



New Statistical and Econometric Approaches to the Modeling of Budget Policy on the Example of Tax Revenues and Information Management

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Abstract

The article presents the results of studies on the development of new statistical and econometric approaches to modeling budget policy. The obtained results are applied on the example of tax revenue modeling. Accounting for various factors, including through the use of mathematical methods, will allow you to plan reforms with a scientific position. In particular, this is especially true in connection with the introduction of multi-year budget planning. To identify the main threats to the tax base, the phenomenon of “tax passes” was used, which is based on an assessment of the effectiveness of a tax credit. The main participants in the formation of the “gross gap” in the value added tax revenues in Ukraine are shown. A correlation and regression analysis of the natural logarithms of the gross domestic product and tax revenues is carried out. This allowed us to determine the elasticity of tax revenues and GDP in Ukraine. A change in

GDP directly affects the amount of tax payments to the budget, and the rate of change of indicators is proportional and changes insignificantly. These results allow us to strategically model the reform of discretionary tax policy mechanisms based on a quantitative assessment of tax gaps and the elasticity of tax payments. The authors were able to substantiate some proposals for reforming the budget policy regarding tax revenues.

Keywords: Model; Budget modeling; Tax system; Value added tax; Econometrics; Statistics; Tax gap; Information technology management.

Introduction

Budget planning plays a key role in the system of public finance management. It links into a single entity all areas of public finance: budget services rendering, debt management, management of budget procurement, planning of public investment, planning of intergovernmental relations and so forth.

The fundamental problems of budget planning in Ukraine are following: discrepancy of current, medium-term and strategic planning; the lack of continuity in fiscal policy; the annual budget is out of keeping with long-term objectives of the government in the field of public finance as well as targets of deficits and debt in the long-term challenges; program approach to planning is missing; complexity connected to planning and implementation of investment programs is available. Recent years, planning at the macro level turns out the subject of extensive discussions purposely not only to avoid crises, but also to regulate the processes of the national product distribution.

Improving of tax management within discretionary policy is urgent problem, which is reflected in the works of many scientists. Researching European integration processes which caused the necessity of national tax policy transformation, the authors emphasize that in Ukraine there is only adaptation of tax legal framework to EU requirements. During the tax reforming in 2010–2019 many problems remained unsolved. However European countries to fight against the financial crisis used different tax mechanisms and tools. Most of countries conducted complex of stimulating actions of the fiscal policy in the crisis period, included budgetary stimulating and the tax burden reduction.

Literature Review

The planning of budget is the subject of research of foreign and Ukrainian scientists. Among Ukrainian scientists should be noted scientific works of Fedosov and Yuriy (2019), Vdovychenko and Zubryc'kyj (2013), Perevozova et al. (2019). The authors consider the foundations of the

formation of financial flows (Bazylevych and Balastryk (2002), Vasylyk (2000), Oparin (2005) and others). The problems of modeling tax revenues are described in the scientific works of Gurs'ka O. (2017), Homutenko (2014), Moldovan (2014), Najdenko and Kostjana (2012), Chalapko (2011). Researches design models of the distribution mechanism for fuel industry enterprises' rental income in the state, region and enterprise systems (Halynska and Oliinyk (2020), Mavlutova et al. (2021)). Recently some authors research tax risk management in the economic crisis (Oliinyk (2017), Meshherjakov and Panasejko (2018), Mottaeva (2019)). But in modern economics the issue of transition from the medium-term budgeting to strategic budgeting doesn't paid enough attention. In addition, there is an acute problem of modeling budget revenues (including tax revenues) in the context of the economic crisis. That's why this issue requires further research.

Data and Methodology

Budget planning is the process of size forming of the budget funds, which can be mobilized as income, cost funding, borrowings attraction and repayment.

The purpose of budget planning is to maintain stability and equation, to achieve sustainable economic growth, to create conditions for effective financial management.

Budget planning tasks include:

- definition of the financial resources volume for each source of income and the total amount of revenue;
- identification of economically feasible size of the financial resources for each source of income;
- forming areas of financial resources, including quantitative and temporal section;
- balancing material, labor, financial, intellectual and other kinds of resources and their economical and efficient use;
- creating conditions for strengthening the stability of the budgets of public and law entities;
- minimizing the impact of negative external and internal factors, etc.

