Shvets, Serhiy

Article

Modeling the impact of public debt on economic growth in Ukraine

Economy and forecasting

Provided in Cooperation with:
ZBW OAS

Reference: Shvets, Serhiy (2020). Modeling the impact of public debt on economic growth in Ukraine. In: Economy and forecasting (3), S. 126 - 136. http://econ-forecast.org.ua/?page_id=189&lang=uk&year=2020&issueno=3&begin_page=126&mode=get_art&flang=en. doi:10.15407/econforecast2020.03.126.

https://doi.org/10.15407/ econforecast.2020.03.126
JEL: O41, H63, E63, C32

***Serhiy Shvets*[1]**

MODELING THE IMPACT OF PUBLIC DEBT ON ECONOMIC GROWTH IN UKRAINE

The study considers modeling approaches to determine the relationship between the level of public debt and economic growth. Empirical evidence for the positive, neutral, and negative correlation between the indicators arrive in a nonlinear function in the form of inverted U-curve, whose theoretical argumentation is associated with the implementation of the golden rule of public finance.

To verify the empirical evidence on the example of Ukraine's economy, the author provides a scenario assessment based on the constructed econometric model of fiscal-monetary interaction. The results of modeling confirm the existence of a relationship that corresponds to a second-order polynomial trend. The maximum level of public debt, above which the GDP rate declines, is 63.8%, and the critical level of public debt, at which the rate of economic growth changes to negative, is 87.4%. As the development of Ukraine's economy is approaching the upper limit of the determined functional entry, to accelerate growth, it is necessary to focus the limited resource of public debt to finance large-scale infrastructure projects with a high capital return.

Keywords: *growth, debt threshold, fiscal-monetary interaction, scenario modeling, econometric macro model*

Introduction. Public debt as one of the important macroeconomic indicators is the subject of in-depth study, being at the center of many related topics, and covering various sectors of the economy and transitive channels of redistribution of resources, as well as economic growth as the most aggregate and informative indicator of economic development. The relationship between the level of public debt and economic growth is not clear. In the scientific literature on certain topics there are radically opposite conclusions, which, however, do not contradict the fact of the existence of a certain limit of "debt overhang", the transition over which leads to a slowdown in economic dynamics. The research field can be divided into three groups depending on the nature of the relationship between the dynamics of public debt and economic growth, which can be positive, indifferent or negative.

In addition to the above, there are also studies aimed at determining the critical level of public debt, thus establishing the framework of the fiscal space within

[1] **Shvets`, Serhiy Mykhailovych** – PhD in Economics, Senior Researcher, State Institution "Institute for Economics and Forecasting, NAS of Ukraine" (26, Panasa Myrnoho St., Kyiv, 01011, Ukraine), ORCID: 0000-0002-3102-9784, Scopus Author ID: 57218000426, e-mail: smserg@ukr.net

which the state can use the instrument of borrowing to achieve economic policy objectives. Such studies a priori suggest the existence of three empirically confirmed types of relationship between public debt and economic growth. Being in the field of fiscal space, public debt has a positive effect on economic growth. As the growth rate increases, this connection becomes less and less noticeable and becomes neutral at its apogee, which corresponds to the critical level. Beyond a certain critical point, the impact of public debt on economic growth is becoming negative.

According to the basic idea of the study, and with the use of the modeling tools previously developed by the author to determine the critical size of the "debt overhang", the task was set to determine the approximate functional relationship between the level of public debt and economic growth.

Analysis of research and publications

The question of the probability of positive or negative impact of increased debt burden on economic growth relates to the definition of scenario conditions for economic development, sources of the government borrowing and fiscal policy goals, which provide for the direction of borrowed funds to cover current and capital expenditures. The theoretical basis for substantiating the positive nature of the relationship between public debt and economic growth is the Keynesian school, or rather, the effective action of the Keynesian fiscal multiplier, as well as the famous Wagner's law, which is called "the law of increasing state activity") [1]. The effect of fiscal multiplier has two components: short-term and long-term ones. The short-term effect is manifested through the encouragement of aggregate demand by increasing government spending, which can be financed by borrowing funds on domestic and foreign capital markets. The long-term component of the manifestation of productive government spending is associated with the effect of attraction. Due to this effect, private investments are actively accumulated of in response to increased productive government spending, which has a positive impact on economic growth in the long run.

