Modeling of Capital Investments Public Financing Volume Using Logistic Curves

Vitalii Kuzmenko¹ Svitlana Urvantseva¹ Serhii Khodakevich¹.*
Volodymyr Romanyshyn¹

¹Kyiv National Economic University named after Vadym Hetman, Kyiv 03057, Ukraine
*Corresponding author. Email: khs@kneu.edu.ua

ABSTRACT
The methodological justification of the threshold value of the public financing of capital investments as a point of reverse (LPI) is provided within the current research. The point of reverse means a share of public expenditures in the structure of GDP, excess of which will slow down economic growth. The authors propose the solution of the scientific problem that considers a point of reverse calculation for the Ukrainian financial system. The LPI threshold method is based on the construction of mathematical functions used to model and predict S-shaped processes, namely: the modified exponent, the Pearl and Reid logistic curve and the Gompertz function. According to the empirical studies' results in Ukraine, the modified exponent is showing the most adequate results in the verification of the criteria fulfillment (Adjusted Multiple Determination Ratio, Akaike’s Information Criterion, Bayesian Information Criterion). The upper threshold of public capital expenditures in Ukraine (LPI) is 7% of GDP, while the national economy growth in the form of GDP growth will not be possible in case of public capital investments reduction to 0.86%. The analysis shows that the amount of capital expenditures from the state budget is an indicator of the national financial policy that facilitates the extension of economic agreements or their restriction due to the multiplier effect. Thereby, public investment should be limited and targeted. At the same time, they should not be a substitute for all existing sources of investment activity financing.

Keywords: public finances, economic growth, economic reverse, public expenditure, capital investment, public investment, financial policy, financial resources, modified exponent, Pearl and Reid logistic curve, Gompertz function

1. INTRODUCTION
The transformation processes dynamics within the economic system, increasing dependence of its development on the challenges of internal and external environment actualize the issue of strengthening the state role in the structural correction of the economy and ensuring the foundations of sustainable development on the national and regional level.
The effectiveness of structural and technological renewal, including innovation and investment modernization of production, primarily depends on sufficient resources for these processes and the public role in its formation. It is known that the conceptual foundations of public financial policy, including investment, depend on the type of economic model and the role of the state in social and economic relations. Public capital expenditures can both stimulate economic growth and provide a damaging effect on market agents (reducing private sector savings through fiscal pressure or reducing free financial resources in the market through a “crowding-out effect”, which slows down capital accumulation in private sectors in the long run). In such circumstances, it is an important task for public financial policy to determine the target volume of public capital expenditures (public investment) that would ensure capital accumulation and GDP growth in the long term.

2. REVIEW OF RELATED LITERATURE
The research of most scholars in the field of public finance is mainly concerned with the features, trends, optimal size of public spending as a whole, without substantiating the size and impact of public capital expenditures (public investment) on the economic development. Thus, O. Vasilik [1], V. Oparin [2], V. Fedosov, P. Yukhimenko [3] studied the functions of the state budget, but did not determine the quantitative parameters of public expenditures and their distribution between individual units. V. Zimovets [4] investigated the problems of forming the state financial policy of economic development and proposed a theoretical approach to determining the optimal size of public spending in a corrupt extraction economy.
D. De Avila and R. Strauch [5], V. Tanzi and L. Schuknecht [6], as well as M. Connolly and C. Li [7] empirically established the relationship between public spending and the economic development of OECD countries. D. Lupu, M. Petrisor, A. Bercu and M. Tofan [8] considered the correlation between real GDP growth and 10 different categories of public expenditures, according to their functional classification, for 10 selected Central and Eastern European countries (using an autoregressive-distributed lag model (ARDL)). E. Hsieh and K. S. Lai [9] take into account Barro’s endogenous growth model and make attempts to reveal the nature of the relationship between government expenditures and economic growth by examining the intertemporal interactions between the growth of a real GDP per capita, the share of government spending, and the ratio of private investment to GDP of the G-7 countries. A. Illarionov and N. Pivovarova [10] calculated the marginal level of government expenditures in GDP for the post-Soviet countries. R. Sánchez [11] analysed the optimal structure of public expenditures and their distribution between public consumption and public investment.

