GROSS DOMESTIC PRODUCT AND EXTERNAL COSTS: THE CASE OF SUSTAINABLE MANAGEMENT IN SERBIA

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Abstract. *This paper defines a complicated calculation model of sustainable development. Social welfare can be expressed quantitatively by GDP growth. The empirical data on changes in Serbian GDP growth in the period: 2002-2011, served as a base values on which the assumed correction of external costs was applied. For our analysis we used numerical simulation approach. Our results show that variable GDP has the sixth-degree polynomial form with the empirical Serbian data in observed period. Consequently, the results show the viability of the economic and ecological development in the framework of our assumptions. We defined the external costs or social costs of externalities as "the costs of nature", and they are structured so that they make the sum of losses of the environment due to exploitation of non renewable resources, pollution and the necessary investments for the elimination of pollution costs. Additionally, the paper presents utility function that includes both market and non-market assets, or consumption of these assets by an individual.*

Keywords: *GDP, external costs, sustainable development, utility function, numerical simulation.*

1. INTRODUCTION

The external costs and their inclusion, as a correction factor, to the calculation of the commercial effects of the companies, at micro level, respectively the negative impact of unsustainable use of natural environmental the macro level, still represents the research challenge. However, the marginalization of external costs leads to maximizing the benefits and profits for market factors whose target function is to maximize profits. The problem of calculating the external costs, especially their negative impact on the relations between economy and ecology requires further research and analyses. Specifically, in economic science and its relationship with the border areas of other sciences, ecology, in this case, the problems of negative external effects that arise due to human economic activities have been scrutinized for a long time. Most often, the problem of negative externalities is related to the question of free pollution of the environment and so-called social or general expense. We will try to analyze the problem of external costs calculation that arises during the economic activities. They are most often defined as external social costs, presenting the negative consequences in terms of pollution or environmental degradation. These costs are most often, not born by market representatives, who tend to maximize profit by economic activity, so the costs themselves become the "cost of nature" which synonymous is "external social costs".

In this paper, we expand the content of the concept of negative externalities and include two more, in our opinion, important segments. The first makes free or insufficient nature paid use of renewable and nonrenewable natural values and natural capital. The second segment makes the costs that must be paid for the elimination of consequences of natural environment pollution in order to return, if possible, the status quo ante. These segments are defined as a concept "costs of nature". The measure of social and economic development is generally expressed through gross domestic product (GDP). In the past decades, the methodologies for calculation of GDP growth or decrease were also developed. The defect of applied methodologies for GDP calculation is that they do not include the "cost of nature". Respectively, the costs are partly erroneously encompassed in the calculation, but as a factor of GDP growth, instead of as a correction factor that decreases the statistically calculated GDP growth. This approach opens the possibility for the development of measurement methodology for sustainable growth.

It should be noted that the exploitation of natural resources is unilateral process in which the natural capital, through human activities and implementation of technology, is transformed into created capital-processed nature, and further into its cash forms and financial capital. This capital is spent in short or long time horizon, even in cases when some of its parts are not used at all. Generally it is one-way process. There are some exceptions when the reverse flow is possible which means that the cash equity, along with the use of created capital- technology, is engaged as capital investment for continuation or self-continuation support to some of environmental segments. Speaking about positive external flow, we only speak about the cases when the nature itself has ability to regenerate and establish the status quo ante.

The paper is structured as follows: Section 2 presents literature review; Section 3 introduces the concept of utility and utility function, in Section 4 a model of sustainable development on the case of Serbia is presented and numerical simulation for solving this model is applied, and Section 5 is Conclusion.

2. LITERATURE REVIEW

Tobin (1981) defines the structure of material wealth of a society as follows: "*Material wealth of a country consists of* *its natural resources, inventory of goods and net claim from the rest of the world*". Accordingly, the material wealth of a country presents the cumulative structure of: natural resources, generated goods made by labor and capital, and net surplus or deficit resulting from international trade.

According to the presented approach, the material wealth of a country represents the cumulative structure: natural resources, labor and capital goods, and generated a net surplus or deficit resulting from international trade.

Ponting (1993) described case of exploitation of natural resources – phosphates from islands Ocean and Naurua in Polynesia during the first half of the twentieth century. The empirical case of exploitation of natural capital from the above islands is de facto complete and simple model that accurately shows then on-inclusion problem of negative externalities in the calculation of economic efficiency.