Wagner's law explains the strengthening of the active position of the public sector, which is identified with growing needs of the society to develop and increase welfare, which occurs against the background of increasing incomes at the macro level. In our case, we are talking about the size of public sector, which produces socially necessary costs (whose funding includes the use of borrowed funds) for infrastructure, defense, education, etc., whose development of which correlates with the rate of acceleration of scientific and technological progress.

Traditionally, the pronounced positive nature of the impact of government borrowing on economic growth is tracked by scholars in developing countries and in the initial or middle stages of the formation of the trajectory of debt accumulation. To confirm this, we should pay attention to the study conducted on the panel data of 93 countries related to emergent and low-income economies, and covers the period 1975-2004. By using linear regression, fixed effects (English: fixed effects, FE) and the generalized method of moments (GMM), the study [2] found a positive

and non-linear relationship between domestic public debt and economic growth. In the paper, in particular, it is noted that ¾ of this connection is translated through the channels of investment efficiency and aggregate productivity factor, which is less consistent with the accumulation of debt burden.

Fixation of the neutral relationship between public debt and economic growth is based on the well-known Ricardian Equivalence Hypothesis. According to the postulate on which the hypothesis is based, a change in the amount of government spending financed by borrowed funds automatically leads to a change in private savings, which ultimately encourages the dynamics of economic growth. In this context, an important basic prerequisite for the application of the hypothesis is the absence of restrictions on the amount of borrowings, which do not depend on the level of income of private agents guided by rational expectations. Although the Ricardian Equivalence Hypothesis was later criticized as to the fairness of its basic principles, the results of empirical research could not completely refute the existence of a neutral effect of public debt on economic growth.

Among the little evidence of the indifference of the impact of public debt on economic growth is a thorough study conducted by a group of authors on the example of 179 countries with different levels of development in the period 1960-2009 using GMM and panel vector auto regression (PVAR). Indifference of the connection was confirmed by critical debts, which ranged from 14.6 to 93.7%. The results of PVAR-modeling also showed the presence of the reverse effect, i.e. the impact of economic growth on the dynamics of public debt, which found no wide confirmation in topical studies [3].

The negative impact of public debt on economic growth in theoretical aspects is associated with the concept of "debt overhang". The concept was first introduced to the scientific community by Meyer in 1997. Its essence lies in the distortion of the expectations of private agents (in this case, Ricardian households guided by conscious choice when planning their economic activities) on the feasibility of increasing investment spending in response to rising public debt. Such fears are associated with increased likelihood of the expansion of debt burden in the future to ensure the government's fulfillment of its debt obligations, which may adversely affect the companies' financial condition [4]. There are two channels of the negative impact of growing public debt: the first is due to the restriction of current consumption of private agents, which is explained by the theory of rational expectations (Ricardian households), and the second is due to the effect of crowding out private investment as a result of increased government demand for temporarily free cash balances.

As to the confirmation of the negative impact of public debt on economic growth, among recent publications, one should point out the work [5]. The study operated a sample of five groups of countries (86 in total), ranked by the level of public debt in the period 1960–2009. The theoretical basis for constructing the basic econometric equation was a modified Solow growth model, which was tested using PVAR tools. The results for the sample of countries with debt levels up to 60% showed a positive impact on economic growth, while the rest of the model calculations conducted for ranged samples with debt levels from 61% to 150% +

confirmed the negative nonlinear nature of this relationship. According to the total distributed estimate, 10% increase in the level of public debt was associated with a decrease in economic growth by 2-23 basis percentage points.

Another study, also conducted using VAR tools on the panel data of 31 EU and OECD countries, did not reveal any significant relationship between the dynamics and level of public debt and GDP, even taking into account the division of countries into groups with different per capita incomes. At the same time, the study established the fact of a long run reverse negative impact of economic growth on the level of public debt through the interest rate channel. The paper also emphasizes the need to consider the rate of debt accumulation, which at some stage can provoke a slowdown in economic growth [6].

