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DIVERGENCE AS A MEASURE OF INTENSITY OF CAPITAL EXPENDITURES

Abstract. *Due to spontaneously emerging situations in utilization of capital expenditures, investors need to clarify conditions and evaluate intensity of conversion of finances into materialized elements of productive and non-productive expenditures. The main aim of this article is to find a complex estimate for the rate of utilization of such expenditures. We suggest a characteristic depending on the dynamic divergence of capital expenditure and values of fixed assets. We show that this characteristic is an adequate and credible measure of intensity of capital expenditures by analyzing data for Federal districts of Russia and European countries.*

Keywords: *divergence, capital expenditures, intensity of utilization.*

JEL classification: E17, C61, O49, P51

1. Introduction

Investments in the form of capital expenditures play an important role in the activity of a subject of economy (an enterprise, a region, or a country). Expenditure in fixed assets of such a subject leads to development, improvement, timely maintenance, or replacement, which creates opportunities for improving production efficiency, increasing production assets, expanding sales, and improving product quality. The main effect of capital expenditures is creation of new production capacities and introduction of non-production facilities. At the level of a company, such investments result in growth of product and service sales.

Capital expenditures can be divided into productive (denoted by I_K) and non-productive (denoted by I_L). Productive expenditures include tools that allow us to

- update fixed assets and expand the reproduction;
- accelerate scientific and technological progress and improve product quality;
- restructure public production and balance development of various sectors of the economy;

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- develop and create the required raw materials for the company and for the industry of the state in general.

Non-productive expenditures include investments towards improvement of the conditions and quality of work and life of workers and members of their families. They are focused at

- civil construction, utilization of health care, improvement of education;
- solution or alleviation of the unemployment problem;
- environment protection, as well as other goals aimed at improvement of the quality of life and work.

In the first place, investments are needed for improving the national economy. As the economy grows, many social problems connected with the quality of life can be solved. The investment strategy of a subject of economy is a complex multi-factor model of activities towards achieving the goals and objectives in developing the economic potential of the subject.

Due to spontaneously emerging situations in utilization of capital expenditures, investors need to clarify conditions and evaluate intensity of conversion of finances into materialized elements of productive and non-productive expenditures. The assets turnover is uncertain due to unpredictable final results of investment activities. For development of renewable factors of production, it is important to find the trends and laws of capital growth.

One of the challenges in the development of investment strategies is the nature of intensity of capital expenditures. Slow rate of construction or even ``freezing'' are possible problems. Funds that are withdrawn from production are unable to bring profit before completion of the construction; hence, the ``freezing'' is a risk to the investor.

Problems that arise in utilization of capital expenditures and efficiency of their use were studied by S. I. Abramov [1], A. G. Aganbegyan [2-3], D. Astrinsky [4], I. V. Bardash [5], L. A. Waag [6], L. Valras [7], V. Danilin [8], D. Keynes [9], A. A. Cuev [10], V. N. Livshits [11], T. S. Khachaturov [12], R. Pike [13], and a number of other scientists. In their works, the problem was considered from the point of view of obtaining the fullest effect of utilization of capital expenditures and taking into account various factors that affect the final result.

Among the temporal characteristics of efficiency of capital expenditures in the industrial sector, we mention the payback period. Economists working in this field are focusing their efforts on reducing the duration of construction on the basis of normative data by adjusting them to real production conditions [14].

V. M. Kirnos, analyzed the actual data and suggested several models that take into account the impact of economic, organizational, and

technological factors on the duration of construction of objects [15]. He also suggested an equation of regression that takes into account the dependence of the reconstruction time on the workload. In [16], models were suggested that allow us to consider varying normative times and costs of construction.

The behavior of capital expenditures during construction of an object generalizes intensity of capital expenditures [17].

In the analysis of utilization of capital expenditures, the coefficient QUINTA is used which measures intensity of occurrence of unfinished constructions. This coefficient is the ratio of the planned coefficient to the standard coefficient of the distribution of capital expenditures [18].