Hotelling (1931) described the economics of exhaustible resources. He examined the small tax effect on social value of the resource. The author showed that even a small tax on a monopoly resource significantly reduces social utility. The Hotelling's Rule is connected with using nonrenewable natural resources such as mineral resources, land and other natural resources that do not possess the ability to regenerate. Hotelling's Rule, which still occupies a central place in the economy of natural resources, demands (so that the exploitation or extraction of nonrenewable resources in the course of time be optimal), net cost of resources to grow in the future at the same or a minimum rate at which the interest rate increases (Hotelling, 1931). The net price represents the difference between sales and market price and costs of resource exploitation.

3. UTILITY FUNCTION

The concept of utility or usefulness is complex. There are two aspects of understanding. Due to the difficulty of its synthesis, the concept is not operational enough for analytical expression of natural values and benefits that arise from them. The economic approach is based on the anthropocentric factor – the consumption of goods and services by an individual represent happiness and benefit for some individual. Goods are divided into: market goods (consumer goods such as food, beverages, another products and services) and non-market goods (such as clean air, charity work, and enjoying nature).

The utility function includes commercial and non-market goods or consumption of goods by individuals. All goods that are used for consumption represent the market basket of the individual. The value of market goods consumption can be directly monetary expressed through product of quantities and prices, while on-market goods are directly evaluated and often cannot be expressed monetary. Social utility or welfare could rise even when one social group has the growth of consumption of goods or profit at the expense of other social groups that experience the declining consumption of market goods and the deterioration of the environment (Robinson, 1964). The taxes could be viewed from two aspects. The standard tax concept defines percentage burden (increase) of market goods which affects the growth of their prices and reduced demand for them, reduce consumption, leading to a reduction of individual utility. The taxes do not affect the utility of non-market goods. No standard approach is related to the consumption of natural resources, resources or environmental pollution. These are fees, they are not a standard tax, but they have a similar function as the standard tax. Thus, they increase the cost of goods, reducing demand for them, and lead to less consumption.

The function of individual utility can be expressed in the following term (Drašković, 2010):

$$U_s = C_s \sum_s (Z_s - c_s) \tag{1}$$

where:

- U_s,- function of individual utility
- C_s– total consumption
- Z_s – average consumer basket of market and non-market goods in time t
- c_s – consumption, expenditure as "production" of polluted air, contaminated water and land
- s – individual or economic agent.

Total consumption C_s makes the difference between the total sum of individual consumption of market and non-market goods. The consumer basket of market and non-market goods Z, presents a pleasure (welfare, utility) for individual (so called positive externalities). Then, shown benefit is decreased for social cost of negative externalities, c_s representing the natural environment pollution, that arise from a negative function of the consumption process of goods by individuals (Drašković, 2010).

In the theory of social choice preferences themselves, are of crucial importance. Urošević (2008) states that it is important when the preferences can be described as an ordinal utility function. The ordinal utility function U reflects the aggregate of all consumer baskets Z on the aggregate of all real numbers R, so that (Urošević, 2008):

$$\mathbf{U(x) > U(y) \Leftrightarrow x > y}$$
$$\mathbf{U(x) = U(y) \Leftrightarrow x = y} \tag{2}$$

It is assumed that on the market there are N consumer goods. The vector $\mathbf{x} = (x_1, x_N)$ □R^Ndefines arbitral consumer basket of consumer goods. Z is arranged aggregate of all consumer baskets which can be formed from existing N consumer goods. The index $\mathbf{x} \succ \mathbf{y}$ means that an economic agent "prefers strongly **x** in relation to y" where as the index x = y means that a consumer is indifferent in choosing between the two consumer baskets (Urošević, 2008)

The function of utility U reflects the preference relation on the aggregate Z on the standards arrangement of real numbers aggregate, where the consumer basket, which corresponds to higher level of utility is preferred in relation to the basket which utility level is lower (Urošević, 2008).

4. THE NUMERICAL SIMULATION OF THE SUSTAINABLE MANAGEMENT

There is a large number of sustainable development definitions which can be reduced to one of the most common, from the standpoint of essential meaning, quite acceptable, and it is a formulation that is exposed in the Bruntland Commission Report (WCED, 1987), in which sustainable development is defined as: *"Development that meets present needs, without the danger of the future generations not to be able to meet their needs."*This means that there are two general aspects. The first is that the current generations do not exhaust the natural resources by using them up during this time, hence not leaving natural resources for the future generations. Another aspect is that the present generations must take care not to contaminate the environment, hence leaving the future generations with the environment of less quality or its usefulness of quality, that which the current generations enjoy.