Most publications are devoted to determining the critical amount of public debt, as this topic, depending on the observation period, in one way or another corresponds to the three known types of relationship, that is, the positive, indifferent and negative ones. The most popular is the work by Reinhart and Rogoff, which based on a sample of 44 emerging and developed economies over two centuries and 3700 observations using a statistical approach, concluded that there is a critical point of public debt (at 90%), above which economic growth declines [7].

Testing the critical amount of debt involves the presence of a nonlinear relationship between the studied indicators. Such a connection in the form of a second order polynomial was recorded in [8], where the example of 12 EU countries in 1970–2011 reproduces the nature of the relationship between the level of public debt and GDP growth. Among the channels of manifestation of a certain dependence are private savings and investments, public investments, aggregate productivity factor and long-term nominal and real interest rates. Two years later, the authors presented a theoretical justification for the nonlinear form of communication [9]. However, as noted in [10], such a justification by the authors is valid only in the case of applying the golden rule of the fiscal regime, when the budget deficit is associated exclusively with public investment.

Later, Chinese scientists also tested the above-mentioned second order polynomial dependence between the level of public debt and GDP on the example of a panel data of 102 countries with different development levels of in the period 1980-2016 and received confirmation of its application. Factors that can change the results of determining the critical amount of debt were the balance of payments, aggregate savings, the crisis and the level of openness of the economy. The paper also notes that developing economies are in most cases associated with a lower critical level of public debt as compared to developed economies [11].

Confirmation of the existence of a nonlinear relationship between public debt and economic growth in [8] and [11] is somewhat biased, since the use of linear regression with components forming a second order polynomial involves a nonlinear communication. The theoretical substantiation of the nonlinear form of communication presented in [9] and [10] tends to force the given conditions, which are complementary with the golden rule of fiscal regime. Even the use of other techniques, in particular the approach based on panel smooth transition regression

(PSTR), is not without this bias, because it uses the logistics function among the basic components of communication. In this context, we should highlight the study [12], where the author on the example of 24 developed and 111 developing countries, in the period 1970–2012 using the above mentioned PSTR method confirms the nonlinear nature of the relationship between public debt and GDP growth. The paper also confirmed the existence of a lower critical level of debt for developing economies as compared to developed ones, which averaged 88%.

The objective of the study. Given the above results of the analysis of publications on the relationship between public debt and economic growth, it can be argued that, despite the variety of empirically proven types of such relationships from negative to indifferent and positive, question remains about the nature of the dependence and accuracy of defining the critical amount of public debt for a particular economy.

Thus, taking into account the above remark, the purpose of writing this article is to establish an approximate functional relationship between the level of public debt and economic growth in Ukraine by applying scenario based modeling on the author's econometric model of fiscal-monetary interaction. The study should confirm or deny the existence of an inverted U-curve in the relationship between these macroeconomic variables, as well as establish a reasonable maximum (maximum extreme point) and critical amount of public debt in Ukraine at the end of 2019.

Presenting the main material. The construction of the model of fiscal-monetary interaction is based on separate assumptions, whose theoretical substantiation should be revealed in detail with an emphasis on fundamentally important points. To derive the relationship between the increase in public debt and economic growth, we use the equation of the budget constraint imposed by the central bank, which is based on individual items of its liabilities and assets. According to this equation, the increase in government debt to the central bank in the current period relative to the past (ΔD) together with the central bank's income transferred to the treasury in the current period (RCBt) is equal to the amount of interest paid by the fiscal system to the central bank on past borrowings (iD) and increase in central bank's liabilities, which are represented by the difference between the monetary base in the current and past periods (ΔMB) [13, p. 136-137]:

$$\Delta D + RCB = iD + \Delta MB \quad (1)$$

It is known that government debt obligations are not limited to relations with the central bank, but they also constitute a significant part of the portfolio of securities in the commercial banks. The operation of commercial banks to purchase government securities in the primary market is often accompanied by accumulation of the required amount using refinancing instrument. This is most evident in times of crisis, when the government's financial needs increase due to the implementation of countercyclical fiscal policy. In this case, refinancing serves as an indirect incentive to repurchase, on the primary market, a certain number of government securities to operate with the necessary amount of funds, whose purpose is to cover the

budget deficit. Since refinancing usually mobilizes emission instrument, this directly affects the size of the monetary base, which corresponds to equation (1).