We should also mention the authors who researched the impact of public investment on real GDP. Their studies are grouped according to the evaluation methods they used: a vector autoregression (A. Pereira and O. Roca-Sagales [12], J. Creel and G. Poilâne [13]) and the vector model of error correction (G. Everaert [14], A. Pereira and J. Andraz [15], M. Ramirez [16], A. Pina and M. Aubyn [17], C. Annala, R. Batina and J. Feehan [18]). It should be noted that A. De la Fuente establishes a limit on public investment for developed countries at 2% of GDP [19]. At the same time, the latest analysis of OECD.Stat has shown that the share of government spending on financing the investment needs of the economy in developed countries ranges from almost 9% of GDP in Greece to 2% in Israel. Besides, industrial countries have outrun all other highly developed countries in this ratio, which is related to the need of production modernization and the need of resource consolidation for its implementation. Therefore, an important theoretical and practical assignment is to determine an adequate level of public capital expenditures, which will have a stimulating effect on GDP growth, private investment, and the accumulation of productive capital in the non-governmental sectors in the long run.

3. RESEARCH PURPOSE

The research aims to determine the threshold for public financing of capital investment as a point of reverse, namely a share of public expenditure in GDP. The economic growth will slow down in case of the above-mentioned share exceeding in a particular timeframe. The empirical study determines the calculation of this indicator for Ukrainian financial system.

4. THE MAIN RESULTS OF THE STUDY

4.1. Theoretical Background

The threshold of capital investments public financing is determined using the logistic curves construction. Logistic curves or S-curves are not selected as the current research instrument by accident. The above-mentioned curves are the best instruments to describe the exponential processes, when the growth depends on the already reached level rather than on various restrictions. In fact, S-curves describe two sequential processes: one process is connected with acceleration of development, the other one is connected with its deceleration. The inflection point determines its culminating moment, while asymptote - the limit of the process development. For instance, there are at least three mathematical functions that can be used to model and predict S-shaped processes. In particular, the modified exponential, the logistic curve (Pearl and Reed) and Gompertz function are among them [20].

The modified exponent differs from the simple exponent due to its additional component - the asymptote \( K \) (it is the upper asymptote in our case):

\[
Y_t = K - ab^t, \quad (1)
\]

where parameter \( a \) means the difference between the coordinate \( Y_t \) in case of \( t \) equal 0 and the asymptote \( K \), the parameter \( b \) characterizes the ratio of successive increases of the ordinate.

The exponent is modified to describe the process, influenced by a singular restricting factor, which influence is increasing in accordance with \( Y_t \) growth. Although the restricting factor influences the process only in case of its exponential development till particular moment, then this process is mainly approximated by an S-curve with a point of inflection at which accelerated growth is slowed down. The modified exponent serves as a base curve, on which basis the Gompertz function and the logistic curve (such curves are used more often) are obtained through certain transformations.

As a rule, the Pearl and Reid logistic curve is presented as:

\[
Y_t = \frac{K}{1 + be^{-at}}, \quad (2)
\]

If the process indicator (proportion) varies from 0 to 1, then the formula of the logistic function is simplified:

\[
Y_t = \frac{1}{e^{a+bt} + 1} \quad \text{or} \quad Y_t = 1 + e^{a+bt}, \quad (3)
\]

where \( e \) is the basis of the natural logarithm; \( a, b \) – curve parameters.

At the same time, Gompertz function is presented in the following way:

\[
Y_t = K a^{bt}, \quad (4)
\]

The Pearl and Reid logistic curve and the Gompertz function describe the dynamic processes that concern the ratio of increments to ordinates change. Their differences are described in accordance with some peculiarities. In particular, Gompertz function has the ratio.
of the primary logarithm differences to the ordinates spaced apart and the Pearl and Reid logistic curve has the ratio of the first inverse ordinal differences. At the same time, the logistic curve is centrally symmetric to the inflection point. The Gompertz curve is asymmetric.

If the asymptote of one of the above-mentioned curves is unknown or cannot be determined, then the estimation of the function parameters is complicated. In these cases, different methods of analysis can be applied, namely: the three-sum method, the three-point method [21, p. 114-122], regression [21, p. 125-130], the Bryant method [22], Fisher, Yule, Rhodes, Neuro methods, etc.