In the analysis of efficiency of capital usage, the evaluation coefficient of capital flows is used. This coefficient combines a group of indicators that estimate receipt, withdrawal, and use of funds at the end of a reporting period. Intensity of capital flow also evaluates utilization of capital expenditures. For construction of objects, the graphical representation of capital flow is a line of utilization of capital expenditures. Visual analysis of this line allows us to distinguish between extensive and intensive behavior in utilization of capital expenditures, determines the proportionality of the loss of contractor and the customer in relation to the reduction in construction time.

In a number of works, models are suggested for the impact of utilization of capital expenditures on economic growth of a subject [19-21].

In all these approaches, efficiency of productive and non-productive capital expenditures are analyzed separately. Such an analysis does not allow us to consider the whole process and to evaluate intensity of utilization of capital expenditures of a region or a country and to foresee failures in planning for putting productive and non-productive funds into operation.

The aim of this article is to obtain a characteristic of utilization of capital expenditures that takes into account the flow of invested funds at the stage of their conversion into fixed assets. We suggest an analytical formula for analyzing intensity of utilization of both productive and non-productive capital expenditures judged as a single indicator for intensity of utilization of expenditures. This indicator can be also used as a measure of instability in utilization of capital expenditures.

2. Methodology

Consider the space of the renewable factors of production, where K denotes fixed assets and L denotes labor resources. At a moment of time t, we introduce an infinitesimal augmentation and obtain new values of these factors at the moment of time $t + dt$. In the three-dimensional space of the variables (K, L, t), we consider a surface dS_1 at the time t.

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This surface represents the value of fixed assets, the amount of labor, and capital expenditures $\bar{I} = (I_K, I_L)$ for a group of similar subjects of economy (for example, enterprises of the same industry, Federal districts, or a group of countries). During the period of time dt, capital expenditures cause variation of the factors of production. The rate of variation of fixed assets and labor resources is determined by the formulas $v_K = \frac{dK}{dt}$ and $v_L = \frac{dL}{dt}$. The velocity vector is tangent to the trajectory of development of the factors of production. As a result, we obtain a surface called the corridor of utilization of expenditures. This line does not intersect the lateral surfaces, see Figure 1 [22].

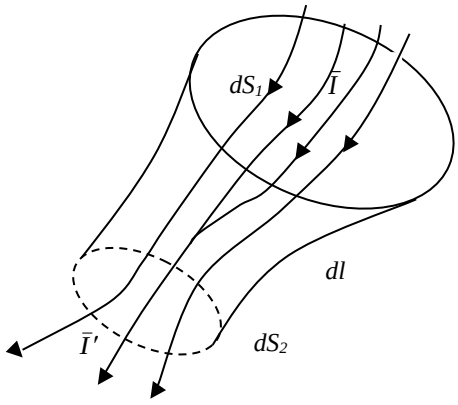

Figure1. The corridor of utilization of expenditures

Let $(\bar{a} \cdot \bar{b})$ denote the scalar product of vectors. Then $(\bar{I} \cdot d\bar{S}_1)$ lines of investment entered the corridor at the time *t*. In the figure, the number of lines of utilization of capital expenditures that meet a unit area is proportional to the numerical value of the vector of capital expenditures. After the period of time dt, we pass to a new surface dS_2 at a distance dl with a new value of the factors of production and capital expenditures $\bar{I}'$. Their part equal to $(\bar{I}' \cdot d\bar{S}_2)$ has already been utilized, see Fig. 1. The total flow of capital expenditures during the period of time is the difference between the flows on the surfaces dS_2 and dS_1, i.e., is equal $(\bar{I}' \cdot d\bar{S}_2) - (\bar{I} \cdot d\bar{S}_1)$. The total volume of the created factors of production during the period of time dt is equal to $dV = dldS$. The

divergence of the flow per unit volume of the created factors is equal to $\frac{\left(\bar{I}' \cdot d\bar{S}_2\right) - \left(\bar{I} \cdot d\bar{S}_1\right)}{dldS}$.