The standard methodology for calculating the gross domestic product (GDP), on the level of individual countries, reflects the state of economy of a country. The calculation results in aggregate sizes, which are expressed for each of the individual years. Economic science has not found a better method. Lack of existing methodologies, calculations and showing the movement of GDP from an environmental standpoint, is that it does not include, in a proper way neither the benefit nor gifts of nature, i.e. natural capital. Furthermore, the calculation also does not include the nature cost that is expressed as pollution and, partially as environment damage. Namely, when it comes to cost and expenses for eliminating the consequences from environmental accidents, these costs are calculated so that they are expressed as the incentives for GDP growth. The problem of GDP calculation, which does not include the costs appropriately and nature as a source of wealth and as a space for waste by-products of economic activity, duly indicates the paradox included in the application of sustainable development.

We constituted a sustainable development model using Serbia as an example, which we are presenting here under. In constituting the model historic data on the movement of the size of GDP in Serbia for the period from 2002 to 2011 was used. Values are expressed in Euro, at the current exchange rate. Following assumptions were introduced:

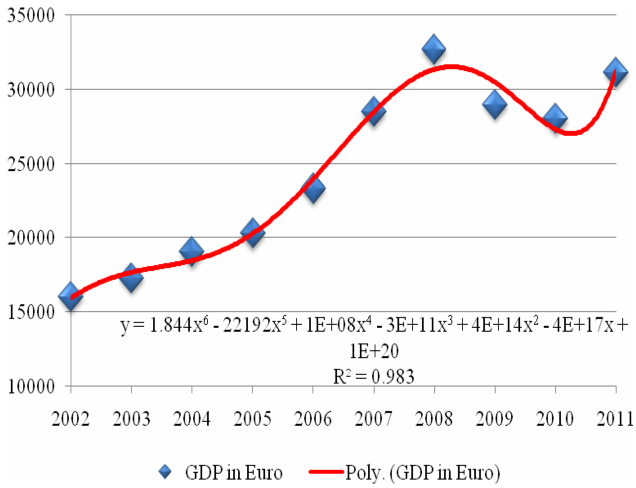
- nominal value of the reported GDP is not realistic, because it does not include the costs of nature and the cost that is necessary to remedy the damage that is imposed to the environment and which represent negative externality,
- the growth of nominal GDP is projected at a rate of 3.5%,
- the calculation should be based on the assumption that the cost of nature and cost of removing the damage caused by economic activities should to be add, and their sum results as a subtrahend of the officially reported GDP.

The result should demonstrate development sustainability or the price that has to be paid for the development to be sustainable.

Social welfare can be expressed quantitatively by GDP growth. The amount of GDP represents the total amount of consumption, satisfactory use of measurable material goods and services. The value of GDP in Euro is observed at the site of the Statistical Office of Republic Serbia (http://webrzs.stat.gov.rs/WebSite/).

In Figure 1 we drew the values of GDP from 2002 through 2011, with blue dots. The red line in Figure 1 represents the trend line for which we got to be sixth degree polynomial form. This means that the GDP variable has a multifunctional character and in its calculation at least six different factors should be included. In the best case GDP (marked as y) would have the sixth-degree polynomial form, whereby the assessed coefficients of the given polynomial form are presented in Figure 1. The determination coefficient, R^2, is quite high (98.3%) which means that the trend line fits well to the actual data values for GDP.

Figure 1. Real Value of GDP in EURO (blue dots). Red line represents the trend line.



Source: Statistical Office of the Republic of Serbia, and authors' calculation

In case that there is no impact of pollution as a negative factor that reduces the benefit, social welfare (GDP) will grow continuously in the considered period. The average GDP growth rate in the perceived period was 3.5% per annum. The stated continued growth does not take into account the problem of benefit distribution in the society itself, amongst the social groups that make up its structure.

We will introduce the assumption that there are harmful effects of the economic activities that generates goods and services as a necessary utility segment, i.e. GDP growth. The detrimental consequences of *c* (costs) are air and water pollution, reduction of biodiversity and the like. Investments which should be introduced to repair the damage of these negative effects we marked with *I* (investments). We will examine the effect of the negative harmful effects due to environmental pollution, as well as the effect of investments in order to repair the damages, on reduction of GDP growth, or usefulness.

