular GDP, which, as a resulting indicator, synthesizes the actual possibilities of economic development. GDP calculation, both in actual and in predicted terms, is a complex process when practical experts and scientists take part in practical calculations. Each country develops its own methodology according to national regulations, which must be in line with international standards. Given the need to regulate the

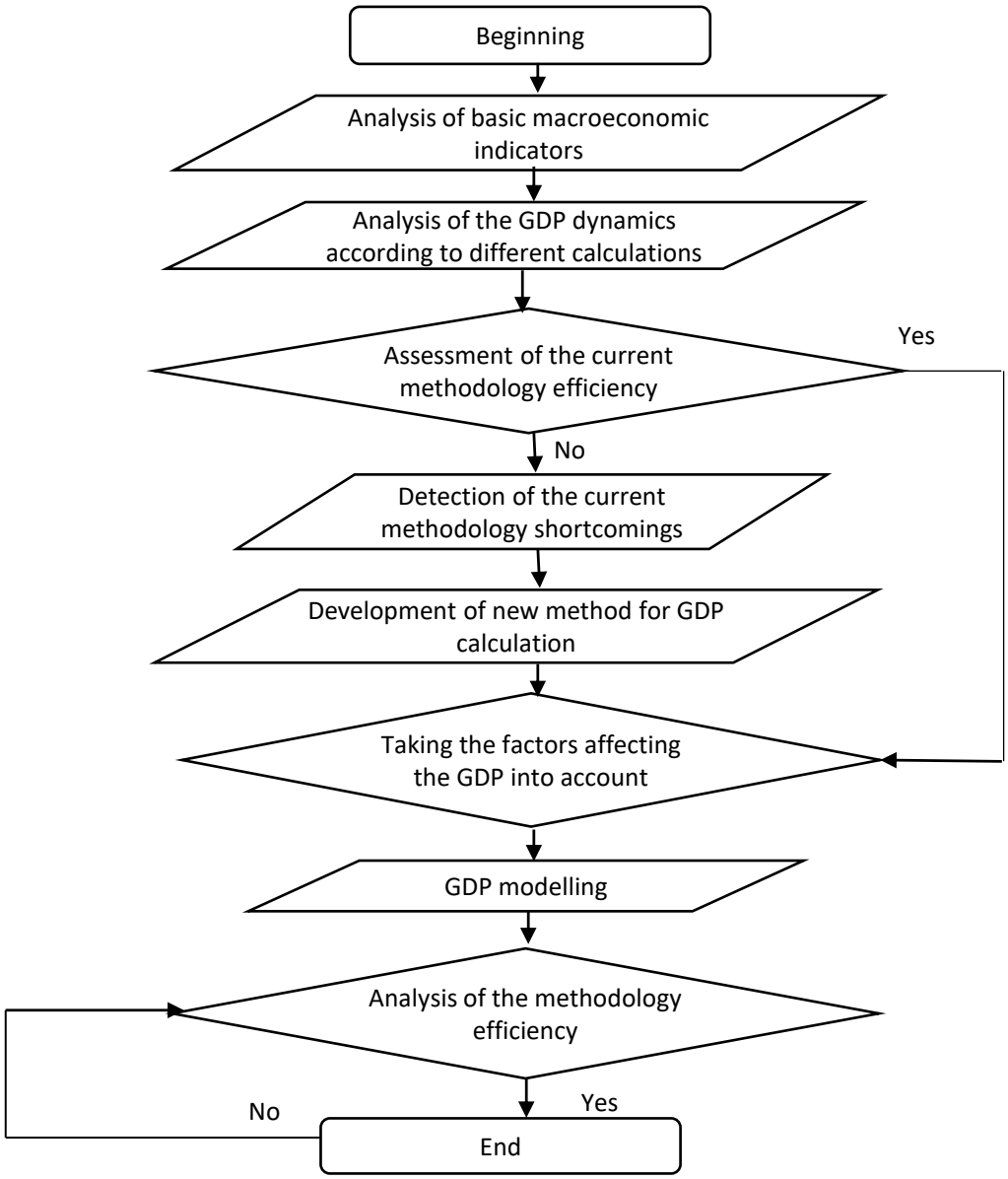

Figure 1. Algorithm for conducting the research on formation of the methodology of GDP modelling

research process and in order to ensure the effectiveness of obtaining a more perfect method for GDP calculation, the appropriate algorithm is determined (Figure 1).