Central bank revenues and the amount of accrued interest on borrowings by the fiscal system are of the same order of magnitude, mostly many times less than the absolute change in the monetary base and government debt to the central bank. Considering this and ignoring the smaller values, let us assume that the change in government debt to the central bank is equal to the change in the monetary base. In this case, the budget deficit is covered by increasing domestic public debt through the issuance of government securities, which are repurchased by the central bank using a currency issue. Under certain conditions, we will have:

$$\Delta D \cong \Delta MB \tag{2}$$

The described mechanism is called "quantitative easing" (QE). We write the well-known equation of Fisher's quantitative exchange in the relative values of the increase in change of the indicators to the previous period, which, assuming a constant velocity of money, is transformed into a ratio according to which the change in output of goods and services in the economy ΔY is equal to the difference between money supply ΔM and change in the price level ΔP:

$$\Delta Y \cong \Delta M - \Delta P \tag{3}$$

Note: The transformation of the Fisher equation, which consists of factors, into an equation, which includes changes in the corresponding components, is performed via sequential application of logarithmic and differentiation operations to both parts of the equation.

Given the postulates of the modern money theory, which is described in detail in Ray's work of the same name [14], we can assume that price change ΔP is mainly due to the manifestation of "monetary inflation", which, in turn, is the result of changes in the monetary base ΔMB. Substituting ΔD from equation (2) in equation (3) for ΔP, we obtain:

$$\Delta Y \cong \Delta M - \Delta D \Rightarrow Y \cong \frac{M}{D} \tag{4}$$

Equation (4) shows that the volume of output of goods and services in the economy corresponds to the dependence of money supply in the economy on the volume of domestic public debt. When the central bank's money issue is only used for the needs of public debt monetization, economic growth slows down. In this case, the so-called "crowding-out effect" is fully manifested, when real sector investments are replaced by the government's growing demand for temporarily free cash balances. If the expansion of the money supply exceeds the increase in government debt to finance the budget deficit, then part of the supply of temporarily free cash balances of the banking system can be used to meet the investment needs of the real sector via lending. According to the results of analysis of the described scenario, the investment component of the real sector acquires the signs of a strong factor in accelerating economic growth in the economy as a whole.

The described mechanism of interrelation between rates of economic growth, change of money supply and internal public debt was tested on the statistical data of Ukraine's economy for 2007–2019. As can be seen from Fig. 1, in periods when $\frac{\Delta M2}{\Delta D\text{int}} > 1$, economic growth accelerated as much as the ratio was higher, and vice versa, in the periods when the ratio $\frac{\Delta M2}{\Delta D\text{int}} \leq 1$ was fair, economic growth slowed down in proportion to the decrease in this ratio. In addition, it is noteworthy how similar the described trajectory is to the dynamics of real GDP (correlation coefficient equal to 0.7).