The asymptote for the modified exponent is defined using the three-point method according to the following algorithm:

1. Data division into 3 groups I, II and III under the following conditions:
   a) if the total number of elements is divisible by 3 without rest, namely
      \[ n = 3k \]
      then we form 3 groups, containing \( k \) elements for each one;
   b) if \( n = 3k + 1 \), then group II consists of \( k + 1 \) elements,
      and groups I and III contain \( k \) elements for each one;
   c) if \( n = 3k + 2 \), then group II consists of \( k \) elements and
      groups I and III - \( k + 1 \) elements each one.

2. The median value calculation within three groups. These values are marked respectively: \( y_{III}, y_{II}, y_{I} \).

3. A system of three equations (nonlinear) with three unknowns is solved:

\[
\begin{aligned}
   y_{I} &= \alpha \beta^{al} + \gamma, \\
   y_{II} &= \alpha \beta^{al} + \gamma, \\
   y_{III} &= \alpha \beta^{al} + \gamma.
\end{aligned}
\]

This system can be solved as follows:

a) determine the difference between the second and first equation and between the third and second ones:

\[
\begin{align*}
   y_{III} - y_{II} &= \alpha (\beta^{al} - \beta^{al}), \\
   y_{II} - y_{I} &= \alpha (\beta^{al} - \beta^{al}).
\end{align*}
\]

b) divide term by term equation (6) by equation (7), marking:

\[
\Delta = x_{III} - x_{II} = x_{II} - x_{I};
\]

\[
\frac{y_{III} - y_{II}}{y_{II} - y_{I}} = \beta^{\Delta},
\]

where: \( \ln \beta = \frac{1}{\Delta} \ln \left( \frac{y_{III} - y_{II}}{y_{II} - y_{I}} \right) \)

c) define: \( \alpha = \frac{y_{III} - y_{II}}{\beta^{al} - \beta^{al}} \) and \( \gamma = y_{I} - \alpha \beta^{al} \).

Finally, we get the following formula:

\[
\begin{align*}
   A &= \frac{1}{\Delta} \ln \left( \frac{y_{III} - y_{II}}{y_{II} - y_{I}} \right), \\
   \beta &= e^{A}, \\
   \alpha &= \frac{y_{III} - y_{II}}{\beta^{al} - \beta^{al}}, \\
   \gamma &= y_{I} - \alpha \beta^{al}.
\end{align*}
\]

4.2. Calculation of the reverse point (LPI) for the Ukrainian financial system

The data on GDP growth rate and the level of capital investment public financing in Ukrainian GDP in 2008-2018 are selected within the empirical research. The asymptote is determined, using the three-point method (the above-mentioned algorithm). In our case, the asymptote level is 7.44% (Table 1).

| Table 1 The asymptote calculation in accordance with the three-point method |
|---|---|---|---|---|---|---|
| GDP growth rate, % | The public investment level within the economy, % to GDP | Normalized data | Xi | Yi | \( \Delta \) | ln \( \beta \) | \( \beta \) | \( \alpha \) |
| I | 32,93% | 3,25% | 1,31 | 1,98 | 0,67063 | 0,60904 | -1,3893 | 7,44% | 0,0773 | - 6,003 |
| | 31,91% | 2,82% | 1,23 | 1,43 | 0,61871 | 0,57422 | -1,3893 | 7,44% | 0,0773 | - 6,003 |
| | -4,42% | 1,51% | -1,75 | -0,21 | 0,55645 | 0,52108 | -1,3893 | 7,44% | 0,0773 | - 6,003 |
| | 18,32% | 1,42% | 0,11 | -0,32 | 0,49181 | 0,45645 | -1,3893 | 7,44% | 0,0773 | - 6,003 |
| II | 20,40% | 1,86% | 0,28 | 0,23 | 0,43820 | 0,40381 | -0,71865 | 0,032176 |
| | 8,15% | 1,70% | -0,72 | 0,03 | 0,38504 | 0,35065 | -0,71865 | 0,032176 |
| | 4,36% | 0,85% | -1,03 | -1,04 | 0,33189 | 0,30750 | -0,71865 | 0,032176 |
| | 4,22% | 0,55% | -1,04 | -1,02 | 0,45645 | 0,42206 | -0,71865 | 0,032176 |
| | 25,31% | 1,07% | 0,69 | 0,77 | 0,69456 | 0,66017 | -0,71865 | 0,032176 |
| | 19,96% | 1,51% | 0,25 | 0,21 | 0,38504 | 0,35065 | -0,71865 | 0,032176 |
| | 25,05% | 1,91% | 0,66 | 0,29 | 0,33189 | 0,30750 | -0,71865 | 0,032176 |
| An average value | 16,93% | 1,68% | | | | | | |
| \( \sigma \) | 12,22% | 0,80% | | | | | | |
The parameters of these curves are gradually determined, starting with the modified exponent. The function is considered by logarithm to a linear form to estimate $a$ and $b$ (Table 2). Then, a system of normal equations of the form is constructed, using the least squares method:

