DETERMINATION AND COMPENSATION OF EXTERNAL COSTS IN SERBIA AS PARAMETER OF SUSTAINABLE MANAGEMENT1

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Abstract:

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 environment at the macro level, still represents the research challenge. The marginalization of external costs leads to maximizing the benefits and profits for market actors whose target function is to maximize profits. Instead of presenting an analysis of examples of companies that do not bear the costs of externalities, in this chapter we have presented the clear 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 the non-inclusion problem of negative externalities in the calculation of economic efficiency. Analogous to this example, the chapter defines a model of sustainable development, where the empirical data on changes in GDP growth in Serbia in the period: 2002-2011 served as a base values on which the assumed correction of external costs was applied. The results show the viability of the economic and ecological development in the framework of these 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.

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INTRODUCTION

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[4] is related to the question of free pollution of the environment and so-called social or general expense. In this chapter, 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 non-renewable 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". 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 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 don't 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

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[4] A negative externality, or external effect, occurs when a production or consumption activity has unintended damaging effects, such as pollution, on other firms or individuals, and no compensation is paid by the producer or consumer to the affected parties. A positive externality occurs when activities have beneficial effects for others who do not pay the generator of the effect, such as freely available research results (Stern, 2004).

growth. This approach opens the possibility for the development of measurement methodology for sustainable growth.

Stern (2004) defines non-renewable resource as a natural resource such as petroleum, which has zero natural growth over ordinary human timescales; though it may be replenished over geological time. He defines renewable resources such as forests grow or regenerate at rates that are relatively fast on human timescales.

Brundtland's (1987) report highlighted three fundamental components to sustainable development: environmental protection, economic growth and social equity. The concept of sustainable development focused attention on finding strategies to promote economic and social advancement in ways that avoid environmental degradation, over-exploitation or pollution, and sidelined less productive debates about whether to prioritize development or the environment.[5]

Sneddon et al., (2006) pointed out that the world's political and environmental landscape has changed significantly after the publication of Brundtland's (1987) *Our Common Future*. These authors using pluralism as a starting point for the analysis and normative construction of sustainable development, they pay particular attention to how an amalgam of ideas from recent work in ecological economics, political ecology and the "development as freedom" literature might advance the Sustainable Development debate beyond its post-Brundtland quagmire. They concluded that enhanced levels of ecological degradation, vast inequalities in economic opportunities both within and across societies, and a fractured set of institutional arrangements for global environmental governance all represent seemingly insurmountable obstacles to a move towards sustainability. While these obstacles are significant, they suggest how they might be overcome through a reinvigorated set of notions and practices associated with sustainable development, one that explicitly examines the linkages between sustainability policies and sustainability politics (Sneddon et al., 2006).

Heal & Barrow (1980) showed that if resource markets are functioning efficiently, there will be a strong association between the rates of change of resource prices and the rates of return on other assets. In particular, they showed that as certain commodities (for example, copper, tin, lead and zinc) are exhaustible resources, the theory would predict that in an efficient allocation the rates of change of their prices would be related to return on other assets. They constructed and tested a series of models of resource markets whose demand and supply functions incorporate the idea that an exhaustible resource is an asset

[5] http://www.earthsummit2012.org/about-us/historical-documents/92-our-common-future

whose rate of price appreciation is a factor determining holding decisions and which explicitly recognizes the possibility of arbitrage between resource markets and markets for other capital assets (Heal & Barrow, 1980).

Smith (1981) reported the results of an evaluation of the performance of arbitrage models for explaining the price movements for exhaustible natural resources. His appraisal was based on the *ex post* forecasting performance for eleven years outside the sample period. He distinguished two features the alternative descriptions of arbitrage in these resource markets. They are: the description of the process for each natural resource's expected rate of price appreciation, and the measure of the expected rate of return for alternative assets. Overall, his results indicated that the Heal-Barrow (1980) specification was consistently among the 'best' models for the twelve minerals studies. It was not, however, uniformly superior to naive models for forecasting price movements (Smith, 1981).

Halvorsen & Smith (1991) used duality theory to derive an econometric model that provides a statistical test of the theory of exhaustible resources. They used a restricted cost function to obtain estimates of the shadow prices of unextracted resources. These authors illustrated the procedure with data for the Canadian metal mining industry. For this industry the empirical implications of the theory of exhaustible resources are strongly rejected (Halvorsen & Smith, 1991).