We pass to the limit as the variation of the factors of production tend to zero. We obtain the dynamic divergence [23]

$$DIV\left(\bar{I}\right) = \lim_{w \to 0} \frac{\int_{\Gamma} \bar{I} \cdot d\bar{S}}{\int_{w} dV}.$$

As it is shown [22], the dynamic divergence of capital productive and non-productive expenditures describes intensity of utilization of these expenditures. The divergence is determined by the formula

$$\varepsilon = DIV(\bar{I}) = \frac{v_L}{|\bar{v}|^2}\frac{\partial I_L}{\partial t} + \frac{v_K}{|\bar{v}|^2}\frac{\partial I_K}{\partial t} + \frac{\partial I_L}{\partial L} + \frac{\partial I_K}{\partial K}, \qquad (1)$$

where the vector $\bar{I}$ consists of two components, I_K is the productive capital expenditures and I_L is the non-productive capital expenditures. The capital and labor resources vary at the rates $v_K = \frac{dK}{dt}$ and $v_L = \frac{dL}{dt}$ respectively. The absolute value of the square of the rate of renewal of the renewable factors of production is determined by the formula $|\bar{v}|^2 = v_K^2 + v_L^2$. We denote by $\frac{\partial I_p}{\partial t}$ the partial derivatives of capital expenditures in the *p*th factor of production with respect to the time variable and by $\frac{\partial I_p}{\partial p}$ the partial derivatives with respect to the *p*th factor of production.

We evaluate the rate of utilization of capital expenditures. We pass to a discrete analog of representation (1). Instead of continuous functions v_K, v_L, $\frac{\partial I_p}{\partial p}$, and $\frac{\partial I_p}{\partial t}$, we consider their finite-difference analogues. Assume that we know the values of capital expenditures, fixed assets, and labor resources at the moments of time *t* and $t + \Delta t$. We vary the factors of production using uncentered temporary differences, i.e., we have

$$\Delta K = K(t + \Delta t) - K(t), \quad \Delta L = L(t + \Delta t) - L(t), \quad v_K \approx \frac{\Delta K}{\Delta t}, \quad v_L \approx \frac{\Delta L}{\Delta t},$$

$$\frac{\partial I_K}{\partial K} \approx \frac{\Delta I_K}{\Delta K}, \quad \frac{\partial I_L}{\partial L} \approx \frac{\Delta I_L}{\Delta L}, \quad \frac{\partial I_K}{\partial t} \approx \frac{\Delta I_K}{\Delta t}, \text{ and } \frac{\partial I_L}{\partial t} \approx \frac{\Delta I_L}{\Delta t}.$$

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Assume that capital expenditures $\bar{I} = (I_K, I_L)$ were fully utilized during the interval Δt of time. Then the finite temporal analogue of formula (1) assumes the form

$$\varepsilon = \frac{\Delta I_L \Delta L + \Delta I_K \Delta K}{(\Delta L)^2 + (\Delta K)^2} + \frac{\Delta I_L}{\Delta L} + \frac{\Delta I_K}{\Delta K}.$$

If capital expenditures are instantly utilized and immediately start to return profit then $\varepsilon = 3$. Divergence may differ significantly from this ideal value due to slow rate of utilization and/or the possibility of "freezing." If $\varepsilon < 3$ then capital expenditures are developed slowly. Negative values reflect negative growth of fixed assets or labor resources. Values with $\varepsilon > 3$ correspond to intensive utilization.

Capital expenditures are measured in monetary units divided by units of time (mon.un./un.tim.), while fixed assets and their variation are measured in monetary units. Labor resources and their variation are measured with the use of wages in monetary units. The divergence ε is measured in 1/un.tim., which corresponds to the rate of variation of capital expenditures.