$$\sum \ln Y = n \ln a + \ln b \sum t, \quad \sum t \ln Y = \ln a \sum t + \ln b \sum t^2.$$  

Then, the solution potentiation, the following parameters are obtained: $a = 0.0658$ and $b = 0.4356$. As the result, we obtain the following equation:

$$Y_{t} = 0.0744 - 0.0658 \times 0.4356 t.$$  

Then, the Pearl-Reid curve is constructed. Although the authors have previously calculated the asymptote for all considered functions (Table 3), Fisher's method is additionally used for the data comparison within the logistic curve construction. The method is based on the determination of asymptote derivative; which $t$ differentiation enables to provide the equation:

$$\frac{dy_t}{dt} = ay_t \left(1 - \frac{Y_t}{K} \right). \quad (10)$$

### Table 2 Calculation of the modified exponent parameters

| GDP growth rate | The public investment level within the economy, share of GDP | $Y=\lim_{Y} Y_t$ | $\ln Y$ | $X$ | $X \ln Y$ | $X^2$ |
|-----------------|-------------------------------------------------------------|------------------|--------|-----|-----------|-------|
| 0.329           | 0.033                                                       | 0.042            | -3.173 | 0.329 | -1.045    | 0.108 |
| 0.319           | 0.028                                                       | 0.046            | -3.073 | 0.319 | -0.981    | 0.102 |
| -0.044          | 0.015                                                       | 0.059            | -2.824 | -0.044 | 0.125    | 0.002 |
| 0.183           | 0.014                                                       | 0.060            | -2.810 | 0.183 | -0.515    | 0.034 |
| 0.204           | 0.019                                                       | 0.056            | -2.866 | 0.204 | -0.589    | 0.042 |
| 0.081           | 0.017                                                       | 0.057            | -2.857 | 0.081 | -0.233    | 0.007 |
| 0.044           | 0.009                                                       | 0.066            | -2.719 | 0.044 | -0.118    | 0.002 |
| 0.042           | 0.005                                                       | 0.069            | -2.674 | 0.042 | -0.113    | 0.002 |
| 0.253           | 0.011                                                       | 0.064            | -2.752 | 0.253 | -0.697    | 0.064 |
| 0.200           | 0.015                                                       | 0.059            | -2.825 | 0.200 | -0.564    | 0.040 |
| 0.251           | 0.019                                                       | 0.055            | -2.894 | 0.251 | -0.725    | 0.063 |
| $\Sigma$        | 0.184                                                       | -                | -31.486| 1.862 | -5.454    | 0.464 |