The proposed algorithm takes into account all the main stages of the study, which involve obtaining optimal results of forecasting the GDP. The stages of the study include: analysis of the existing techniques used in Ukraine, identifying their drawbacks and developing an advanced methodology based on economic and mathematical modelling using dynamic programming.

Given that GDP resources are formed in the Ukrainian environment, it is expedient to find out the main characteristics of this environment. In order to compare indicators in the dynamics for the period 2007–2017, they will be submitted in UAH and USD terms (Table 1).

The analysis of these indicators revealed the following trends:

- significant instability across all indicators in USD terms due to a great UAH depreciation against the USD;

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Table 1. Analysis of basic macroeconomic indicators of Ukraine

Source: State Statistics Service of Ukraine.

Indicators	Years										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nominal GDP											
UAH bln	721	948	913	1,082	1,302	1,409	1,452	1,567	1,979	2,262	2,909
USD bln	143	180	117	136	163	176	177	130	91	93	109
Total public debt											
UAH bln	88.7	189	317	432	473	516	584	1,100	1,572	1,929	2,142
USD bln	17.6	36	39.7	54.3	59.2	64.5	73.1	69.8	65.5	71	76.3
Minimum official wage (at the end of the year)											
UAH	460	605	744	922	1,004	1,134	1,218	1,218	1,378	1,600	3,200
USD	91	115	96	116	126	142	152	102	63	63	120
FDI											
USD bln,	9.9	10.9	4.8	6.5	7.2	8.4	4.5	0.4	3.0	3.3	2.2
UAH bln	50	57.3	34	51.5	57.4	70.3	36	4.7	65.5	84.3	58.5
Exports											
USD bln	64	85	54	69	89	89	85	65	48	46	54
UAH bln	323	445	424	549	708	717	682	770	1,045	1,174	1,430
Imports											
USD bln	72	99	56	72	98	105	101	70	50	52	61
UAH bln	364	521	439	581	779	835	806	834	1,084	1,323	1,619
Imports over exports											
USD bln	8	14	2	3	9	16	16	5	2	6	7
UAH bln	41	76	15	32	71	118	124	64	39	149	189
Inflation, %	6.6	22.3	12.3	9.1	4.6	–0.2	0.5	24.9	43.3	12.4	13.7
Unemployment rate, %	6.9	6.9	9.6	8.8	8.6	8.1	7.7	9.7	9.5	9.7	9.9
UAH to USD exchange rate, yearly average	5.05	5.26	7.79	7.93	7.97	7.99	7.99	11.89	21.84	25.55	26.6

- weak attraction of foreign direct investment, which have significant fluctuations over the years. This testifies to significant problems in the investment environment;
- permanent excess of imports over exports, which is a manifestation of insignificant competitiveness of domestic commodity producers;
- significant inflation outbursts – from deflation of 0.2% in 2012 to 43.3% of inflation in 2015, conditioned by the influence of negative external and internal factors;
- low social standards, which results in low incomes of the population.

These indicators are a reflection of all processes occurring in Ukraine, and, accordingly, they affect the GDP volume. As these indicators are characterized by instability during the period under study, it is obvious that they adjust the GDP accordingly. The GDP dynamics in different units of measurement as a percentage of the previous year will be further analyzed.

While comparing and analyzing the volumes of GDP, calculated according to separate currencies and according to different methods, significant fluctuations can be revealed, which testify to the unsustainable development of the economy. This is influenced by various factors, which determine the corresponding GDP, in particular:

- in UAH terms: during the period under study, the decline was recorded in comparison with 2009, 2012, and 2016 due to the consequences of the global 2007–2008 financial crisis and the instability of the social environment during the period 2014–2016;
- in USD terms: the decrease occurred in 2009, 2014–2015, when compared to the previous

Source: Ministry of Finance of Ukraine.