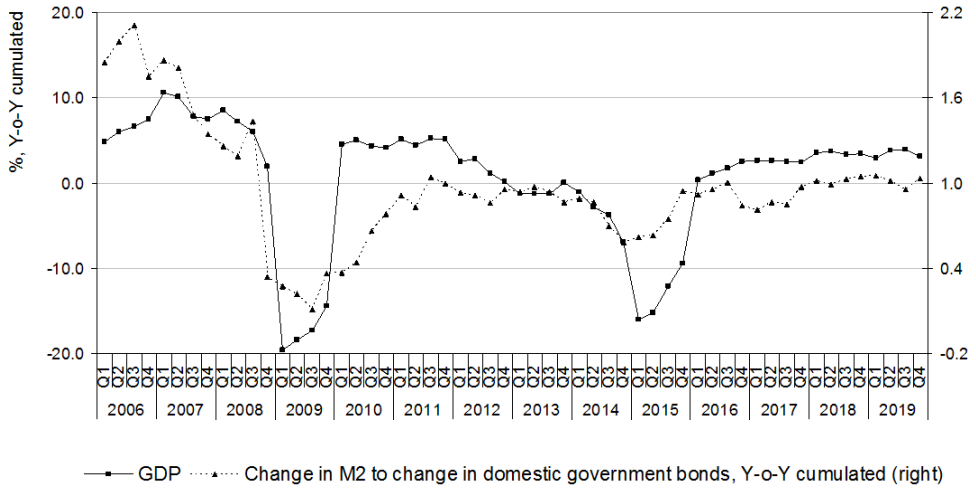

Fig. 1. GDP alongside the ratio of change in M2 to change in domestic government bonds

Source: State Statistics Service of Ukraine (URL: http://www.ukrstat.gov.ua/), National Bank of Ukraine (URL: http://www.bank.gov.ua/), Ministry of Finance of Ukraine (URL: http: / /www.mof.gov.ua/) and author's calculations.

The results of the above-stated theoretical substantiation were used in the development of the model of fiscal-monetary interaction. The model covers three structural blocks: real, fiscal and monetary. The capital factor is represented by the volume of public investments. Since the dynamics of changes in the total sum of capital investments in Ukraine during the dominance of the public debt factor on macroeconomic dynamics is largely determined by the influence of the volatility of funding from the government and local budgets, the proposed approach can be justified. The relationship between the real and budget sectors is realized via fixing capital flows in the money and foreign exchange markets. The initial parameters of the model include the amount of domestic public debt on securities, whose vast majority are domestic government bonds (IGLBs), and the number of economically active population. In this case, the change in the volume of IGLBs in circulation is both a source of covering the budget deficit, and a significant factor influencing the interaction between the money and foreign exchange markets, which ultimately determines the dynamics of the CPI and exchange rate. The resulting indicator of the model is real GDP.

Note: the initial variable domestic public debt on securities was used, considering the fact that this component is dominant (over 90%) in the structure of domestic public debt (excluding government-guaranteed debt).

From a technical point of view, the model is a system of simultaneous equations constructed using quarterly time series. The time interval of the retrospective includes the period 2005–2019 (60 observations). The approximation of the forecast values of the dynamics of IGLBs in circulation is reproduced using a second-order polynomial ($y = 0.27x^2 - 0.99x - 7.36$, R^2=0,98). *The range of domestic government bonds movement is normalized to the volume of total public debt. The reason for this approximation is the relative parity between the shares of domestic and foreign public debt in Ukraine with slight fluctuations.* For the model's detailed structure and statistical characteristics of the regression equations see the author's work [15].

The scenario modeling is reproduced for the period 2016–2019, which is characterized by relative macroeconomic stability between two adjacent crises. The GDP dynamics in this period is characterized by an upward linear trend of the type $y = 0.09x + 1.08$ To determine the maximum extreme of the relationship between the level of public debt and GDP change, the polynomial trend approximating the dynamics of government borrowing deviated upwards in proportion to the change in the inclination angle. In response to the increase in government borrowing, the rate of GDP change gradually slowed down, corresponding to the decrease in the angle of linear trend. Based on the results of scenario modeling, the maximum level of public debt (63.8%) was determined, above which the GDP rate begins to decrease (Table 1).

Table 1

The culmination of the relationship between public debt and GDP

Public debt, *% to GDP*	Slope of the GDP trend
58,9	0,09
59,4	0,08
60,0	0,07
60,6	0,06
61,1	0,05
61,7	0,04
62,2	0,03
62,7	0,02
63,3	0,01
63,8	0,00
64,3	-0,01
64,8	-0,02
65,3	-0,03
65,8	-0,04

Source: author's calculations.