### Table 3 Parameters of the logistic curve calculation

| GDP growth rate | The level of capital investment public financing, share of GDP | $z_t = \frac{1}{2} \ln \frac{Y_{t+1}}{Y_{t-1}}$ | $Y = \lim_{Y} \frac{Y_t}{Y_{t+1}} - 1$ | $\ln Y$ |
|-----------------|-------------------------------------------------------------|-----------------------------------------------|-----------------------------------------|---------|
| 0.329           | 0.033                                                       | -                                             | -                                        | -       |
| 0.319           | 0.028                                                       | -0.385                                        | 0.622                                   | -0.474  |
| -0.044          | 0.015                                                       | -0.341                                        | 0.294                                   | -1.223  |
| 0.183           | 0.014                                                       | 0.106                                         | 0.253                                   | -1.375  |
| 0.204           | 0.019                                                       | 0.089                                         | 0.429                                   | -0.847  |
| 0.081           | 0.017                                                       | -0.391                                        | 0.375                                   | -0.980  |
| 0.044           | 0.009                                                       | -0.569                                        | 0.249                                   | -1.391  |
| 0.042           | 0.005                                                       | 0.112                                         | 0.950                                   | -0.051  |
| 0.253           | 0.011                                                       | 0.510                                         | 0.001                                   | -6.736  |
| 0.200           | 0.015                                                       | 0.291                                         | 0.297                                   | -1.215  |
| 0.251           | 0.019                                                       | -                                             | 0.442                                   | -0.817  |
| $\Sigma$        | 0.184                                                       | -                                             | -                                       | -15,1102|
The growth rate is marked through \( z_i \), where 
\[ z_i = a - \frac{a}{K} y_i \text{'}. Namely, there is a possibility to assume 
that the intervals between the levels of a series of 
dynamics can be equal and the \( z_i \) estimation may be carried 
out in the form of the following equation by 
prolinearizing expression (10):
\[ z_i = \frac{1}{2} \ln \frac{y_i}{y_i} \text{'}, \text{ where } t = 2, 3, ..., n-1. \]

(11)

Then, the least squares method is used to construct the 
regression equation, which in our case has the following 
form:
\[ Y = K \left( 1 - e^{-b t} \right) \]

In case \( -\frac{a}{K} = -15.5751 \),
then \( K = -0.1657 \), the upper asymptote of 
public investment is approximately 1.06%.

Primarily, the parameters \( a \) and \( K \) are provided. Then, the 
parameter \( b \) is calculated. The function \( Y_t = \frac{K}{1 + be^{-at}} \) is 
represented as for these goals. The equation 
\[ Y = be^{-at} \rightarrow \ln Y = \ln b + at \] 
is obtained through denoting the left part of equality by \( Y \) and providing its logarithm.

In the above-mentioned expression, \( b \) is a free term that 
also be estimated by the least squares method. If the 
asymptote is given, then this function is reduced to a linear 
look by double logarithm:
\[ \ln \left( \frac{Y_i}{K} \right) = b' \ln a \rightarrow \ln \left( \frac{Y_i}{K} \right) = t \ln b + \ln(\ln a) \]

(12)

After replacing \( \ln \left( \frac{Y_i}{K} \right) \) through \( y' \), \ln \( b \) through \( B \) 
and \( \ln(\ln a) \) through \( A \), the Gompertz function is 
represented in linear form: \( y' = A + Bt \).

In the case of unknown asymptote, it may be determined 
using the regression method in the same way as for the 
modified exponent. For this purpose, it is necessary to 
transform the Gompertz function into a modified exponent 
by prologarithmizing the equation:
\[ \ln y = \ln K + \ln a \cdot b' \rightarrow Y = k + A \cdot b' \]

(13)

where \( Y = \ln y; k = \ln K; A = \ln a \). Then, the 
authors find the absolute increments and express them through the 
parameters of the modified exponent:
\[ \Delta Y = k + Ab' - k - Ab'^{t-1} = Ab'^{t-1}\left(b' - 1\right) \]

(14)

Recalculating this equality through logarithm, we get:
\[ \ln \Delta Y = \ln A + (t - 1) \ln b + \ln(\ln b - 1) \]

(15)

Expressing \( \ln A + \ln(\ln b - 1) \) through \( d \), the authors find the 
linear equation in logarithms \( \ln \Delta Y = d + (t - 1) \ln b \), 
the parameters can already be estimated through the least 
squares method. The calculation of the parameters for 
the Gompertz function creation is presented in Table 4.

**Table 4 Calculation of the Gompertz function parameters**

| GDP growth rate | The level of capital investment public financing, share of GDP | ln Y | | ln (\( A \) ln Y) | t-1 | k |
|----------------|----------------------------------------------------------|------|------|----------------|-----|-----|
| 0.329          | 0.033                                                    | -3.425| -1.932| 0.0671         | -3.410|
| 0.319          | 0.028                                                    | -3.570| 0.145| -0.681         | -3.555|
| -0.044         | 0.015                                                    | -4.195| 0.625| -0.470         | -4.157|
| 0.183          | 0.014                                                    | -4.252| 0.057| -2.863         | -4.231|
| 0.204          | 0.019                                                    | -3.983| 0.268| -1.315         | -3.963|
| 0.081          | 0.017                                                    | -4.073| 0.090| -2.413         | -4.045|
| 0.044          | 0.099                                                    | -4.765| 0.692| -0.367         | -4.735|
| 0.042          | 0.005                                                    | -5.211| 0.446| -0.808         | -5.181|
| 0.253          | 0.011                                                    | -4.542| 0.669| -0.402         | -4.524|
| 0.200          | 0.015                                                    | -4.191| 0.351| -1.048         | -4.171|
| 0.251          | 0.019                                                    | -3.960| 0.231| -1.464         | -3.942|