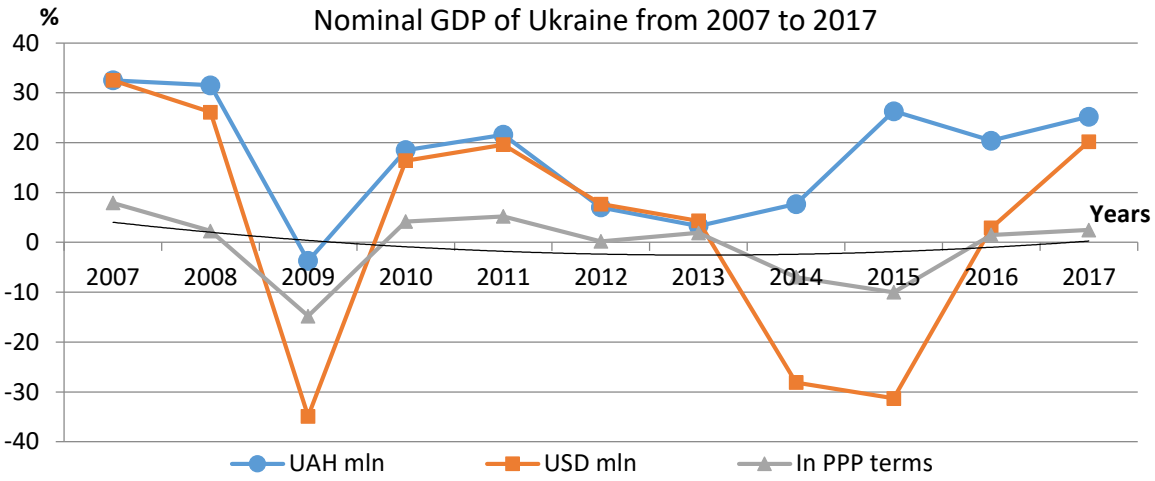

Figure 2. Comparing the GDP dynamics according to different calculation scenarios

years, caused by the same factors as for GDP in UAH terms, but the decrease of the indicators in those years was much higher, which is caused by significant UAH depreciation against USD in the period 2014–2015;

- in PPP terms: given that the nominal GDP is adjusted to inflation, where significant fluctuations are also recorded, especially in 2009 and 2014–2015, the deviations are somewhat lower than in other terms.

Thus, it can be concluded that GDP is significantly influenced by both internal and external factors, which was particularly evident in 2009, when all GDP values fell in three terms, and during the period 2014–2015, when internal social disturbances almost suspended economic development.

Given the complex social processes that negatively affected the GDP, it is obvious that it is extremely difficult to calculate and predict current GDP values.

Let's evaluate the efficiency of the current methodology for calculating the GDP with an emphasis on the production-based method (by value added). It should be noted that State Statistics Service of Ukraine calculates the actual values of GDP, and Ministry of Economic Development and Trade of Ukraine is in charge of the predicted values. In Ukraine, State Statistics Service of Ukraine defines the GDP as a macroeconomic indicator that shows the market value of all final goods and services produced in a year in all sectors of the economy on the territory of the state for consumption, export and accumulation, regardless of the nationality of production factors used (State Statistics Service of Ukraine, 2018). Using this definition, one can conclude that GDP is an integral indicator of the country's economy. It determines the final result of the production activity of economic entities and is measured by the aggregate value of goods and services produced by them for the ultimate use. These calculations are based on the international standards of the National Accounts System 2008 and the European System of National and Regional Accounts 2010. Actual GDP and its components are calculated taking into account the seasonality using the DEMETRA program, which is based on the TRAMO/SEATS method. Calculations of quarterly and annual GDP data are based on the National Accounts System (NAS) international standards approved in 2008 by the Commission of the European Communities, the International Monetary Fund (IMF), the Organization for Economic Cooperation and Development (OECD), the United Nations, the World Bank, and the European System of National and Regional Accounts 2010 (Eurostat, 2013). In order to ensure comparability of statistical data for Ukraine and the European Union countries, the basic 2010 prices were adopted in real terms. According to international standards, GDP and its components in fixed prices of the base year are non-additive due to changes in the weight structure of indicators.

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State Statistics Service of Ukraine calculates the GDP according to the production-based method (State Statistics Service of Ukraine, 2018):

$$GDP = \sum_{i=1}^{3} GDP_1 + GDP_2 - GDP_3, \quad (1)$$

where GDP – Gross Domestic Product calculated using the production-based method, GDP – amount of gross added values of all economic activities, GDP_2 – product taxes, GDP_3 – product subsidies.

Given the methodology analysis, the current environment in Ukraine and the main world trends, the following drawbacks of this methodology have been revealed both in practical application and in forecasting:

- at the statistical level: fluctuations with significant changes in UAH against other currencies exchange rate, the recalculation of export-import transactions in trade operations, price discrepancies in evaluating the products, while releasing and selling cause some inaccuracies;

- at the enterprise level: the complexity of calculating the volumes of manufactured and sold products with the change in sales prices for the same product group, final appraisal of commodities, intentional reduction of output or tax payments, writing-off products for various production or implementation reasons, which also makes adjustments to GDP volumes. There are also problems with the reliability of data on enterprises located in temporarily occupied territories, but registered in other regions of Ukraine;

- at the household level: certain formality in determining the physical volumes of products, in particular for agricultural purposes, given that its proportion for its certain types, namely honey, milk, fruit and vegetable crops, is quite significant; therefore, it is a priori difficult to determine the volume of GDP because of different prices in different regions and because of seasonal fluctuations;

- at the psychological level: the human factor in this process can also play a significant role. Thus, in recent years, quite a significant level of shadow economy has been recorded in Ukraine, which, according to various estimates, fluctuates within 35-45%. This, along with corrupt manifestations, makes important adjustments in the GDP calculation. In addition, this influence may result in staff inattention, regulatory and guidance documents obscurity, in particular tax law, personnel incompetence, mercenary motives, etc., which also impacts the reliability of the GDP calculation.