Chermak & Patrick (2001) generalized extant developments of the economic theory of exhaustible resource production, derived and extended a Halvorsen-Smith (1991) type test of the theory, and applied the test to a sample of natural gas resources. To facilitate their empirical test, they extended the model developed in Chermak and Patrick (1995) to explicitly account for the fact that the extracted resource (gross product) must be processed to obtain the final (saleable) product. They used duality theory to derive econometric models with which the theory is statistically tested, using panel data from 29 natural gas wells. These authors are estimated shadow prices of the resource stock through time, which are generally unobservable but necessary for the test, via the indirect cost function. Contrary to the extant literature, they found that (i) at any point in time, *ceteris paribus*, the *in situ* resource price (a) decreases with gross production and (b) increases with final production, and (ii) they could not reject the theory of exhaustible resources, i.e., producer behaviour is consistent with the theory (Chermak & Patrick, 2001).

Anand & Sen (2000) integrated the concern for human development in the present with that in the future. In arguing for sustainable human development, their paper appeals to the notion of ethical "universalism" - an elementary demand for impartiality of claims - applied within and between generations. They pointed out that economic sustainability is often seen as a matter of intergenerational equity, but the specification of what is to be sustained is not always straightforward. They explored the relationship between distributional equity, sustainable development, optimal growth, and pure time preference (Anand & Sen, 2000). Borghesi & Vercelli (2003) drawed some hints from a critical assessment of the literature on the Kuznets curve and the environmental, in order to clarify to what extent the recent process of globalisation may be considered as sustainable. They are argued that the optimistic implications of this literature on the sustainability of globalisation are ungranted and that the Kuznets approach is in principle unable to give reliable answers to the questions raised in their work. They conclude that these conditions can be met by implementing a systematic policy strategy aimed at shifting both Kuznets relations downwards (Borghesi & Vercelli, 2003).

Brekke & Howarth (2002) explored relationship between economic growth, human wellbeing and environmental conservation through the analysis of existing theoretical and numerical models. In contrast to the standard neo-classical economic models, the results of the empirical models explored by these authors underscore the fact that endogenously defined social norms play a key role in motivating economic behaviour (Brekke & Howarth, 2002).

Langhelle (1999) told in the purpose of the article is to offer an interpretation of Brundtland’s (1987) *Our Common Future*, where the concept of sustainable development was linked to the broader framework of normative preconditions and empirical assumptions. His structure of the argument is to demonstrate that relationship between sustainable development and economic growth has been over-emphasized and that other vital aspects of the normative framework have been neglected (Langhelle, 1999).

Norton & Toman (1997) addressed underlying theoretical difficulties, paying special attention to two clusters of issues: reversibility and substitutability, and how to assess environmental values. In highlighting these two broad problem areas, they also note that cross-disciplinary disagreements cannot be resolved without making considerable progress in other areas of ecological and economic theory. They suggested that a “two-tiered” system might prove a useful beginning point for finding a more unified and interdisciplinary approach to decision making (Norton & Toman, 1997).

The chapter is structured as follows: Section 2 presents an example from the history of natural resources and the marginalization of external costs, Section 3 introduces the concept of utility and general utility function, in Section 4 the Hotelling's setting of social utility (welfare) is presented, in Section 5 a model of sustainable development on the case of Serbia is presented and numerical simulation for solving this model is applied, and Section 6 is Conclusion.

NATURAL RESOURCES AND MARGINALIZATION OF EXTERNAL COSTS, AN EXAMPLE FROM HISTORY

The material wealth of a society presents the natural resources available to a certain territory and human resources of a given society. The combination of these two factors, "processed nature „is created, that is, produced for goods and services. The exchange of missing resources, both natural and created is carried out by international trade. The excess of natural or created resources, available to a country, is exchanged for missing resources. The missing resources present the excess of natural or created resources of other countries. The American economist, John Tobin[6] 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" (Tobin, 1981). Accordingly, the material wealth of a country presents the cumulative structure of: natural resources, generated goods made by labour 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, labour and capital goods, and generated a net surplus or deficit resulting from international trade

We'll try to analyse 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 order to simplify the analysis of external costs, we are going to present the simple historical example of exploitation of a natural resource, price, profit and unpaid external costs. The example is detailed and later it will serve as a base for explaining the problem of externalities and its impact and implementation in BDP calculation.
Let us present the empirical case which is often interpreted in ecological literature.