As a result, the equation is obtained:
\[ \ln \Delta Y = -3.4623 - 2.5438(t - 1) \]

Then, \( b = e^{-2.5438} = 0.0786 \), and \( d = -3.4623 \).

At the same time \( \ln a \cdot (b - 1) = e^{-3.4623} = 0.0314 \),
\[ \ln a = \frac{0.0314}{(0.0786 - 1)} = -0.0340; a = 0.9665. \]
The parameters $a$ and $b$ are distinguished. Thereby, authors can find $k$ for each entry from Table 4 as $k = Y - Ab^t$. Then, an average value of $k$ is estimated.

The upper asymptote $k = \ln K \rightarrow K = e^k$ is determined on its basis. In our case $K = e^{-117.4} = 0.015$. After paying attention to these calculations, the Gompertz function is presented in the following way: $Y = 0.015 \cdot 0.9665^{0.073k}$.

Each of the above-mentioned features will be tested against a number of criteria to identify the best fit for the selected model. The following criteria are selected:

1) Adjusted Multiple Determination Ratio:

$$R^2 = 1 - \frac{\sum_{i=1}^{n} e_i^2}{n - m - 1} = 1 - \frac{n - m - 1}{n - 1} = 1 - \frac{s^2_x}{s^2_y}$$

(16)

where $D(e) -$ selective residual variance, $D(y) -$ selective variance of the dependent variable, $s^2e -$ the unbiased estimate of the variance of the residuals, $s^2y -$ the unbiased estimation of the variance of the dependent variable. The model will be better in case of the greater value of the adjusted multiple determination factor.

2) Akaike’s Information Criterion:

$$AIC = \log(\frac{1}{n} \sum_{i=1}^{n} e_i^2) + 2 \cdot \frac{m + 1}{n}$$

(17)

In accordance with this criteria, more specified model has lower AIC value.

3) Bayesian Information Criterion:

$$BIC = \log(\frac{1}{n} \sum_{i=1}^{n} e_i^2) + \frac{m + 1}{n} \cdot \log n.$$  

(18)

In accordance with this criteria, the model is better approximated in case of smaller BIC value. The results of the calculation of the above-mentioned criteria are represented in Table 5.

**Table 5 Comparative table of functions selection criteria**

| Function                     | $R^2$ | $\bar{R}^2$ | AIC    | BIC    |
|------------------------------|-------|-------------|--------|--------|
| Modified exponent           | 0.4773| 0.4192      | -1.6252| -1.5528|
| Pearl and Reid logistic curve| 0.0769| -0.055      | -0.5109| -0.4671|
| Gompertz function           | 0.1155| 0.0049      | 0.1779 | 0.2384 |

The modified exponent showed the most adequate results in the verification of the criteria fulfillment. Thereby, the further conclusions are provided on its basis.

5. CONCLUSION

The quantitative manifestation of the government direct participation in the investment processes is the amount of the budget capital expenditures, their share in total budget expenditures and the correlation of government capital expenditures to the GDP of the country. Public investment, on the one hand, contributes to economic growth and, on the other hand, encourages this growth by reducing the use of budget levers, lack of financing and imbalances participation of the country's main financial plan by creating a target for overcoming or minimizing budget deficits in the social focus of budget resources. Finally, this leads to inefficient use of budget levers, lack of financing and imbalances within entire industries and regions, slowing down the economy and innovative development.

REFERENCES

[1] O. Vasilik *Theoryfinance*, Kiev, Ukraine: NIOS, 2000.