Additional disadvantages when forecasting GDP can be: the complexity of taking into account the numerous force majeure circumstances that arise quite often in the unstable Ukrainian public environment, including external ones; traditional discrepancies between estimated and actual data at the end of the reporting period at the UAH rate, inflation rate, debt borrowing, especially external one, changes in the external market situation, etc. Consequently, there are weighty arguments regarding the improvement of the current methodology for calculating the GDP.

The advanced method for GDP forecasting will be developed using the following provisions:

- systematic approach has been chosen as the key method;

- GDP is a resultant indicator of the entire economic system functioning;

- the formation of GDP, including in the long run, is influenced by the domestic and world trends that have emerged in the previous period;

- taking into account changes in the economic development parameters, which must be conditioned by actions of the authorities at all levels, in particular: reform implementation; development plans for economic sectors; economic entities' plans taking into account investment; increasing the level of management professional competence at all levels; control over inflation processes, UAH exchange rate; avoidance of social unrest, etc.;

- considering the Ukrainians' way of thinking, which forms specific features of the economic system, in particular the shadowing of the economy, corruption manifestations, inefficient management decision making, etc.;

- using domestic experience in forecasting the GDP, avoiding the shortcomings of the existing techniques as much as possible, ensuring the development of new mechanisms, methods, in particular in statistical accounting, which in aggregate will facilitate the obtainment of real or documented data;

- applying dynamic programming, which is based on the gradual consideration of the states of the economic system and is combined with the systematic approach.

Taking into account the typical scheme of dynamic programming, this research uses four stages, namely collecting and processing of information arrays, theoretical substantiation of predicted phenomena, processes, etc., analysis and evaluation. As for the data collection, one can note that forecasting the GDP, which needs a large number of experts from various areas of expertise, can be effectively implemented only under relative political, economic, demographic, military, and social stability of society. According to domestic experience, any GDP forecasts in Ukraine, which were developed by 2014 for several years in advance, have not been confirmed. That is why, assuming gradual social stabilization in Ukraine, it can be argued that the proposed methodology can be used.

While theoretically substantiating the keynotes, the influence of factors on the GDP formation will be found out and the actual structure of GDP in 2017 will be analyzed.

To find out the influence of factors on the GDP volume, it will be viable to explore their meaning in more detail. Note that according to the systematic approach, any element, in this case, it is an economic entity, is affected by the external and internal environment, where the relevant factors are developed. As an example of negative factors influence on the GDP formation, four groups of factors having the greatest impact on GDP will be described.

Political factors. In Ukraine, these factors, both external and internal, do not ensure the implementation of certain reforms in the judicial, law-enforcement, medical, innovation, etc. areas, which in aggregate does not contribute to the economy development. Also, the contentious relationship with Russia due to the unpredictability of military actions has a significant impact on GDP.

Social factors. The low wages make our compatriots go abroad in search of more decent wages. This fact does not contribute to increasing production volumes, deductions for budgets of all levels, and filling the Pension Fund revenues. The growing volumes of the cumulative public debt and the permanent deficit of the state budget make it impossible to raise social standards that does not ensure the good life of large segments of the population.

Military factors. Permanent military actions in the East of Ukraine are forced to adjust the functioning of enterprises, especially the military industrial complex. It should be noted that about 15% of the economic potential of Ukraine is currently in uncontrolled territories.

Economic factors. The above factors do not contribute to the dynamic development of the economy, in particular to the formation of an attractive investment climate, the optimal functioning of small and medium-sized businesses, the development and implementation of new technologies, and the effective functioning of the regions.

All these factors together form a quasi-economy, which is costly, has high level of shadowing and is slowly reformed.

It is necessary to find out the current state of GDP structure. The financial basis of the GDP is the body of economic entities and institutions that are united into the relevant branches. The proportion of the economic sectors in GDP in 2017 is given in Figure 3.