The transition to the current stage of reforming public finances highlights the need to fiscal and strategic planning binding.

Budgeting can be medium-term (perspective), annual and intra- annual ones.

Annual planning process involves the draft budget forming for the next fiscal year. The main document (the result) of the annual budget planning is a draft budget for the next fiscal year, intra- annual budget planning is a cash budget (at present it is also a consolidated list because of containing quarter lay-out).

The medium-term financial planning process involves procedures of the development, adoption, monitoring and adjustment of the medium-term financial plan (after the adoption of the

budget, or within so-called "rolling three-year plan"). The main document (the result) of the medium-term budget planning is the medium-term financial plan, or long-term budget (2010).

Term financial plan is drawn up for three years.

In general, there are four main models of the mid-term budget planning, including:

1. traditional planning for a fixed term;
2. forecasting of economic structure of expenditure;
3. forecasting of functional structure of expenditure;
4. program medium-term planning of budget expenditures.

Usually in traditional planning basic program and all funding for a fixed period are pre-determined for typically 5 years.

Forecasting of economic structure of expenditure involves compiling of sliding projections (on a "top-down") of total expenditures according to economic categories.

Forecasting of functional structure of expenditure is similar to the previous method, since it is connected with the preparation of sliding projections (on a "top-down") of total expenditures according to economic categories, but it happens to be particular for each ministry and fiscal authorities.

Program medium-term expenditure planning focuses on carrying it out on the basis of programming. At the same time, it does not exclude the determination of expenditure according to economic and functional categories, but it serves as the starting point of the program to be realized by budget organizations (2014).

The cycle of medium-term budget expenditure planning can be sliding or circulating:

Sliding planning is carried out during the budget preparation each year or every two years. Thus, one or two-year cycle of sliding planning necessarily coincide with the previous and subsequent cycles (2014).

There are two basic approaches to the construction of "rolling" budget. The first one is based on the requirements of the Ministry budget, drawn up in accordance with the handed down limit of expenditure.

The second approach is based on the incremental change in the base or reference levels of expenditure (so-called "incremental budgeting"). Common thing among these approaches is that the starting point of both of them is the calculation of the base (reference) level of expenditure.

In the framework of a multi-year budget the base levels of expenditure are calculated by transferring (specification of) last year's assessment of expenditure onto one-year forward estimates of expenditure, so the last year's assessments as they are transferred from the forecasts of the previous year in the preparatory process for the upcoming budget year.

On the contrary, in the case of periodic planning these cycles are following one another. Periodic planning is carried out at the beginning of the period to which it relates, and it shall continue until the expiration of this period. Each of sliding and periodic planning can be adjusted in the middle of the term of its action, which may consist of two, three, four or five years, including the next financial year. The three-year term is most commonly used.

The most common methods of budget planning and forecasting include the following (Fedosov&Yuriv (2019), Homutenko&Homutenko (2014)).

Itemized (normative) budgeting means that in accordance with the approved agency budget classification the items of expenditure are justified in details. With this method, the attention is focused on cost analysis and targeted use of funds. State funded organizations prepare an estimate of their planned expenditures, which are analyzed and corrected by budgetary funds managers, and then they are passed for approval to the government.

Index method of planning is based on a variety of indexes reflecting the dynamics of prices, the dynamics of the standard of living of the population and its real incomes. Currently indexes-deflators are fairly well used in the budget planning. The index method specificity of is that the index quantitatively incomparable values are commonly united, making them comparable and commensurable entities.

Using the balance method allows to link the financial resources of public authorities with the need for them arising from the socio-economic development forecasting, to link the budget expenditure with income, to set the distribution of funds' proportion between the budgets of different levels as well as to distribute quarterly income and expenditure (Gura (2020)).

Performance-based budgeting is a system of the budget process organizing and the state (municipal) administration, in which the expenditure planning is carried out in direct connection with the achieved results according to two main budgeting directions: the first one is that funding is linked to the achievement of specific results and the second one is that the managers themselves choose the "path" to achieve these results. Perhaps, namely such an approach of government policy guidance mixing (in the form of imposing strict parameters) with the freedom of managers, i.e. the full involvement of managerial skills, all that gave impetus to the spread of such type of government expenditure financing.