We have certainly used a case to present and calculate lower economic account of costs, rents, income and loss for nature as external social costs. In the Pacific, in the area of Polynesia, there are two small islands: Ocean and Nauru. Until the beginning of the 20th century, the islands were inhabited by the natives, covered

[6] Tobin won the Nobel Prize for Economy in 1981.

with forests, and local population lived from fishing and agriculture. The island communities had a bad luck because under the arable land area there were large natural deposits of solid phosphate, mineral deposits, which were among the richest in the world. In 1901, Great Britain annexed and colonized the island Ocean, and the year before, the British company Pacific Island made the agreement with local chief on the purchase of the island and exploitation of mineral reserves at a price of 50 pounds. The contracted lease price for exploitation of natural phosphate deposits was paid in goods at several times higher prices. In the next five years, 100.000 tons of phosphate were exploited annually on the island. Another island Nauru, also rich in phosphates, was under the colonial administration of Germany. The mentioned English company made an agreement to carry out the exploitation of natural resources on the island under the German administration. At the beginning of 1914, the island was occupied by Australian army and after 1919, the exploitation of phosphate on this island was taken over by the company Pacific Island, which was private and then became public, under the administration of the government of Great Britain, Australia and New Zealand. Phosphate ore is used to produce fertilizers for agricultural purposes. Till the beginning of 1920’s the annual exploitation of ore was about 600 000 tons. In short, for the period of 80 years, from 1900 to 1980 about 80 million tons of phosphate was excavated from the island, and complete exploitation was finished. The workers were imported from China. Local residents Banabians, who refused to sell the land for “nothing” were deported. The arable land and forests were destroyed by the mercilessly exploitation (Pointing, 1993).

No doubt that the British company “took care” about the future of local people-Banabians. They carried out the internalization of externalities by paying 250 pounds per year into the fund for the future of Banabians. Later, it was determined that 6 pennies per ton of exploited ore will be paid into the fund.
From the exploitation of phosphate the company Pacific Island made a profit of 20 million pounds a year and revenues on the company's stocks amounted to 40-50% per year. After the abolition of colonialism, in the mid twentieth century, the British government offered Banabians the compensation for the exploitation of phosphate and for the forced exile from the island in the amount of 500,000 pounds (Ponting, 1993)[7].

This offer represented the value at which Britain and its company evaluated and defined the price of natural resources and damages inflicted upon the nature and

[7] The data are taken from the book Ponting (1993), „A New Green History of Word, The Environment and the Collapse of Great Civilisations“, translation into Serbian „Ekološka istorija sveta, životna sredina i propast velikih civilizacija“, Odiseja, Beograd, 2009, pp. 203-206.

the population.The goal was to achieve the benefits of providing themselves cheap phosphate fertilizers for agricultural production in Australia and New Zealand, and to import cheap food in Britain.

According to presented data, the following analytical model could be established. For the period of 80 years, 80 tons of phosphate was exploited, actually 1 million tons annually. The average profit per ton was realized in the amount of 20 pounds, and the result is obtained by dividing the annual profit with annual average production quantities of phosphate. Total profit for 80 years, expressed in nominal amounts is 160 million pounds. The manpower for the exploitation was imported from China. The rent for the use of natural resources has been paid in the following amounts:

- For the initial agreement on the right of exploitation of phosphate 50 pounds;
- For population fund 6 pence per ton or for a total of 80 million tons 4.8 million pounds;
- Compensation offer to local people by the British government in the amount of 500,000 pounds.

The total amount of accrued and offered compensation for the use of natural resources is nominally 5.380.050 million pounds. The total nominal profit that was made for a period of 80 years amounts to 160 million pounds. If we assume that the average profit rate was 45%, which was the average revenue on the stocks, we have the total nominal value of produced phosphate in the amount of 355.5 million pounds. So all the exploitation costs amounted to 195.5 million pounds, and they present the difference between total revenue of 355.5 million and appropriated profit of 160 million pounds.