An analysis of the actual structure of GDP for 2017 confirms insufficient use of available economic potential, in particular low volumes of basic industries in Ukraine – processing industry, agriculture, transport and a quite high share of wholesale and retail trade, public administration. Also, de-

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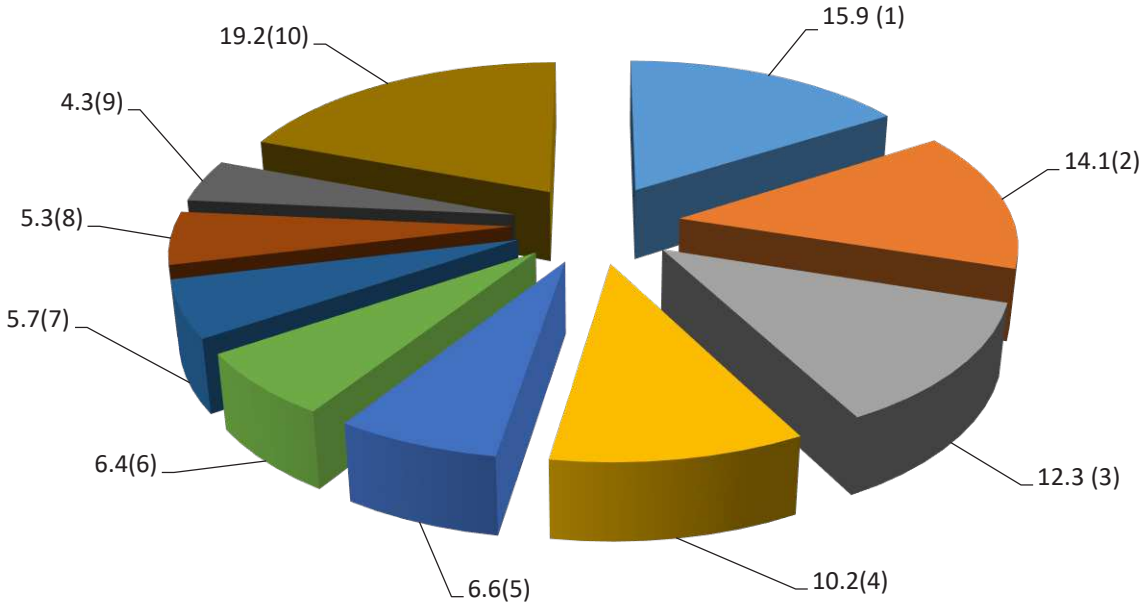
Source: State Statistics Service of Ukraine.



Note: The constituents are in parentheses: 1 – product taxes, 2 – wholesale and retail trade, 3 – processing industry, 4 – agriculture, 5 – mining industry, 6 – transportation, storage facilities, postal service, 7 – real estate transactions, 8 – government control, defense, compulsory social insurance, 9 – education, 10 – other.

Figure 3. GDP structure according to economic sectors in 2017

spite the low purchasing power of Ukrainians, the share of product taxes is quite significant. These data confirm the general inefficiency of the domestic economy. At the analytical stage, appropriate calculations will be made to determine the extent to which the influence of the elements and factors of the economic system on GDP is significant. Exports of goods and services, total public debt, foreign direct investment will be taken as elements, and unemployment rate, inflation rate, the UAH to USD exchange rate will be used as factors. The analysis will be done using the EXCEL software environment. The data interpolation is performed and the equations obtained are shown in Figures 4 and 5.

The analysis performed according to the determination coefficients of R^2 revealed that GDP is influenced insignificantly by the inflation rate and foreign direct investment, while unemployment rate has a meaningful influence and the UAH to USD exchange rate and total public debt influence GDP significantly.

Let's determine the tools for dynamic programming for GDP modelling. Note that governing bodies of economic system, within which GDP is formed, must be effective.

$$E = f\left(A_1 + A_2 + ... + A_n\right) \to \max, \qquad (2)$$

where E – economic system efficiency, A_1, A_2, … A_n – economic system elements.

To implement the final stages of the methodology for GDP forecasting, the corresponding model will be formed. Given that dynamic programming allows for determining the state of the research object, GDP in this case, in the time measurement, one year as a basis will be taken, which comes after the past (previous reporting). Figure 6 illustrates the logical and structural model of GDP forecasting.

Since the toolset for dynamic programming involves taking into account past and future states in relation to GDP, its values will be written as follows: 0 – index values for the year before, 1, 2, …, *n* – index values for next years, *n* – absolute values index.