Program-target method is a system planning, budget allocation for the implementation of targeted programs under the statutory or other legal acts. Target program is a complex document, the purpose of which is to be solving priority problems at the moment.

The method of expert assessments is based on the estimates made by reasonable and competent professionals, experts in their knowledge sectors of the economy, social sphere, taxation, finance, budget, etc.

Results and Discussion

Preparation of reliable conservative macroeconomic and fiscal forecasts is of fundamental importance. Optimistic approach will lead to excessive expenditure as compared to the probable income as well as to a higher budget deficit and debt.

Most governments make up at least pessimistic and optimistic scenarios (or 3 scenarios – pessimistic, realistic and optimistic).

The Ministry of Finance is responsible for the preparation of fiscal projections, revenue collection and allocation of public finance usually through the Treasury subordinated.

The Ministry of Economic Development and Trade has been compiling long-term macroeconomic forecasts on indicators such as GDP, inflation, the share of public debt in GDP, the national currency, etc.

Results of budget planning process are presented in the following documents:

- scenario conditions;
- the main directions of the budget, fiscal and debt policies;
- perspective financial plan;
- the budget for the next year (in the case of the transition to a long-term (three years) budget).

In the framework of budget planning it is important to take into account the existing budgetary rules. The main types of budget rules are as follows (Kuznetsov et. al., 2019; Babenko et. al., 2019; Kazakova & Dobroskok, 2020).

1. The rules of balance or the deficit adjustment.

(i) the balance between revenues and expenditures of the state (the prohibition on government borrowing), or the limit on government budget deficit as a percentage of GDP;

(ii) the balance between structural (or cyclic) income and expenditures or limit on the ratio of the structural (or cyclical) deficit to GDP;

(iii) the balance between current revenues and current expenditures (loans allowed only to finance investments).

2. The rules of borrowing.

(i) the prohibition on government borrowing from domestic sources;

(ii) the prohibition on government borrowing from the central bank or a limit on the ratio of the size of such loans to the size of government revenue or expenditure in the past.

3. The rules of debt limiting and accumulation of reserves.

(i) the limit on the ratio of the gross (or net) public debt to GDP ratio;

(ii) the target ratio of stocks of budgetary reserve funds (for example, social security funds) to the size of the annual social benefits.

4. Rules of expenditures limiting. They include permanent limits on the aggregate, primary or current expenditures in absolute terms as a relative increase or a percentage of GDP.

5. The rules of limiting related to income. They belong to the upper and lower income limits set by in order to increase revenue collection and / or in order to avoid an excessive tax burden.

For example, by virtue of the agreements of the Maastricht Treaty and the related "Pact of stability and development", the member countries of the Eurozone must respect the fiscal parameters laid down for the general government sector. An upper limit for the annual deficit is up to 3% of GDP and total debt is up to 60% of GDP. States should aim for making up of a balanced budget and develop an annual program for stability and growth, reflecting the implementation of these targets.

Up to the present in Ukraine an itemized approach is still being dominated as to planning for one year, which is the main justification of resource requirements for the types of costs in accordance with the functional, departmental and economic classification of budget expenditures. At the same time, budget planning contains elements of performance-oriented budgeting in the form of various sectoral and regional programs.

To improve the quality of budget planning it is necessary:

- to optimize the sequence and content of the procedures of formation of long-term financial plan and budget project;
- to forecast revenue and plan for the liabilities amount in accordance with the available resources;
- to find the optimal balance between equity and debt;
- to ensure maximum compliance with the annual budget of a medium-term priorities.