We postulate the following form for the GDP function (GDP*):

$$GDP_{t+1}^{*} = GDP \cdot (1 - I) - c \cdot GDP_{t}^{*} \qquad (3)$$

Then, we estimate the coefficients *I* (investments), and *c* (costs) which best approximate the given GDP using the following optimization program:

$$\underset{I,c}{Min} \sum_{t} \left(GDP_t - GDP_t^{*} \right)^2 \qquad (4)$$

where GDP is real GDP given by the market, and GDP* is given by the model (equation 3). However, equation (4) shows the management of sustainable development in the observed case.

It should be noted that we assumed that GDP depends on the costs and investments in a linear manner, even though the actual data suggests the fact that the GDP function would be best to approximate by polynomial form sixth degree. For simplicity and lack of publicly available information, linear dependence was used.

In Table 1 we presented the real value of GDP in Euro and theoretically calculated value obtained using the equation (3). We assumed that the coefficients *I* (investment) and *c* (damage) are constant, and they are derived by running numerical simulation by clicking on the "Solver" (see Figure 2) in the software package Microsoft Excel, and by solving the optimization problem given by equation (4). The program itself executes simulation and optimization and gives values for the given parameters.

Actual Theoretical Value of GDP

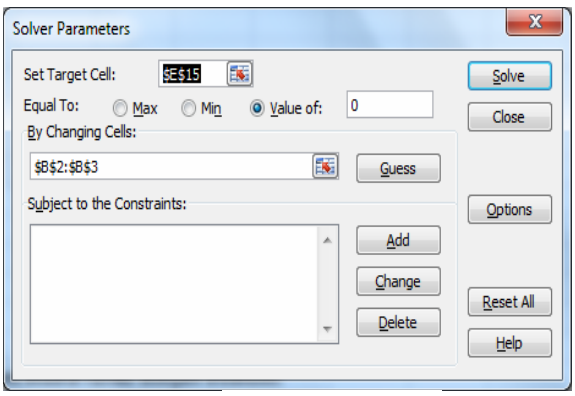
Table 1.

	GDP(in Euro)	GDP*	$(GDP-GDP^*)^2$
2002	16028	17974.5	3788864
2003	17306	19294.8	3955443
2004	19026	20706.7	2824845
2005	20306	22197.5	3577879
2006	23305	23800.5	245513
2007	28468	25436.7	9188574
2008	32668	26993.8	32196155
2009	28957	28514.0	196242
2010	28006	30418.5	5820196
2011	31140	32605.5	2147623
		sum	63941334

Notes: GDP = actual value in Euro, observed on site of the Statistical Office, GDP * = theoretical value that is calculated after calculating the damage and necessary investments to removing the damage.
Source: Statistical Office of the Republic of Serbia, and authors' calculation.

After running the numerical simulation shown in Figure 2, the program gives the value of damage 5.38% (*c* = 5.38%), while the value of investments -12.14% (*I* = -12.14%) in order to satisfy the optimization problem set by equation (4).

Figure 2. Obtaining parameter values of damage and investment by solving the optimization problem



Source: Authors' estimation.

Average growth of GDP's real value in the observed period was 3.5% per annum. We get that the value of damage is greater than GDP's growth, and that the rate of investment must be much higher than GDP's growth, in order to eliminate the damage. So, if one assumes that the GDP's growth rate is constant and is 3.5%, we find that the damage is 5.38% and that the rate of investment has to be much higher, in order to repair the damage, and it should be 12.14%.

Once again, the numerical simulation was re-launched for the same function GDP*, represented by equation (3), but now with slightly modified optimization problem. Specifically, unlike the previous case where the minimization of the sum squares, the differences of real and theoretical given GDP represented management of sustainable development, now the management of sustainable development will be expressed by equation (5) which is the minimization sum difference of real and given theory of GDP. Thus, we estimate the coefficients *I*, and *c* which best approximate the given GDP using the following optimization program:

$$\underset{I,c}{Min}\sum_{t}\left(GDP_t - GDP_t^*\right) \qquad (5)$$

In Table 2 we presented the real value of GDP in Euro and the theoretically calculated value obtained by using equation (3). We assumed that the coefficients *c* and *I* are constant, as was in the previous case, and they are obtained by running the numerical simulation by clicking the "Solver" (see Figure 3) in the software package Microsoft Excel, and by solving the optimization problem given by equation (5). The program itself executes simulation and optimization and gives values for the given parameters.