Influenced by both external and internal factors, organizational actions of the management structures of all levels of the economic system $V \in D$ GDP will be characterized by the value of $P_0(\mu)$ function.

Source: Ministry of Finance of Ukraine.

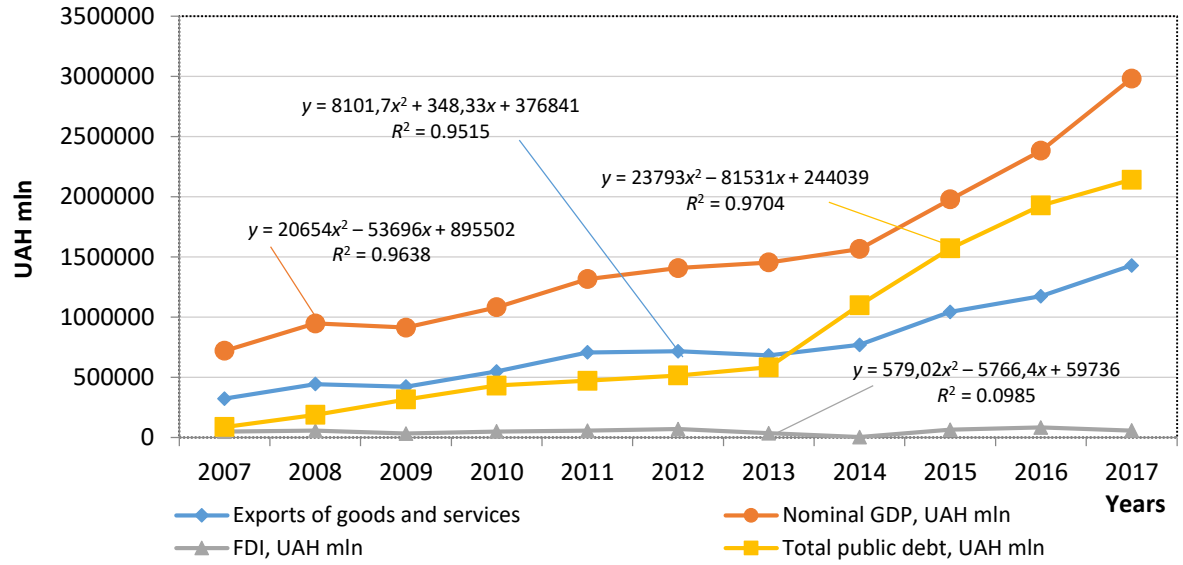


Figure 4. Influence of social system constituents on GDP

Source: Ministry of Finance of Ukraine.

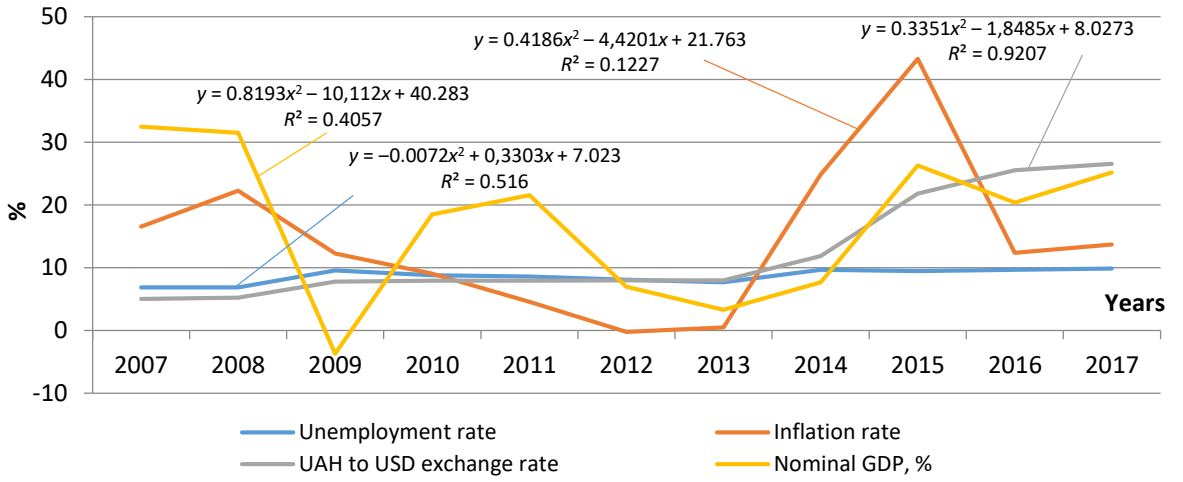


Figure 5. Influence of social system factors on GDP

The task of GDP modelling is to make it possible to select $V \in D$ out of possible values of the maximum and minimum GDP, when the function of $P_0(\mu)$ will take the optimal value. Let's take into account that according to the production-based method of calculating the GDP, together with other incomes, incomes of the economic sectors are taken into account, therefore, formally, the income from the economic sectors in the GDP structure will be presented as follows:

$$GDP = f\left(B_1 + B_2 + \ldots + B_m\right), \quad (3)$$

where B_1, B_2, … B_m – income from economic sectors.

