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Natural Resources Valuation between Quantitative and Qualitative Information

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Abstract

The information regarding the valuation of the natural resources is relevant for the decision-making process at micro and also macroeconomic level, for different purposes such as policy-making or economic analysis. Valuable decisions are based on quality valuation consisting of measurement and estimates. At different stages of economic development, circumscribed within a specific 'maturity level', countries and entities may use specific valuation tools and models. Natural resources represent focal areas for worldwide accounting frameworks such as the System of Environmental − Economic Accounting (2012) or System of National Accounts (2008). These two international accounting frameworks represent important foundations designed to fulfil statistical economic demands for global integration. Different valuation models regarding the natural resources have to respect the basic requirements for information, for comparisons and statistical integration purposes. Price and volume measures have numerical significance but may also present specific qualitative aspects regarding the natural resources flows and stocks. Valuation is influenced by quality differences or quality changes in time. Quality may derive from technological change and innovations, which may transform previous uneconomical resources into exploitable resources. The envisaged objective of the article is to incorporate inside the valuation model the effect of the change in technology, as a driving factor for the application of the anticipation principle within the income approach. The qualitative information is a key-influencing factor for the valuation process and may be included as a parameter under different valuation approaches or methods. Based on our analyses of the Net Present Value approach we propose an enlargement of the calculation model by introducing inside the formula a technological coefficient factor.

Keywords: natural resources, valuation, maturity model, statistical economics, technological coefficient.

JEL Classification: G31, Q00, M21, M41

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1. Introduction

The motivation of the paper is to enhance the importance of the qualitative information represented by the progress of knowledge or future improvements of the related factors of production as an important driver for the evaluation of the natural resources. The main objective was to implement inside the valuation process a quantifiable effect for the qualitative information. The valuation of the natural resources is relevant for environmental policy development and related to decision-making process, at the domestic level, and also between states and at a more international extent. The process of evaluation for natural/environmental resources is a complex task, which includes different measurement techniques. The main approach is based on the principle of market price valuation, adopted by the system of national accounts ('SNA'), but due to the inherent lack of information, the System of Economic - Environmental Accounting ('SEEA') adopts other techniques, too, such as Net Present Value approach, and its cornerstone issue represented by the discounting rates used. The monetary value may be influenced by social valuation aspects, but also by other benefits provided by the environment. In a more precise sense, natural resources are a subcategory of environmental assets including natural biological resources, mineral and power resources, earth resources and aquatic resources, excluding land and farmed biological resources. The final target of performing evaluation of environmental goods in monetary terms is the formation of monetary estimates which can be integrated with information from standard national accounts, in order to measure the national wealth. Our method is based on the analyses of the Net Present Value approach regarding the possibility of bringing on the effect of the influence of technological progress as a calculation coefficient inside the model. The final result of our paper is a Net Present Value model which includes the technological coefficient.

2. Problem Statement

The SEEA, similar with SNA, is considering the value of the accounts based on the marketplace prices (2008, SNA, 3.118), defined "as amounts that willing buyers pay to acquire something from willing sellers" (SEEA Central Framework, 2.144). There are situations when market prices are not findable, and in such situations the valuation process is using market price equivalents, based on similar items. If no equivalent market information is available, the system recommends a secondary way for determining the value, based on the costs of production for goods/services, plus a net return on capital (SNA, 6.125). Ideally, the perfect way of valuing natural resources would be based on the values observed in the markets, where homogeneous goods are traded in significant volumes and the prices are made public regularly. Another secondary approach is represented by the net present value method ('NPV'). In many cases, natural resources have no relevant market transactions or acquisition prices. The net present value NPV approach is using the discounted future returns from the use of the asset. Within the accounting field, the analyses of changes in value over time are based on the changes in prices or changes in quantity, but reasonably we may also take into consideration the change in quality over time. The valuation of environmental assets is also linked to the progress of knowledge, not only with the factors of production, similarly to the process of economic success of a company (Lundvall and Johnson, 1994). The progress of knowledge and technology brings advantages but is also accompanied by significant negative outcomes, such as deforestation, soil erosion, oil/mineral depletion, greenhouse gas increase or water pollution. Traditionally, the NPV method is built on quantitative factors, while the inclusion of the technological factor represents a qualitative facet of the valuation exercise (Corvello, Iazzolino and Ritrovato, 2013). The *United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009* ('UNFC − 2009') performed a classification of the mineral and power assets based on a project development criterion, trying to determine the maturity level for the extraction and exploration projects, i.e., to what extent these natural resources are confirmed, developed or planned. The criteria used by UNFC − 2009 are:

- Economic and social feasibility (*E*);
- Field project status and viability (*F*);
- Geological datum (*G*).