Fiscal practice shows convincing evidences that the short-term tactic of tax reduction causes only temporary improvements and does not solve strategic goal of financial and economic activity such as profit maximizing. Currently there are many works devoted to the strategic management of a company, successfully worked out the problem of value-based enterprise management (Vdovychenko and Zubrycky (2013), Moldovan (2014)). In a market economy the activity of subjects involved in financial relationship is accompanied by various risks: financial, economic, technological, institutional, social, political. The existence of tax risks is shown in the presence of tax gaps, that are defined as the difference between the amount of taxes which should be paid, and the amount of taxes that is actually paid (Bazylevych&Balastryk (2002), Gurska (2017)). In a crisis the risks are intensified, causing impairment in the financial state of entities, problems in public finance and the destruction of the national economy (Vasylyk (2000), Fiscal

Monitor (2010)). There is also a feedback when state tax policy significantly affects the efficiency of taxpayers' activity (Vdovychenko and Zubryckyi (2013), Oparin (2005)). Therefore, in the current crisis conditions in Ukraine evaluation of tax gaps and modeling the relationship between tax budget incomes and macroeconomic indicators to improve the efficiency of discretionary tax policy are actual.

The main goal for application of the tax gaps concept is to evaluate the main threats to the taxation base. The calculation of potential theoretical amount of paid taxes is based on the level of economic energies and includes the assumption that all taxpayers fulfill their obligations in accordance with law.

The gross tax gap allows assessing the amount of unpaid taxes as a result of tax evasion. The net tax gap is the amount of the gross tax gap minus the amounts levied by the results of control and supervision activity of the relevant authorities.

Today there are three main measurement techniques of tax gaps that are used for different types of taxes: the method of «Top down approach» for indirect taxes; method of «bottom up approach» for direct taxes; expert assessments. Assessment for tax gap of VAT, which is one of the main budget-forming taxes in our country, is conducted on the basis of budget losses estimated in the process of working out of circuit tax credit, determined in declarations. We studied the dynamics of VAT tax gaps in Ukraine and other countries former Union of Soviet Socialist Republics for 2000-2019 (World economic and financial surveys) (Table 1).

Table 1. Annual average growth rate of VAT tax gaps in Ukraine and other countries former Union of Soviet Socialist Republics

PERIOD	2000 - 2005	2005 - 2010	2010 - 2015	2014 - 2019
Armenia	12,7694	3,3225	4,4231	4,6802
Azerbaijan	12,1371	15,8582	2,5434	-0,0029
Belarus	7,5484	7,0921	1,2562	0,3740
Georgia	7,4456	4,7334	4,8843	4,1732
Kazakhstan	10,1309	5,6604	4,9968	3,0295
Kyrgyzstan	4,0932	5,0930	5,0381	4,1960
Moldova	7,1186	2,8916	4,0454	3,3016
Russian Federation	6,2332	3,1227	1,7127	0,8552
Tajikistan	9,9950	6,5078	6,3466	6,9632
Turkmenistan	4,4561	10,5543	10,5061	6,3090
Ukraine	8,0219	-0,2943	-2,1862	0,9126
Uzbekistan	5,3786	8,6073	7,4531	5,5706

Efficiency of working off circuit tax credit in 2010-2019 was very high: in total for the category "tax pits" it is 100% and for other categories it is more than 97%. For all categories the level of working off exceeds 94%.

The received evaluation of significant tax gap signals about defects in existing system for planning of tax budget revenue indicators, which are set by Ministry of finance of Ukraine to State fiscal service of Ukraine. According to international standards the setting plans of tax revenue collection for fiscal authorities reduces fiscal transparency and undermines the credibility to tax policy. Instead the sustainability assessments focus should be expanded in order to authorities and the public were able to estimate the tax gap amount.

Consider tax revenues for different groups of countries (World economic and financial surveys) (Table 2).

Table 2. Tax revenues for different groups of countries

Group of countries	Average values of tax receipts in 1995	Average values of tax receipts in 2002	Average values of tax receipts in 2019	Change over the period
Around the world	20,3	20,2	20,3	0,1
The developed countries	30,8	31,3	31,7	0,5
Countries in transition	28,4	25,4	25,4	0
Developing countries	17,3	15,7	15,6	-0,1
Africa	19,2	17,4	17	-0,4
Latin America	17,3	15,2	15,7	0,5
Asia and Oceania	16,6	15,2	15,9	0,7

As we can see from the table 2 tax revenues for different groups of countries had a generally positive growth trend in 2019 relative to 2002. The exceptions were developing countries and Africa, where this indicator was negative.