Consider the annual variation of the divergence of capital expenditures, i.e., put $\Delta t = 1$, $\Delta I_K = I_{Ki}$, $\Delta I_L = I_{Li}$, $\Delta K = K_i - K_{i-1}$, and $\Delta L = L_i - L_{i-1}$, where I_{Ki} denotes capital productive expenditures during the *i*th year, I_{Li} denotes capital non-productive expenditures during the *i*th year, K_i denotes fixed assets in the *i*th year, and L_i denotes labor resources in the *i*th year. For the *i*th year, expression (1) assumes the form

$$\varepsilon_i = \frac{I_{Li}(L_i - L_{i-1}) + I_{Ki}(K_i - K_{i-1})}{(L_i - L_{i-1})^2 + (K_i - K_{i-1})^2} + \frac{I_{Li}}{L_i - L_{i-1}} + \frac{I_{Ki}}{K_i - K_{i-1}}.$$

If expenditures reduce then the rate of their utilization rises. As a rule, economic crises are accompanied by reduction in investment and rising inflation; hence, the funds should be utilized rapidly. Therefore, it is natural to expect intensive growth of the divergence in times of crises and stable behavior of the divergence in periods of economic growth.

3. The obtained results

Our formula allows us to model the annual (quarterly, monthly) behavior of the divergence. We consider two groups of Federal districts of Russia. The first group includes Central, North-Western and Volga districts. The second group includes Ural, Siberian and Far Eastern districts. We analyze the behavior of the divergence from 2006 to 2015. We use the data provided by the Russian Federal State Statistics Servise

[24]. We cannot consider longer time series because of the use of different classifications before and after 2005. The *x*-axis is the time axis at each figure below. The *y*-axis indicates values of the divergence of capital expenditures measured in 1/year, i.e., as the rate of utilization (Figure 2).

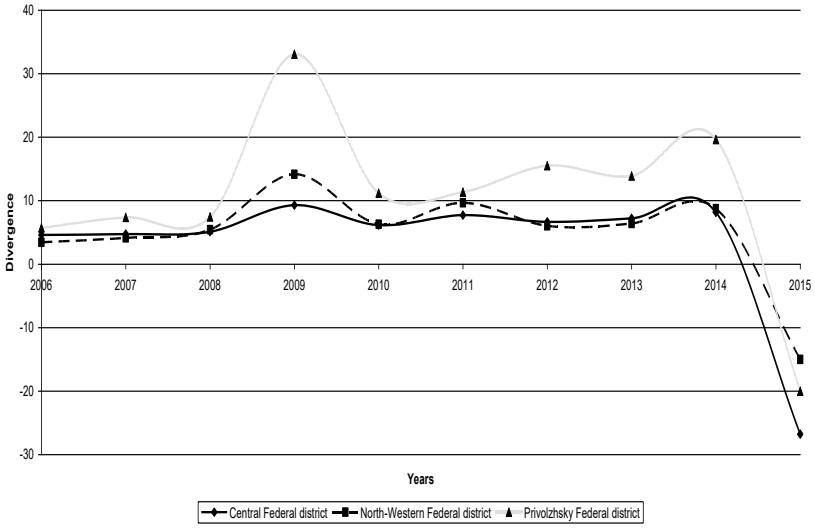

Figure 2. The behavior of the divergence of capital expenditures in Federal districts

In Central Federal district, expenditures in fixed assets from 2006 to 2008 tended to increase. In 2008, they amounted to 2278 billion rubles. In 2009, this value declined sharply to 1928 billion rubles due to the difficult economic situation in the country. This led to acceleration of utilization of capital expenditures and growth of the divergence ε in 2009. From 2010 to 2015, the behavior of the divergence of capital expenditures was stable. Introduction of sanctions against Russia in 2015 immediately affected the economy. Growth in labor resources decreased by 22.4 billion rubles, which resulted in negative values of divergence, and its sharp decline. Similar things can be seen in North-Western and Volga Federal districts. The decline of capital expenditures is observed in all districts in 2009 and negative growth of labor resources occurs in 2015.

The second group of districts shows a slightly different behavior of the divergence of capital expenditures (Figure 3).