The third criterion (G) is related to the level of certainty of geologic cognition and potential exploitation of the resource concerned, being directly dependent on the level of technological development. We may apply this kind of classification to other types of natural resources, considering for each type a specific third criterion, similar to G, which has to be linked with the actual technological knowledge and also with the forecast of the development of this aspect.

The valuation process may be performed under three possible approaches, which aims to determine the financial value of the traded resource by using one of the following criteria (Andriessen, 2005): costs, market, and income. When information regarding costs, or market is difficult to be obtained, the valuation process is totally relied on the income-based approach (i.e. present monetary value the resource will expect to generate). The income approach requires a number of hypotheses or assumptions, which are difficult to be validated. Meanwhile the income approach is grounded on the economic *principle of anticipation*, which means that the foresight regarding the change in technology has to be a decisive factor for the valuation of environmental goods. Also, a prime condition, in order to apply the principle of anticipation is the fact that we need to be able to predict the future. The valuation practitioners are applying the *principle of anticipation* by taking into consideration the future in- or outflows generated by the resource based on historical information. Sometimes the potential impact of the future technological progress is located at a thinner borderline, which makes plausible the usage in the calculation model of the possible quantified influence on the in- or out cashflows generated by the resource. Our review of the literature did not identify a prior proposal for the introduction of this calculated technological future impact inside the Net Present Value Approach. We consider that the introduction inside the valuation model of this explicit influence is justifiable under the context where the influence is significant. If a potential technological development is not providing significant quantitative or qualitative changes, the effect on the valuation process is not worthy to be considered. For example, let us consider the case of the iron extraction as a natural resource. Under the current technological and economical conditions iron is extracted from different minerals, mainly oxides and carbonates. If the technology advancement makes the iron extraction from silicates economical, extensive resources will become available for economical extraction and usage. The impact will be pervasive, and at the moment when the technological progress is perceived as feasible in the near future, it would be justifiable to reassess the valuation of the iron silicates. Another example, maybe the impact of the technological advance in the field of reduction of the greenhouse gases ('GHG') emissions such as carbon dioxide, methane, nitrous oxide. If the technological progress renders possible the storage of the carbon from surrounding atmosphere, in an economical fashion, this event will trigger the extraction production of the fossil fuels, in a significant dimension (Russel, 2016). We consider that the other two valuation approaches (cost and market), are not feasible to be used under our paper perspective because these methods are using historical/market information.

The novelty of our research is represented by the potential use of the envisaged influence of technology *introducing in the NPV method, a calculation coefficient, which can be forecasted by knowledgeable specialists*, with appropriate expertise and time perspective regarding the extraction and technology evolution related to the usage of a specific natural resource. The paper examines the valuation process in the context of technological knowledge valorisation. We try to present from the technique of financial valuation the possibility of creating a mathematical model.

3. Research Questions/Aims of the research

The research question is related to the valuation of the natural resource stock related with the future technological change and innovation impact, which may increase the volume or type of the exploitable resource, or which may transform previous un-economical resources into exploitable resources. The question itself is about whether the future change in technology is taken into consideration, under the methodological recommendations provided by the *System of Environmental − Economic Accounting − 2012*. The purpose of the study is the prospective enlargement of the conceptual framework regarding the valuation of the environmental goods, from the quantitative aspects represented by quantity and prices, to qualitative information represented by the future impact of the prospective technological change. The technological change represents one of the external environmental features, specific to the PEST analysis model (political, economic, socio-cultural and technological), which may open the understanding of a specific market perspective, or the evolutionary direction. We have enlarged the NPV valuation methodology, by including in the calculation formula the technological factor K_t, which may adjust the future cash-flows represented by the nominal value of expected future resource rents. The research approach is qualitative and theoretical, and the verification of the model may be accomplished by the post-checking of the valuation at a certain moment in time for prior natural resources usage, in comparison with known market values. Our next phase target will be to develop and test our proposition for a practical case related to GHG emission reduction within a public investment project. The logical steps of our proposed method are as follows:

- the quantification of yields on environmental goods;
- the calculation of the forecasted model of resource rents based on anticipated extraction profiles and prices;
- the assessment of the asset lifetime;
- the choice of a rate of return on produced goods;
- the selection of discount rate;
- the choice of the technological coefficient.

Beside the improvements in natural resources usage, brought by the technological progress with its inherent environmental downfalls, we may see that technology may also lead to the developments of what may be called environmental technology, with the principal aim of trying to solve some of the anxieties faced by our modern society (e.g. renewable energy, electrical cars, smart technology etc.).

4. Research Methods

The research method we have applied is mainly qualitative and theoretical being based on the analyses of the valuation methodology for the natural resources used by the SEEA (SEEA, 2012, p. 220). We analysed the academic literature for specific points regarding the valuation of the natural assets under the influence of the technological factor but we did not identify a similar approach regarding the impact on the NPV method, or the implementation of a similar formula which is using the technological factor in a similar way. Under our approach we developed a proposal for a new formula model starting from the SEEA − 2012 model. The research method is based on the classification criteria used by UNFC − 2009: Economic and social feasibility (*E*), Field project status and viability (*F*), Geological datum (*G*), and is trying to generalize this categorization concept to other types of natural resources. We consider that for all types of natural resources the technological factor, in a similar way, may contribute to the recognition of the respective type of resource, and also to the valuation process. The methodology aims to identify the similarities, but also the differences between diverse techniques applied to study the natural resources. The method is an example of *applied induction*, which is the operation of using investigation inference from one environment to another (St. Clair, 2005). Consequently, the induction process is pervasively affected by the unknown factors, which cannot be anticipated. As St. Clair argued, this kind of scientific investigation has to be considered as a means to give rise to experimental heuristics for reasoning and exploration. Our research work represents an essay trying to enlighten the possibility of developing a generalized view over the valuation process of the natural resources, taking into consideration the influence of the future technology within the process.

5. Findings

The target of the paper is to propose a method for the valuation of the natural resources which is including in the calculation, the impact of the qualitative factor represented by the future technological change.

The valuation of a natural resource assumes that the value of an asset bise equal to the discounted flow of future asset rents:

$$V_t = \sum_{\tau=1}^{N_t} \frac{RR_{t+\tau}}{(1+r_t)^{\tau}} \quad (1)$$

where:

- V_t is the value at the end of period t;
- $RR_{t+\tau}$ is the nominal value of anticipated subsequent asset rents;
- t is at the end of period;
- τ is 1, 2, …, N_t;
- r_t is the nominal discount rate at time t.

The value of the natural resource stock V_t at the period can be described in terms of quantity (Q_t) and price (P_t) components:

$$V_t = Q_t P_t \quad (2)$$

where:

- Q_t is the stock of the raw natural resource considered as at the end of interval t;
- P_t is the constituent price at the end of period t.

We may obtain a more detailed representation of the equation (1) if we present explicitly the resource rent $RR_t = P_{S,t}S_t$ in order to make possible the calculation of the price estimate P_t:

$$V_t = Q_t P_t = \sum_{\tau=1}^{N_t} \frac{P_{S,t+\tau} S_{t+\tau}}{(1+r_t)^{\tau}} \quad (3)$$

In order to make possible the calculation of the price estimate P_t we may assume two hypotheses:

(a) The extracted stock of the natural resource is based on two components: the ***first component*** is based on the information represented by the most recent extraction figures using the actual technology (S), and the **second component** is the estimate of the future change in extraction using new technologies $S_{t+\tau} = SK_{t+\tau}$, where $K_{t+\tau}$ is the technological coefficient at the moment in time t+τ;

(b) The price P_t evolves in time in line with the expected rate of inflation ρ_t.