[2] V. Oparin *Financial system of Ukraine (theoretical and methodological aspect)*, Kiev, Ukraine: KNEU, 2005

[3] V. Oparin, V. Fedosov, and P. Yukhimenko, “Publicfinance: Genesis, theoretical knowledge and practical conceptualization” *FinanceUkraine* no 2, pp. 110-128, 2017
[4] V. Zimovets. Derzhavafinancialpolicyofeconomicdevelopment, Kiev, Ukraine: NAS of Ukraine, InstituteofEconomicsandForecasting, 2010.

[5] D. De Avila, and R. Strauch, “Public Finances and Long-term Growth in Europe – Evidence from a Panel-Data Analysis”, European Central Bank. Working Paper, №246, 2003.

[6] V. Tanzi, and L. Schuknecht, “Public Finances and Economic Growth in European Countries” in Conference volume of the 31st Economics Conference of the OestreichischeNationalbank Fostering Economic Grown in Europe, Vienna, 2003, pp. 178-196.

[7] M. Connolly, and C. Li, “Government spending and economic growth in the OECD countries”. Journal of Economic Policy Reform, vol. 19, iss. 4, pp. 386-395, 2016 DOI: https://doi.org/10.1080/17487870.2016.1213168

[8] D. Lupu, M. B. Petrisor, A. Bercu, and M. Tofan, “The Impact of Public Expenditures on Economic Growth: A Case Study of Central and Eastern European Countries” Emerging Markets Finance and Trade, Vol. 54, Iss. 3, pp. 552-570, 2018 DOI: https://doi.org/10.1080/1540496X.2017.1419127

[9] E. Hsieh, and K. S. Lai, “Government spending and economic growth: the G-7 experience” Applied Economics, Vol. 26, pp. 535-542, 1994 DOI: https://doi.org/10.1080/00036849400000022

[10] A. Illarionov, and N. Pivovarova, “Dimensions of the state and economic growth”, Economic issues, no 9, pp. 18-45, 2002.

[11] R. Sánchez “Characterizing the Optimal Composition of Government Expenditures”, Economic Working Papers at Centro de EstudiosAndaluces, №E2004/81.

[12] A. M. Pereira, and O. Roca-Sagales, “Infrastructures and private sector performance in Spain”, Journal of Policy Modeling, Vol. 23, Iss. 4, pp. 371-384, 2001 DOI: 10.1016/S0161-8938(01)00068-0

[13] J. Creel, and G. Poilon, “Is public capital productive in Europe?”, International Review of Applied Economics, Vol. 22, Iss. 6, pp. 673-691, 2008 DOI: https://doi.org/10.1080/02692170802407577

[14] G. Everaert, “Balanced growth and public capital: an empirical analysis with 1(2) trends in capital stock data”, Economic Modelling, Vol. 20, Iss. 4, pp. 741-763, 2003

[15] A. M. Pereira, and J. M. Andraz “On the Impact of Public Investment on the Performance of US Industries”, Public Finance Review, Vol. 31, Iss. 1, pp. 66-90, 2003

[16] M. D. Ramirez, “Is public infrastructure spending productive in the Mexican case? A vector error correction analysis”, Journal of International Trade & Economic Development, Vol. 13, Iss. 2, pp. 159-178, 2004 DOI: https://doi.org/10.1080/0963819042000218700

[17] A. M. Pina, and M. S. Aubyn, “Comparing macroeconomic returns on human and public capital: An empirical analysis of the Portuguese case (1960-2001)”, Journal of Policy Modeling, Vol. 27, pp. 585-598, 2005

[18] C. N. Annala, R. G. Batina, and J. P. Feehan, “Empirical impact of public infrastructure on the japanese economy”, Japanese Economic Review, no. 59, pp. 419-437, 2008

[19] A. De la Fuente, “Fiscal Policy and Growth in the OECD” CEPR Discussion Paper Series, no. 1755, 1997.

[20] A. Ėrіna Statistical modeling and forecasting. Kiev. Ukraine: KNEU, 2001.

[21] E. Chetyrkin Statistical forecasting methods. Moscow. Russia: Statistics, 1977.

[22] K. Lewis Methods of economic indicators forecasting. Moscow. Russia: Finance and Statistics, 1986.

[23] StateStatisticsServiceofUkraine. Theofficialwebsite. [Online]. Available: www.ukrstat.gov.ua