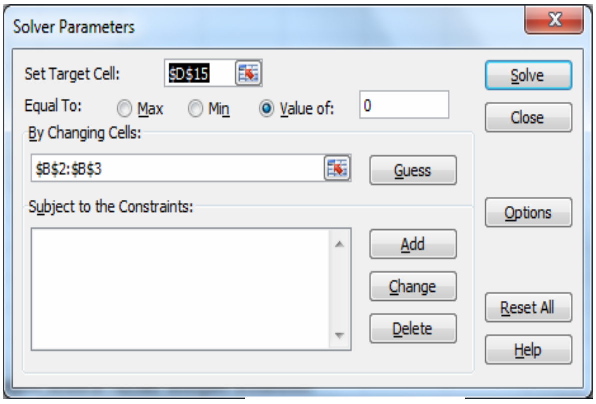
The actual and theoretical value of GDP

Table 2.

	GDP(in Euro)	GDP*	GDP-GDP*
2002	16028	17958.0	-1930.0
2003	17306	19244.7	-1938.7
2004	19026	20616.6	-1590.6
2005	20306	22059.7	-1753.7
2006	23305	23606.7	-301.7
2007	28468	25176.0	3292.0
2008	32668	26652.3	6015.7
2009	28957	28076.9	880.1
2010	28006	29875.8	-1869.8
2011	31140	31943.2	-803.2
		sum	**0.0**

Notes: GDP = actual value in Euro, observed on site of the Statistical Office, GDP * = theoretical value that is calculated after calculating the damage and necessary investments to removing the damage.
Source: Statistical Office of the Republic of Serbia, and authors' calculation.

Figure 3. Obtaining parameter values of damage and investment by solving the optimization problem



Source: Authors' estimation.

After running the numerical simulations shown in Figure 3, the program gives the value of the damage – 4.16% (c = – 4.16%), while the value of investments – 4.11% (I = – 4.11%) in order to satisfy the optimization problem set by equation (5).

Average value of real GDP growth in this period was 3.5% per annum. We get that the value of damage and investment is greater than GDP growth in absolute value. So, if one assumes that the GDP growth rate is constant and is 3.5%, we find that the damage is – 4.16% and the rate of investment has to amount to – 4.11% in order to repair the damage.

The main challenges for the overall environment policy in countries that are in transition are to establish adequate mechanisms and institutions for financing and assisting in solving priority environmental problems. These mechanisms and institutions should be designed to promote the development of market-based mechanisms in accordance with the mechanism of the "polluter pays" (Drašković, 1998).

5. CONCLUSION

The paper defines utility function that includes both market's and non-market's assets, or consumption of these assets by an individual. Then, a complicated calculation model of sustainable development was introduced. The numerical simulation approach was applied in our analysis of Serbian GDP growth in the period: 2002-2011.

Our results showed that variable GDP has the sixth-degree polynomial form. We have simplified the external costs during our analysis and have further defined them in two aspects. One aspect relates to the free cost of nature that is presented as a benefit for the participants of economic activities, those who seek to maximize their own benefits (profits) and have an interest to minimize these costs. Thus, participants have an interest not to settle these costs. The other aspect of external costs, whereby the market participants, led by their own interests avoid to present the costs that occur, as expenses for removing damages inflicted on nature. Both aspects of external costs, i.e., their sum, should be presented as a deduction in relation to reported changes in real GDP.

Implementing this procedure, during our analysis we noticed, using the example of Serbia, that the results on the basis of the starting assumptions, conditions for sustainable development are not met. However, the integration between the economy and ecology, both at micro and macro level still remains, in a satisfactory manner an unresolved problem of internalization of external costs.

6. ACKNOWLEDGEMENTS

This paper is part of research projects numbers 47009 (*European integrations and social and economic changes in Serbian economy on the way to the EU*), 179015 (*Challenges and prospects of structural changes in Serbia: Strategic directions for economic development and harmonization with EU requirements*), financed by the Ministry of Science and Technological Development of the Republic of Serbia. All remaining errors are the authors' responsibility.

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