To determine the functional relationship between the level of public debt and GDP, the scenario modeling was repeated, but this time with the fixation of two other indicators: the arithmetic mean of the level of public debt and GDP for four consecutive years (2016-2019). Based on the scenario simulation, a curve was constructed that indicates the relationship between the level of public debt and GDP in Ukraine (Fig. 2). The curve is well approximated by the functional dependence of the second-order polynomial (R2 = 0.98), which corresponds to the results of the studies presented in [9, 11]. The critical level of debt was 87.4%, which is close to the value of 88% obtained by experts in another study conducted on the elemental basis of developing countries [12]. As can be seen from Fig. 2, the development of Ukraine at the end of 2019 is in a phase that is close to the maximum extremity

point of a certain functional dependence, leaving little fiscal space for maneuver. Therefore, at the current stage of development of Ukraine's economy in order to speed up economic growth, one can only operate within a small amount of increased government borrowing with a focus on more efficient investment projects. Typical objects with high capital return include large-scale infrastructure complexes, innovative social transformations, including health care and education, as well as transitive channels of information exchange.

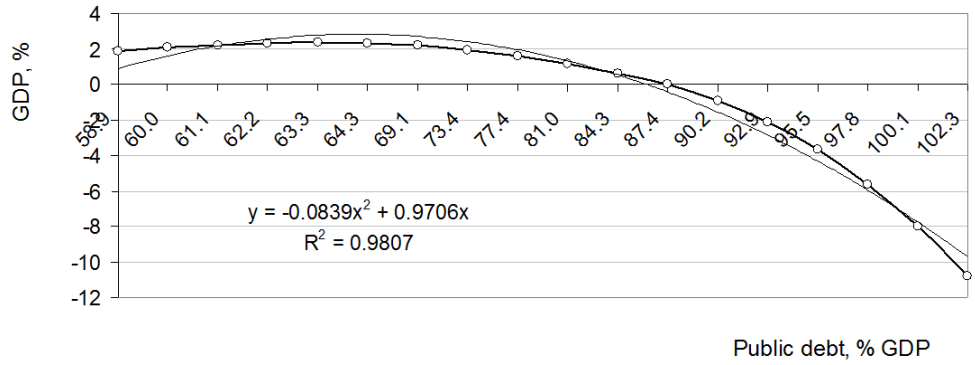

Fig. 2. Scenario modeling results of the relationship between public debt and GDP

Source: author's calculations.

Conclusions

Of the three types of relationship between public debt and economic growth, namely positive, negative and indifferent effects, the imaginary approximation of the trajectory of such a relationship is mostly in the form of an inverted U-curve. The results of the scenario assessment using the econometric model of fiscal-monetary interaction made it possible to build a certain functional dependence for Ukraine's realities. The form of dependence is similar to inverted U-curve, with the point of maximum extreme corresponding to the level of public debt of 63.8%. At the same time, the critical point, i.e. the limit at which economic growth rates become negative, corresponds to the amount of public debt at 87.4% of GDP. Given the fact that the development of Ukraine's economy is in a phase that is close to the maximum extreme of a certain functional dependence, to accelerate economic dynamics, the country's limited debt resource should be focused on funding efficient investment projects with high capital returns.

Further research on the relationship between public debt and economic growth should include a more detailed study of the impact of external sources of budget deficit financing on the development of Ukraine's economy.

References

1. Wagner, A. (1893). Grundlegung der politischen okonomie [text and handbook of political economy]. Leipzig, Germany: C. F. Winter.
2. Abbas, S. & Christensen, J. (2007). The role of domestic debt markets in economic growth. An empirical investigation for low-income countries and emerging markets. *IMF Working Papers*, 07/127. https://doi.org/10.5089/9781451866919.001
3. Arčabić, V., Tica, J., Lee, J. & Sonora, R. (2018). Public debt and economic growth conundrum: nonlinearity and inter-temporal relationship. *Studies in nonlinear dynamics & econometrics, De Gruyter*, 22(1), 1-20. https://doi.org/10.1515/snde-2016-0086
4. Myers, S. (1977). Determinants of corporate borrowing. *Journal of financial economics*, 5, 147-175. https://doi.org/10.1016/0304-405X(77)90015-0