If we will apply the two hypotheses we may rewrite:

$$V_t = Q_t P_t = \sum_{\tau=1}^{N_t} \frac{P_{S,t+\tau} S (1+\rho_t)^{\tau-1} K_{t+\tau}}{(1+r_t)^{\tau}} == P_{S,t} S_t K_t \sum_{\tau=1}^{N_t} \frac{(1+\rho_t)^{\tau}}{(1+r_t)^{\tau}} = P_{S,t} S_t K_t \Omega_t \quad (4)$$

where $\Omega_t = \frac{(1+\rho_t)^{\tau}}{(1+r_t)^{\tau}}$ is the discounting factor, being the inverse of the real interest rate.

From this equation we may finally calculate the unit price of the natural resource stock:

$$P_t = \frac{P_{S,t} S_t K_t \Omega_t}{Q_t} \quad (5)$$

From equation (5) we may notice that the valuation for the stock of the natural resource is linked with the unit resource rent $P_{S,t}$. The novelty of our research is the potential use and introduction of the coefficient K_t, which can be determined/estimated by technical persons, with appropriate knowledge and time perspective regarding the extraction and technology evolution related to the usage of a specific natural resource.

The valuation methodology for the natural resources is presented as guidance in the *System of Environmental - Economic Accounting 2012 − Central Framework* (SEEA, 2012), circumscribed to the *System of National Accounts,* (SNA, 2008) asset boundary. The SNA does not include specific guidance regarding the valuation methods regarding the natural assets and flows, more guidance and explanations being included within the SEEA. Obviously, on the natural resources will have a major impact the environmental regulations, which may significantly influence the economics of natural goods. The NPV method application as a particular valuation approach for natural resources started to be discussed under the SEEA − 2003 version, where the changes in stock were recommended for valuation purposes, by using the unit asset rent as the cost price. Conceptually SEEA − 2012 presents details for valuation of the natural resources by using the price of the original unmoved asset. The two pricing concepts, linked one with another, are different, and also with different implications regarding the value of natural assets. The formula presented in our research (5) shows the link between the price of the natural asset in the existing place and the unit resource rent, via the influence of the technological factor. We consider the significance of the proposed technological factor K_t as being of decisive importance, because under the modern conditions, science and technological progress are influencing the valuation process at an overwhelming speed. A suitable way for obtaining the estimates of the technological factor can be the use of a panel of knowledgeable specialists participating to a structured communication *Delphi technique*, or other qualitative forecasting methods. Principally, the effect on the value of the technological factor may be of providing the benefit of transforming previously uneconomical resources into exploitable resources.

6. Conclusions

The future technological change and innovation impact is a factor which may influence the evaluation process and also the classification taxonomy of the natural resources. We consider that the evaluation methodology may actively incorporate the impact of the future change in technology in conceptual framework regarding the evaluation of the environmental goods. The extension of the valuation methodology by introducing the technological element presents the advantage of implementing the *principle of anticipation* in a direct relation with the prospective change in technology for the valuation of environmental assets. We consider that the actual methodology may be oriented to the future, by using the forecasts and estimates about the progress in technology. Another argument for the employment of this technological coefficient/factor may be represented by the user-friendly method, which can be used for the determination, based on qualitative forecasting methods focused on expert teams. The qualitative aspects of the prospective changes related to the external environment, in their entirety (Political, Economic, Socio-cultural and Technological) may be integrated into the valuation models. In our article, we have enlarged the valuation NPV methodology, by including in the calculation formula the *technological factor*, by adjusting the future cash-flows represented by the nominal value of expected future resource rents. The research approach is qualitative and theoretical, and the verification of the model may open the subject of a future research project in order to verify the viability of the proposed model. The research constitutes an essay which endeavors to increase the understanding of the possibility of developing a generalized view over the valuation process of the natural resources, taking into consideration the influence of the future technology within the process. Within our attempt of solving the research question, the knowledge about future technological change is the key driver used for the calculation of the influence on the value.

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