The basic prerequisite to reduce tax risks is providing efficiency of tax forecasting. To predict the tax revenues of budget a method of trends and elasticity can be used. Calculations based on data for the 2010-2019 showed that the dynamics of GDP and tax revenues to the consolidated budget of Ukraine are describing a linear function with high probability (respectively 0.973 and 0.917):

$$\text{GDP} = 127,8 * t + 468,1, \quad R^2 = 0,973, \quad (1)$$

$$\text{TR} = 30,54 * t + 117,3, \quad R^2 = 0,917, \quad (2)$$

GDP - gross domestic product at current prices, billion UAH;

TR – tax revenues to the consolidated budget of Ukraine, billion UAH;

t – time factor. The next stage of scenario modeling is the development of possible trajectories for development and evaluation of the main parameters.

To determine the elasticity of tax revenues and GDP in Ukrainian conditions the correlation and

regression analysis between natural logarithms at current prices is conducted for the elimination of influence on the results of autocorrelation and inflation analysis. As result statistically significant correlation and regression model is received as multiple determination coefficient is more than 0.99, and level of the factor and the resulting rate much lower than 0.05.

$$TR = e^{1,00116 \cdot \ln()} - 1,4203, \quad R^2 = 0,993 \quad (3)$$

Based on the properties of the exponential function, we concluded that in the studied system change in GDP directly affects the amount of tax payments to the budget, at that time the rate of change in indicators are proportionate and almost unchanged and determined by constant.

Conclusion

Based on the results of the calculations, it is concluded that for the Chilean country studied in the model, the state of development of alternative energy resources is significantly influenced by performance factors. Thus, in the first case, the change in such a factor as generation from NCRE in Chile is influenced by changes in total electricity production, CO₂ emissions and the country's GDP.

With regard to such an effective feature as the import of fuel and energy products, it was found that this factor is associated with changes in total electricity production and changes in electricity production from NCRE.

The findings of the study indicate that the effective feature is the total production of electricity, which changes under the influence of changes in imports of fuel and energy products and generation from NCRE.

This allows us to conclude that the processes of transformation of the energy space, namely the impact of alternative energy resources on it, are characterized by changes in the national economy in general and in the energy market in particular. The results of the analysis confirmed the significant dependence of generation from NCRE and such factors as GDP, CO₂ emissions, total electricity production, which requires

Particular attention should be paid to ensure the transparency and predictability of state financial policy, realistic economic forecasts underlying the budget planning as well as accounting cyclical factors of economic development in order to ensure the stability of fiscal policy, the mandatory reserve funds for unexpected decline in revenue sources by isolation of the financial resources during periods of favorable economic conditions, which can be used in times of financial situation deteriorating and variability of scenarios forecasting and planning.

Overcoming these limitations in practice, the development of financial plans and socio-economic development plans will allow to implement reforms more effectively associated with

the introduction of multi-year budgets in the practice of budget planning and give the plans of socio-economic development of the greater resourcing and justification.

The concept of tax gaps was used to identify the main threats to the tax base of VAT. This concept is based on the data about efficiency of working off circuit tax credit, determined in declarations in terms of taxpayers involved in the scheme of VAT: "beneficiaries", "transmitters", "tax pits". Quantitative evaluation of the annual gross gap for VAT is about one tenth of the tax revenues to the State budget of Ukraine for the year.

To determine the elasticity of tax revenues and GDP in Ukrainian conditions the correlation and regression analysis between natural logarithms in current prices is conducted for the elimination of influence on the results of autocorrelation and inflation analysis. As result statistically significant correlation and regression model is received. Basing on its properties, we concluded that in the studied system the change in GDP directly affects the amount of tax payments to the budget, at that time the rate of change in indicators are proportionate and almost unchanged and determined by constant.

The scientific result of the article consists in strategic directions for reforming mechanisms of discretionary tax policy based on quantitative assessment of tax gaps and elasticity of tax payments. This reforming must be provided in the following directions: firstly – to displace fiscal targets from setting planned indicators of tax revenues to the budget to minimize the net tax gap; secondly – to improve forecasting of tax revenues through the using of alternative scenarios of the developments; thirdly - to form the report about fiscal risks, in which sensitivity of tax revenues to changes in economic conditions must be revealed.

The prospect of further research in this area is an assessment of the tax gaps for the corporate profit tax and forecasting of its revenue to the budget.

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