Since industry income consists of incomes of economic entities, the aggregate income of a particular industry will be:

$$GDP_n = \sum_{i=1}^{n} D_i, \quad (4)$$

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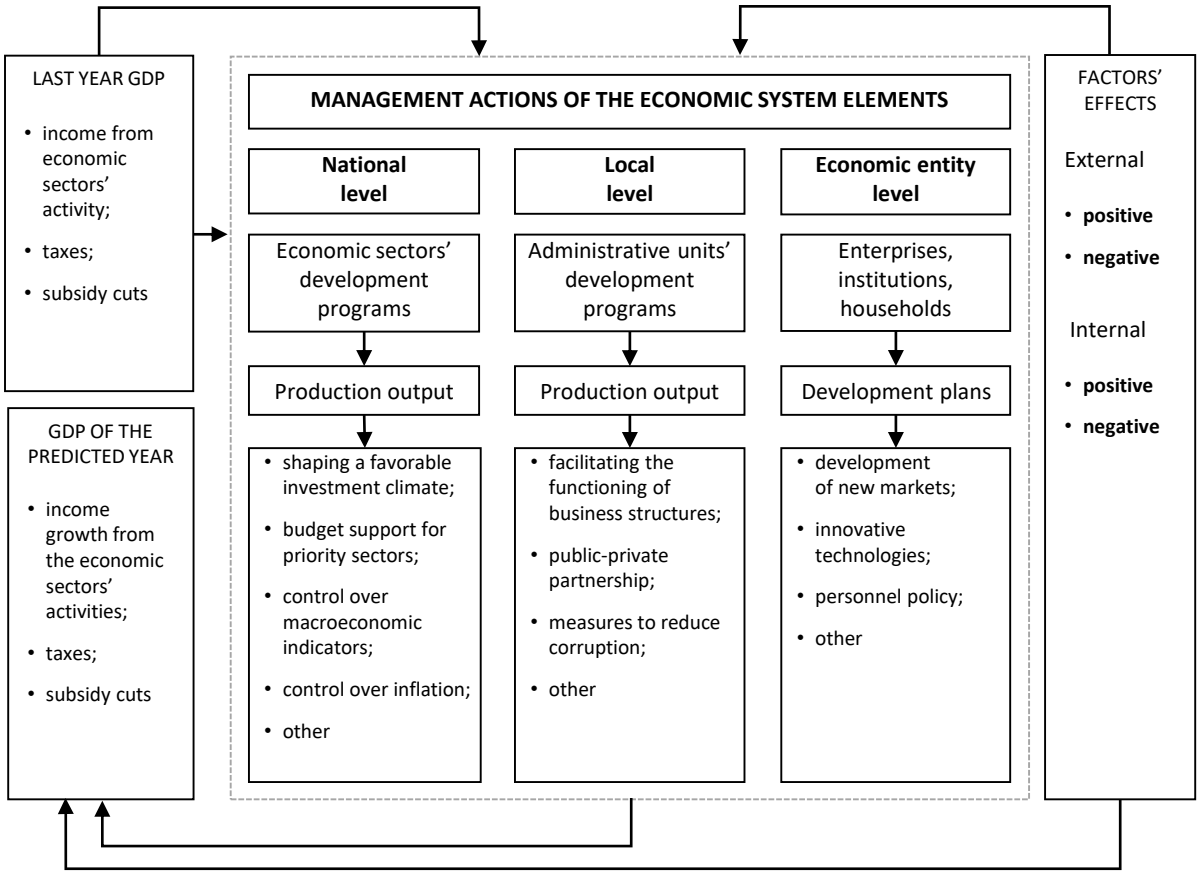

Figure 6. Logic and structural model for GDP forecasting

where B_i – income from the *i*-th economic sector, D_i – income from the *i*-th enterprise.