When the amount of compensation for the use of natural resources, phosphate, is set in relation to total revenue from the sale of phosphate, we obtain the percentage of 1.52%. In fact, the natural resource is evaluated only 1.52% of total revenue structure. If we have the relation between the fee or “price „of natural resources of 5.38 million pounds and all costs of exploitation of 195.5 million pounds we get a percentage of 2.75%and, finally comparing the fee for the use of natural resources with realized profit, we gain the percentage of 3.36%. Accordingly, the use of all capital resources (equipment, machinery, ships, energy, and labour) for the exploitation of natural resources - phosphate was rewarded with revenue of 160 pounds or with the 45% revenue on invested capital. The natural resource itself has been evaluated with only 5.38 million pounds, or with only 1.51% of total market realized value of produced phosphate.

We should also mention that the synthetic production of phosphate would be too expensive, and the profit would be marginal. Thus, the basis of all realized market value for phosphate for mentioned 80 years is in the natural resource - phosphate deposits in the land.

Further, if we introduce into the analysis the problem of the costs to eliminate the negative effects on nature caused by the exploitation of phosphate, we will have the problem of internalisation of external costs. The external costs affected the nature and the local population, and these costs are not included in the price of manufactured goods.

Should these costs be calculated now and suppose it would be necessary to invest about 355 million pounds for the revitalization of the two islands, certainly none of the governments of the countries that had benefited from the exploitation of phosphate, would be willing to accept these costs. Thus, the internalization of external costs is unacceptable for them, it shows up to be too expensive.

Now, we are opening another issue, and that is the problem of irreversibility of conversion of that, derived from the nature, created material and financial capital, into natural capital. We find necessary to mention Hotelling's rule regarding the use of non-renewable natural resources such as mineral resources, land and other natural resources that do not possess the ability to regenerate. The Hotelling's Rule , which still occupies a central place in the economy of natural resources, demands (so that the exploitation or extraction of non-renewable 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.

The interpreted rule applied, for example, to the price of building land in exclusive ecological sites in cities or in special districts of natural values and parks, (pursuant to the above rule), implies the price growth annually at a minimum interest rate of 11% as the average interest rate of the National bank of Serbia on the financial risk-free loans of banks in Serbia.

The following empirical historical example opens the possibility for analysis of utilitarian point of view of natural resources, creating wealth on the basis of exploitation of natural resources for specific groups of the population while creating poverty and the negative environmental consequences for other population groups.

UTILITARIANISM

The concept of utilitarianism 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 him/her. Goods are divided into: market goods (consumer goods such as food, beverages and other 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 non-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 reduce 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):

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

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 ordinal utility function (engl. *Utility Function*). The ordinal utility function *U* reflects aggregates of all consumer baskets *Z* on the aggregate of all real numbers *R*, so that (Urošević, 2008):

$$U(\mathbf{x}) > U(\mathbf{y}) \Leftrightarrow \mathbf{x} \succ \mathbf{y}$$
$$U(\mathbf{x}) = U(\mathbf{y}) \Leftrightarrow \mathbf{x} \sim \mathbf{y} \quad \cdot \qquad (2)$$

It is assumed that on the market there are *N* consumer goods. The vector $\mathbf{x} = (x_1, x_N) \in R^N$ defines 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" whereas the index $\mathbf{x} \sim \mathbf{y}$ 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).

HOTELLING'S CONCEPT OF SOCIAL WELFARE

Utility is the level of satisfaction (or happiness) of an individual. In a more aggregate context, we refer to the social welfare of a group of people, which is an indicator related to the utilities of the individuals in society (Stern, 2004).

Hotelling (1931) introduced the notion of Social Value of Resources, which is in fact, the total utility identified as:

$$u(q) = \int_0^q p(q)\,dq \qquad (3)$$

where p is the net price obtained after paying the cost for exploitation of mines and q is the quantity of the extracted mine. Under the assumption that there are no production costs, and furthermore the assumption that the function of demand is linear.

Demand function where the price linearly depends on the mine quantity is:

$$p = \alpha - \beta q \qquad (4)$$

where α and β are the parameters. Hotelling (1931) introduces the following variables in its non-renewable sources economy model:
- v – mine extraction tax per unit
- a – initial mine quantity
- γ – interest rate (assumption: is a fixed rate)
- t – exploitation time
- T – final exploitation time

It is necessary to mention that when the function of demand is linear, the mine exploitation is limited in time, while when the function of demand is exponential, the exploitation is permanently continual at a declining rate. Hotelling (1931) derives that the mine owner (monopolist) will want to maximize the present value of his profit, at which time he will, in the final exploitation period strive to present this profit value toward the constant value, one that represents the quotient of Lagrange's multiplier and interest rate. Furthermore, Hotelling (1931) concludes that the monopolist will have the most profitable production if his demand function has a third degree polynomial form.