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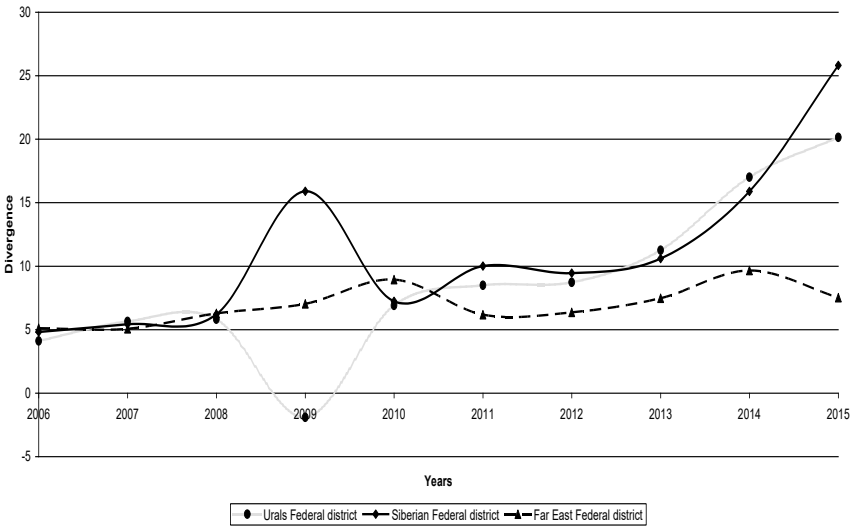

Figure 3. The behavior of the divergence of capital expenditures in Federal districts

In Ural Federal district, capital productive expenditures declined by almost 150 billion rubles and capital non-productive expenditures declined by 20 billion rubles in 2009, while growth in labor force decreased by 25 billion rubles. The reduction in funding and labor resources led to negative values of the divergence. A small decline in expenditure in the fixed capital funds (11 billion rubles) and a significant decrease in the non-productive sector (almost 70 billion rubles), together with continued growth of fixed assets and labor resources led to growth of the divergence of capital expenditures.

The decline of capital expenditures by 110 billion rubles in Siberian Federal district in 2009 caused growth of the divergence that ceased the following year. The decline of expenditure in fixed capital funds was observed since 2013. In 2015, expenditure declines sharply, by 110 billion rubles in productive sector and by 52 billion rubles in non-productive sector. However, the growth of fixed assets and labor resources continues. These factors led to growth of the divergence of capital expenditures since 2013.

In 2009, Far Eastern Federal district showed growth of capital expenditures and fixed assets together with a slight decline in its labor force, which had no effect on the divergence. In 2010, we observe the least gross fixed capital formation and capital expenditures in the fixed capital funds. This affected a small increase of the divergence. The beginning of introduction of sanctions did not affect the Far East. The growth of capital expenditures in productive and non-productive funds

continued and the funds were steadily increasing. These phenomena are reflected in the behavior of the divergence of capital expenditures.

Thus, we see an adequate behavior of the divergence in the case of Federal districts. Now we examine its behavior in the case of economies of whole countries. On the basis of statistical data, we analyze the behavior of the divergence of capital expenditures in EU countries. We consider two groups of countries consisting of the leading (Germany, UK, and France) and ordinary members (Austria, Belgium, and Greece). The behavior of the divergence is analyzed annually from 2002 to 2015. The data were taken at current prices in Euros [25]. For the first group of countries, the graph of the behavior of the divergence of capital expenditures is presented at Figure 4.