If one determines *GDP* in the predicted year, which comes after the past year, it consists of GDP of the year before and a certain increase, which can be written as follows:

$$GDP_n = GDP_0 + \Delta GDP_n. \quad (5)$$

The GDP growth in the predicted year is influenced by the level of capability implementation of the opportunities and factors that can be reflected as follows:

$$\Delta GDP_n = GDP_0 \cdot V_n \cdot F_n, \quad (6)$$

where V_n – economic system capability implementation in the predicted year, F_n – impact factors in the predicted year.

Given that the industry consists of a number of economic entities that also realize their own capabilities and are affected by the relevant factors, GDP in the predicted year will be written as follows:

$$GDP_n = \sum_{i=1}^{n} D_0 \cdot V_{inz} \cdot F_{inz}, \quad (7)$$

where V_{inz} – capability implementation level of the *i*-th enterprise, F_{inz} – factors of impact on the *i*-th enterprise.

Consequently, the proposed method of forecasting the GDP takes into account the disadvantages of the existing methodology as much as possible and contributes to obtaining more optimal results. In addition, one can note that it is not necessary to absolutize the existing mechanisms and methods of calculating the GDP. In this context, Peter Drucker, an American management scholar, expressed a belief that strategic planning is necessary, because we cannot predict anything and this planning does not deal with future decisions, but with the potential of real decisions (Drucker, 2004). As solutions exist only at the moment, it is

important for decision makers to know what their organization would do tomorrow, not what they have to do today to fit themselves for an unknown tomorrow.

Since modelling of phenomena and processes in their all has certain difficulties, then, this study will show how some factors, in particular inflation, can influence economic growth. Based on the works by Lukianenko (2009), Lukianenko and Horodnichenko (2003) and using dynamic programming method, the effect of inflation on economic growth is conditioned as follows: inflation in the predicted period is determined as the dependence of inflation rates in previous periods:

$$L_n = L_{0-1}, L_0, \tag{8}$$

where L_n – inflation in the predicted period.

According to Lukianenko (2009), under instability, which is taking place in Ukraine, the best results can be obtained with inverse and exponential curves, respectively:

$$L_n = \frac{1}{\beta_1 + \beta_{2t}}, \tag{9}$$

$$L_n = e^{\beta_1 + \beta_{2t}}. \tag{10}$$

Note that these curves apply provided that the L_n interval (0, +∞) cannot have negative values, that is, inflation takes place.

Using these methodical approaches, to reveal the relationship of inflation with factors and elements of the economic system, the model is proposed that reflects the processes of forecasting the GDP in an unstable economy:

$$\begin{aligned} L_n = {} & \beta_1 + \beta_2 K_0 + \beta_3 K_n + \beta_4 R_0 + \\ & + \beta_5 R_n + \beta_6 S_0 + \beta_7 S_n + \beta_8 W_0 + \\ & + \beta_9 W_n + \beta_{10} F_n, \end{aligned} \tag{11}$$

where K – export of goods and services, R – UAH to USD exchange rate, S – total public debt value, W – unemployment rate, F_n – GDP deviation in the predicted period as compared to the previous one.

Note that this model presents the most influential elements and factors that, according to the correlation analysis results, interconnect inflation and GDP. For more advanced calculations, other components can be introduced.

So this economic and mathematical model can be used in GDP forecasting.

The efficiency of this technique depends on the following:

- performers' competence;
- executors' responsibility for the results (including administrative, financial and criminal liability);
- use of the latest software;
- involving qualified experts in the GDP forecasting results at the appropriate levels;
- constant monitoring of social processes in Ukraine and abroad.

The proposed methodology will help to obtain more optimal results.

CONCLUSION

Forecasting the GDP both in a single country and in the regions of the world is a painstaking job, because it not only requires verified data, but also appropriate experts. The study identified problems impeding the predictive calculations of this indicator in Ukraine. In order to solve this problem, an advanced method is proposed, which is developed taking into account the results of the analysis of the current situation in Ukraine, elimination of the existing methodology disadvantages and is based on using the mathematical apparatus. The scientific novelty of the research is the development of a logical structural model of GDP forecasting, which involves the use of dynamic programming tools. The main ideas of the research are based on the analysis of the researchers' works and the need to form a sci-

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ence-based research algorithm that would contribute to the logical construction of the research stages, the determination of the importance of the personal factor, taking into account the limited use of the methods of economic and mathematical programming, the presence of conditions in which the results of forecasting the GDP will be optimal. The developed method can be used in the practical activity of the statistical bodies of Ukraine, as well as in the ministries and departments of both Ukraine and other states while conducting the comparative assessment. Given this problem urgency, the promising areas of research may be scenarios of using economic and mathematical programming in GDP calculations.

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