Net profit rate after tax payment v is:

$$y = (p - v)q = (\alpha - v)q - \beta q^2 \qquad (5)$$

Quantity of extracted mine, when the tax for the mine exploitation is included, is given and expressed (Hotelling, 1931), as follows:

$$q = \frac{(\alpha - v)}{2\beta}\left(1 - e^{\gamma(t-T)}\right) \qquad (6)$$

After usingth integral of the previous equation (6) per time, it is possible to get the initial mine quantity:

$$a=\int_0^T q\,dt=\int_0^T \frac{(\alpha-v)}{2\beta}\left(1-e^{\gamma(t-T)}\right)dt \tag{7}$$

Solving the equation (7) we derive that the initial mine quantity which is given by the equation (8), depends on the final exploitation time, interest rate and mine extraction tax, as follows:

$$a=\frac{(\alpha-v)}{2\beta\gamma}\left[T\gamma+e^{-\gamma T}-1\right] \tag{8}$$

Differentiating the previous equation it is possible to get a link between the change of final exploitation time, and change in tax on mine extraction as follows:

$$dT=\frac{2\beta a}{(\alpha-v)^2\left(1-e^{-\gamma T}\right)}dv \tag{9}$$

The rate of production effect *dq* in time *t* is possible to get by writing the total differential over the partial derivatives in the following manner (Hotelling, 1931):

$$dq=\frac{\partial q}{\partial v}dv+\frac{\partial q}{\partial T}dT \tag{10}$$

After several trivial mathematical steps, we note that the effect of production rate dq (unit change of extracted mine) per unit tax change of mine exploiting, is given in the following equation (Hotelling, 1931):

$$dq=\frac{dv}{2\beta}\left\{-1+e^{\gamma(t-T)}\left[1+\frac{2\beta a\gamma}{(\alpha-v)\left(1-e^{-\gamma T}\right)}\right]\right\} \tag{11}$$

Differentiating the equation (4) and inserting into equation (11) we get that the link between unit change in price and unit change in tax on the mine extraction has a form (Hotelling, 1931):

$$dp=dv\left\{\frac{1}{2}-e^{\gamma(t-T)}\left[\frac{1}{2}+\frac{\beta a\gamma}{(\alpha-v)\left(1-e^{-\gamma T}\right)}\right]\right\} \tag{12}$$

Let's analyse marginal cases for equations (11) and (12):

- If *a* and *T* indefinitely large => $dp = dv/2$ and $dq = -dv/2b$
- When $t = T$, tax price for the buyer is lower for $\beta a\gamma/(a-v)(1-e^{-\gamma T})$, than the price, if there are no taxes.
- The price will be so high, that a very low quantity of goods will be bought.

Combining equations (3) and (4) we get that the social utility is expressed as follows:

$$u = \int_0^q p\,dq = \int_0^q (\alpha - \beta q)\,dq = \alpha q - \frac{\beta}{2}q^2 \qquad (13)$$

Total present values of social utility when the interest rate is equal to one ($\gamma = 1$) is (Hotelling, 1931):

$$U = \int_0^T u e^{-t}dt = \int_0^T \left(\alpha q - \frac{\beta}{2}q^2\right)e^{-t}dt \qquad (14)$$

Substituting equation (6) into (14) and solving the integrals, we derive that the total present value of social utility is given by the following equation:

$$U = \frac{(\alpha - v)}{8\beta}\left[4\alpha\left\{1 - e^{-T} - Te^{-T}\right\} - (\alpha - v)\left\{1 - 2Te^{-T} - e^{-2T}\right\}\right] \qquad (15)$$

From the equation (15) it is noted that the total value of social utility is function of the final mine exploitation time, and tax on mine extraction, all remaining parameters are constant.

Jovanovic (2007) pointed out that Hotelling's (1931) model of non-renewable resources also contains a continuum of bubble equilibrium. Jovanovic showed that in all the equilibrium the price of the resource rises at the rate of interest. In a bubble equilibrium, however, the consumption of the resource peters out, and a positive fraction of the original stock continues to be traded forever (Jovanovic, 2007).