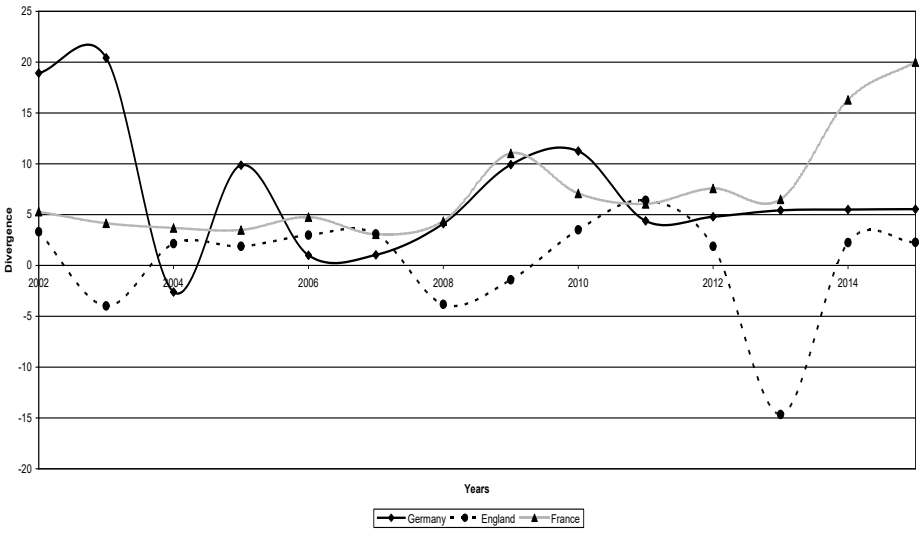

Figure 4 . The divergence of capital expenditures

As above, the *x*-axis is the a time axis for the time interval from 2002 to 2015 and the *y*-axis indicates the divergence of capital expenditures.

If expenditures reduce then the rate of their utilization rises. As a rule, economic crises are accompanied by reduction in investment and rising inflation; hence, it is natural to develop funds rapidly. A small decrease of the Total investment (TI) indicator in Germany from 19.9% of GDP in 2002 to 19.6% in 2003 coincided with the program of accelerated development of industry, whose share in GDP reached 29% in the year under review. Due to insufficient capital expenditures, the rate of utilization increased. In 2004, fixed capital funds declined, which led to negative values of the divergence. In 2005, TI decreased again, to 18.8% of GDP, which is immediately reflected in growth of the

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divergence. According to the International Monetary Fund, the most rapid decline of TI was recorded in Germany in 2009. The value of TI in 21% from GDP in 2008 decreased to 18.1% of GDP in 2009, which is the largest decline over the study period. The decline in investment led to growth of the divergence. The fastest growth of TI is observed in the following year, it rose to 19.6% of GDP. As a result of this growth, the divergence decreased. In 2011, investment growth to 21% from GDP continued and there was a further decline in the divergence of capital expenditures. During all subsequent years, the rate of TI amounted to approximately 19,3% of GDP, which reflected in the behavior of the divergence [26].

In the economy of France, the same indicator TI showed relatively stable behavior from 21.2% of GDP in 2002 to 24.1% in 2008. Next year, a sharp decline to 21.3% had an immediate impact on growth of the divergence of capital expenditures. New growth of TI started next year and it reached 22.3% in 2013. It the last two observed years, TI decreased. The divergence declined until 2013. In 2013, the French government froze most government spending turned down measures to stimulate the economy, and abolished tax benefits to bring the budget deficit to EU standards. These government activities caused a shortage of financial resources, which led to growth of the divergence.

Reduction of fixed capital funds was observed in the UK in 2003, 2008, 2009, and 2013, which led to negative values of the divergence. From 2004 to 2007, stable growth of TI was observed from 18.3% of GDP to 19.2% of GDP, which corresponded to a stable behavior of the divergence. In the next three years after the 2008 crisis, the divergence of capital expenditures increased. That is associated with a sharp decline of TI from 18% of GDP in 2008 to 15.3% of GDP in 2009. According to forecasts, the TI indicator of the UK will amount to 18% of GDP only in 2017.

We consider the second group of countries, i.e., Austria, Belgium, and Greece. Although these economies are very different from the previous three, the behavior of the divergence of capital expenditures is the same and the variation ranges from -10 to 20 (1/year). For the graph, see Figure 5.