5. Swamy, Vighneswara (2019). Debt and growth: Decomposing the cause and effect relationship. *International journal of finance and economics*, 1-16. https://doi.org/10.1002/ijfe.1729
6. Jacobs, J., Ogawa, K., Sterken, E. & Tokutsu, I. (2019). Public debt, economic growth and the real interest rate: a panel VAR approach to EU and OECD countries. *Applied Economics*. https://doi.org/10.1080/00036846.2019.1673301
7. Reinhart, C. & Rogoff, K. (2010). Growth in a time of debt. *American Economic Revie*w, 100, 573-578. https://doi.org/10.1257/aer.100.2.573
8. Checherita-Westphal, C. & Rother, P. (2010). The impact of high and growing government debt on economic growth: an empirical investigation for the euro area. *European Central Bank Working Paper Series*, 1237.
9. Checherita-Westphal, C., Rother, P. & Hughes Hallett, A. (2012). Fiscal sustainability using growth-maximising debt targets. *European Central Bank Working Paper Series*, 1472.
10. Greiner, A. (2013). Debt and growth: Is there a non-monotonic relation? *Economics Bulletin, AccessEcon*, 33(1), 340-347.
11. Liu, Z., Lyu, J. (2020). Public debt and economic growth: threshold effect and its influence factors. *Applied Economics Letters*, 27(3). https://doi.org/10.1080/13504851.2020.1740157
12. Karadam, D. (2018). An investigation of nonlinear effects of debt on growth. *The Journal of Economic Asymmetries*, 18, e00097. https://doi.org/10.1016/j.jeca.2018.e00097
13. Walsh, C. (2010). Monetary theory and policy. The MIT Press.
14. Wray, L. (1953). Modern money theory: a primer on macroeconomics for sovereign monetary. University of Missouri-Kansas City, US.
15. Shvets, S. (2017). Internal public debt and economic growth: the case study of Ukraine. *Public and Municipal Finance*, 6(4), 23-32. https://doi.org/10.21511/pmf.06(4).2017.03

Received 24.08.20
Reviewed 17.09.20
Signed for print 29.12.20

***Сергій Швець*[2]**

МОДЕЛЮВАННЯ ВПЛИВУ ДЕРЖАВНОГО БОРГУ НА ЕКОНОМІЧНЕ ЗРОСТАННЯ В УКРАЇНІ

Розглядаються модельні підходи до визначення залежності між рівнем державного боргу і темпами економічного зростання. Емпіричні докази наявності позитивного, нейтрального і негативного зв'язку між показниками зводяться до нелінійної функції виду перевернутої U-кривої, теоретичне обґрунтування якої асоціюється з використанням золотого правила фіскального режиму. Для перевірки емпіричних доказів на прикладі економіки України подано сценарну оцінку на засадах використання побудованої економетричної моделі фіскально-монетарної взаємодії. Результати сценарного моделювання підтвердили існування функціональної залежності, що кореспондується з поліномом другого порядку. Встановлено також максимальний рівень

[2] **Швець, Сергій Михайлович** – канд. екон. наук, старший науковий співробітник, ДУ "Інститут економіки та прогнозування НАН України" (вул. П.Мирного, 26, Київ, 01011), ORCID: 0000-0002-3102-9784, Scopus Author ID: 57218000426, e-mail: smserg@ukr.net

державного боргу (63,8%), вище за який темпи ВВП зменшуються, та критичну межу державного боргу (87,4%), за якої темпи економічного зростання починають набувати від'ємних значень. Оскільки, за результатами моделювання, розвиток економіки України наближається до точки максимального екстремуму визначеної функціональної залежності, для прискорення економічної динаміки варто сфокусувати обмежений борговий ресурс держави на фінансуванні масштабних інфраструктурних проєктів, що характеризуються високою капітальною віддачею.

Ключові слова: *економічне зростання, критичний розмір боргу, фіскально-монетарна взаємодія, сценарне моделювання, економетрична макромодель*