Otherwise, for environmental protection it would be necessary to introduce the environment protection expenses in accordance with the *Polluter Pays Principle*, which the developed countries introduced a long time ago. According to this *Principle*, companies and other polluters should be using their own funds to finance the environmental protection expenses. Public expenditures for providing collective environmental services, such as clean water and wastewater treatment, should be financed through user fees, i.e. taxes in cases when the benefits can't be directly linked to the entities. These expenses can be facilitated through the financial market (Drašković, 1998).

Fernando (2003) pointed out that regardless of the state of theory and practice in sustainable development, there is no doubt that an ethical/moral imperative exists to address socioeconomic inequality and degradation of the environment. He told that the state must play a pivotal role if social transformative efforts are to bear fruit and break through the impasse capitalism has imposed on realizing the goals of sustainable development (Fernando, 2003).

The recent process of globalisation of international markets has managed to sustain the economic growth of the countries that have actively participated in this process. The available empirical evidence suggests, however, that it has been accompanied by a worldwide increase in environmental degradation and economic inequality. Therefore, there is growing concern that these features of the globalisation process may jeopardise its social and environmental sustainability (Borghesi & Vercelli, 2003).

Sustainability is no declining individual consumption or utility over time (Stern, 2004). Stern (2004) defines economic growth as an increase in economy-wide economic production, usually measured by an increase in gross domestic product (GDP); also, the process of the economy growing over time (Stern, 2004).

Social Welfare, GDP, and External Expenses – Numerical Simulation Approach

Thompson (2012) added a non-renewable resource to capital and labour in the neoclassical growth model. The non-renewable resource introduces its depletion dynamics and expands the influence of input substitution on the growth path. Optimal depletion implies a rising resource price but investment or labour growth may raise extraction along the growth curve. Substitution between inputs plays a critical role in the model dynamics. Thompson developed the fundamental conditions for intergenerational equity, and also examines the tragedy of the commons and a myopic resource owner (Thompson, 2012).

Solow (1956) supposed that the single composite commodity is produced by labour and capital under the standard neoclassical conditions. The adaptation of the system to an exogenously given rate of increase of the labour force is worked out in some detail, to see if the Harrod instability appears. He analysed the price-wage-interest reactions as an important role in this neoclassical adjustment process. Then some of the other rigid assumptions are relaxed slightly to see what qualitative changes result: neutral technological change is allowed, and an interest-elastic savings schedule. Finally, Solow considered the consequences of certain more “Keynesian” relations and rigidities (Solow, 1956).

Sturmer & Schwerhoff (2012) proposed an endogenous growth model with an essential non-renewable resource, where economic growth enables firms to invest in innovation in the extraction technology and to allocate more capital to resource extraction. Innovation in the extraction technology offsets the deterioration of ore qualities and keeps the production costs of the non-renewable resource constant. Aggregate output as well as production and use of the non-renewable resource increase exponentially. Their model explains the long run trends of non-renewable resource prices and world production over more than 200 years. If historical trends in technological progress and in the deterioration of ore qualities continue, it is in the realm of possibility that non-renewable resources are de facto inexhaustible. Their results suggest that the industrialization in China and other emerging economies contributes to keep non-renewable resource prices constant in the long run (Sturmer & Schwerhoff, 2012).

Groth & Schou (2006) compared effects of taxing non-renewable resources with the effects of traditional capital taxes and investment subsidies in an endogenous growth model. In a simple framework they demonstrated that when non-renewable resources are a necessary input in the sector where growth is ultimately generated, interest income taxes and investment subsidies can no longer affect the long-run growth rate, whereas resource tax instruments are decisive for growth.
The results stand out both against observations in the literature from the 1970’s on non-renewable resources and taxation - observations which were not based on general equilibrium considerations - and against the general view in the newer literature on taxes and endogenous growth which ignores the role of non-renewable resources in the “growth engine” (Groth & Schou, 2006).

Grimaud & Rouge (2003) considered a Schumpeterian model of endogenous growth with creative destruction in which they introduced a non-renewable natural resource. They characterized the optimum and the equilibrium paths, and they derived the precise levels of economic policy instruments that allow the implementation of the optimum. Moreover, they study the effects of these policies on the relevant steady-state variables, in particular the rate of extraction of the resource (Grimaud & Rouge, 2003).