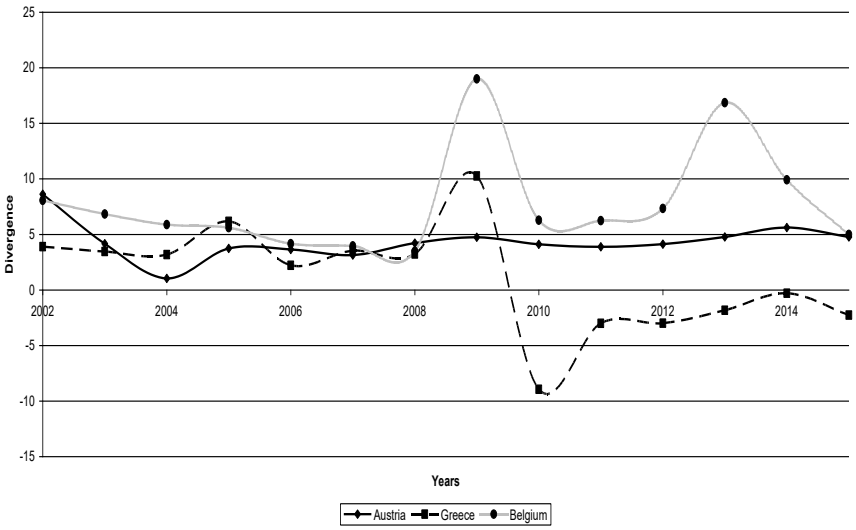

Figure 5. The divergence of capital expenditures

Austria is one of the most stable countries in Europe. It relatively easily passed through the economic crisis of 2008. Global economic downturn led to a short recession in the Austrian economy. In 2009, decline in GDP by 3.8% was replaced by growth of 2% in 2010, and by 2.7% next year. Over the last 35 years, the TI indicator of Austria varied little and was located near 23% of GDP [27]. The divergence varied slightly too and ranged from 1 to 6.

In recent years, Greece was one of the most problematic countries of Europe. The first fluctuation of the divergence is explained by decline of TI from 25.3% of GDP in 2004 to 22.1% in 2005. Further rise of the indicator to 26.1% of GDP in 2006 led to decline of the divergence. The year of 2009 was a challenging year in Greece, as in most European countries. In 2009, TI decreased to 18.3% compared to 25% of GDP in the previous year. This caused an increase in the divergence. In the subsequent six years, the value continued to decrease and reached 9.8% of GDP. Throughout this period there was a negative dynamics of GDP, except for 2014 (0.6%), and unemployment from 7.3% in 2008 to 25.6% in 2015, [28]. Fixed assets decreased by more than 100 billion euros [25]. Negative values of growth of labor resources and fixed capital funds led to decrease of the divergence and appearance of its negative values.

Before the 2008 crisis, Belgium was a fairly prosperous country in Europe. In 2009, TI decreased to 21.7% of GDP compared to 25.7% in the previous year. A drop of 4 points reflected in growth of the divergence. The indicator increase started next year. In 2013, a new decrease of TI to 22.1% was recorded. That year, the Belgium GDP grew

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only by 0.1%, and the unemployment rate reached 8.8%. In 2013, the public debt of Belgium was about 100% of GDP, which became negative factor for investors [26]. Investors anticipated strong exposure to the crisis on the Belgian economy. These factors affected the behavior of the divergence of capital expenditures. In 2014, TI started to grow, which led to decrease of the divergence.

4. Conclusion

The divergence of capital productive and non-productive expenditures allows us to evaluate intensity of utilization of expenditures. Together with shortage of funds, steady growth of the divergence is observed. If, in addition, fixed capital funds and unemployment decrease then negative values of the divergence appear, which indicates crisis phenomena in the economy. The values of the divergence depend on the size of a subject of economy much less than on the strategy of the governing bodies. The formula for calculating the divergence takes into account productive capital expenditures as well as investment in the improvement of the living conditions of workers. This makes the indicator more comprehensive. The ideal value of the divergence is $\varepsilon = 3$. Therefore, values of the indicator near this number indicate good rate of utilization of capital expenditures. Among the above discussed examples, we distinguish Austria, where ε varies from 1 to 5,6 (1/year).

In our study, we use uncentered temporary differences because centered differences lead to smoothing phenomena in the economy and lead to not quite correct results. The use of monthly and quarterly statistical data may help to obtain more detailed results.

The suggested indicator can be used as another tool for evaluation of the efficiency of utilization of capital expenditures.

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