Nguyen & Nguyen-Van (2008) analysed the transitional dynamics in a model of economic growth with endogenous technological change and two alternative sources of energy: renewable and non-renewable resources. The conditions for the existence and saddle point property of the steady state are given. Finally, Nguyen & Nguyen-Van (2008) presented the estimation results on the data consisting of R&D energy, non-renewable energy consumption and renewable energy consumption.

Tasrif & Saeed (1989) used a system dynamics model based on an integration of micro-and macroeconomic theories to understand economic growth with a non-renewable natural resource. The case of oil-dependent Indonesia is used as an empirical reference for the study. Long-run growth patterns resulting from various intuitively appealing development policies are analysed, and an attempt is made to identify the best policy set for attaining a sustainable growth pattern. Their study shows that influencing factor prices to facilitate adoption of capital-intensive technologies accelerates development and is a key policy for sustaining growth in the long run (Tasrif & Saeed, 1989).

The standard approach to modelling endogenous technical change in an economy with an essential non-renewable resource ignores that also R&D may need the resource (directly or indirectly). This biases the limits-to-growth discussion in an optimistic direction. Indeed, sustained per capita growth requires stronger parameter restrictions when the resource is directly or indirectly an input in R&D and thus "growth essential" than when it is not. When the resource is “growth essential”, a policy aiming at stimulating long-run growth generally has to reduce the long-run depletion rate. In this sense promoting long-run growth and "supporting the environment" go hand in hand (Groth, 2007).

Ayres (1987) contributed to the basic theory of economic growth. His paper provided for an explicit role for technological change, both independently and in response to the exhaustion of stocks of non-renewable resources.

The standard methodology for calculating the gross domestic product, 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 individual year. 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 the benefit or gifts of nature, i.e. natural capital. Furthermore, the calculation also does not include the nature cost that are 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.

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's (1987) report, in which sustainable development is defined as: *"development that meets the needs of the present without compromising the ability of future generations to meet their own 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.

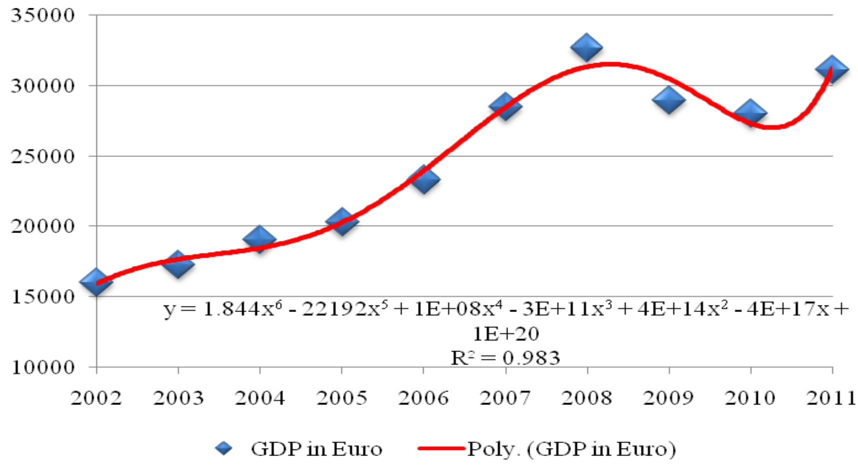
Starting from the presented, while recalling the analysis of historical case that we presented in Section 2 of this chapter, we constituted a sustainable development model using Serbia as an example, which we are presenting here under. In constituting the model historic data on the movement of the size 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 added, 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 we drew the values of GDP from 2002 through 2011, with blue dots.

Figure 1: Real Value of GDP in Euro (blue dots). Red line is trendline.



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

The red line in previous figure represents the trendline for which we got to be sixth degree polynom. 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 polynom form, whereby the assessed coefficients of the given polynom are presented in Figure 1. The determination coefficient, R^2, is quite high (98.3%) which means that the trendline fits well to the actual data values for GDP.

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*):

$$GDP_{t+1}^{*} = GDP \cdot (1 - I) - c \cdot GDP_{t}^{*} \tag{16}$$

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

$$\underset{I,c}{Min} \sum_{t} \left(GDP_{t} - GDP_{t}^{*} \right)^{2} \tag{17}$$

where GDP is real GDP given by the market, and GDP* is given by the model (equation 16). However, equation (17) 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 polynom sixth degree. For simplicity and lack of publicly available information, linear dependence was used.

In next table we presented the real value of GDP in Euro and theoretically calculated value obtained using the equation (16). 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 (17). The program itself executes simulation and optimization and gives values for the given parameters.

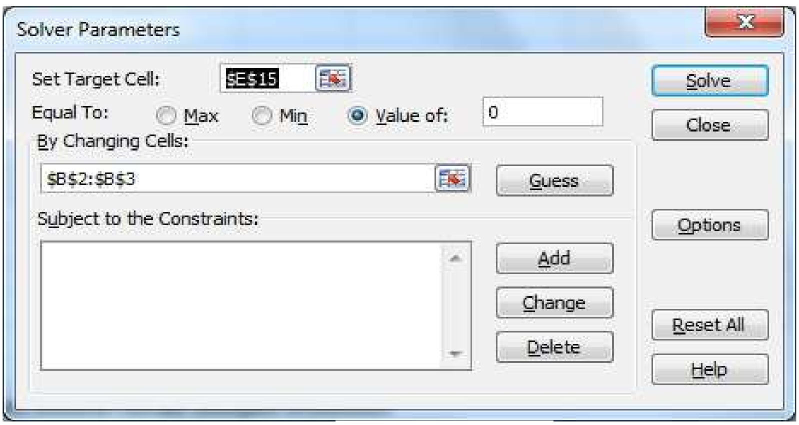
Table 1: The Actual (Real) Value and Theoretical Value of GDP

	GDP(in Euro)	**GDP***	**GDP-GDP***	**(GDP-GDP*)^2**
2002	16028	17974.5	-1946.5	3788864
2003	17306	19294.8	-1988.8	3955443
2004	19026	20706.7	-1680.7	2824845
2005	20306	22197.5	-1891.5	3577879
2006	23305	23800.5	-495.5	245513
2007	28468	25436.7	3031.3	9188574
2008	32668	26993.8	5674.2	32196155
2009	28957	28514.0	443.0	196242
2010	28006	30418.5	-2412.5	5820196

	GDP(in Euro)	GDP*	GDP-GDP*	(GDP-GDP*)^2
2011	31140	32605.5	-1465.5	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.

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



Source: Authors' estimation.

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 (17).

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 (16), 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 (18) 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:

$$\underset{I,c}{Min}\sum_{t}\left(GDP_t - GDP_t^*\right) \qquad (18)$$

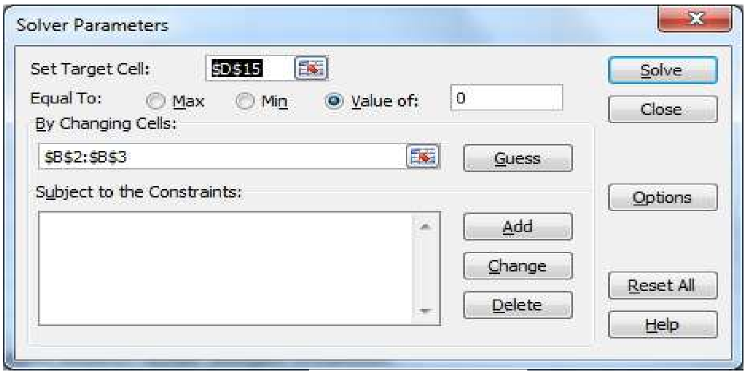
In next table we presented the real value of GDP in Euro and the theoretically calculated value obtained by using equation (16). We assumed that the coefficients *c* and *I* are constant, as was in the previous case, and they are obtained by running the numerical simulation by clicking the "Solver" in the software package Microsoft Excel, and by solving the optimization problem given by equation (18). The program itself executes simulation and optimization and gives values for the given parameters.

Table 2: The Actual (Real) Value and Theoretical Value of GDP

	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 previous figure, 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 (18).

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).

CONCLUSION

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. We have simplified the external costs during our work 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 work we noticed, using the example of Serbia, that the results on the basis of the starting assumptions, conditions for sustainable development are not met.

Further research can be in manner by Sturmer & Schwerhoff (2012). We can to propose an endogenous growth dynamics model for Serbia and other emerging economies in the long run.

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