EFFICIENCY OF THE SUSTAINABILITY BY USING ECOLOGICAL FOOTPRINT

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Abstract

The measurement of ecological efficiency provides some important information for the each state. Ecological efficiency is usually measured by choosen environmental performance indicator – ecological footprint. We try to find improvements for each country from the economics viewpoint. In general, DEA assumes that inputs and outputs are 'goods', but from an ecological perspective also 'bads' have to be considered. In the literature, 'bads' are treated in different and sometimes arbitrarily chosen ways.

Data were obtained from the datasets National Footprint Accounts, available on the www.footprintnetwork.org. Data about international trade were obtained from Eurostat. Our interest is focused on the fact „Is the ecological footprint indeed contributive?" The target of article rest on the identify DEA models for countries EU 27. The paper will presents which country is a truly efficiency from the ecological economic approach and which state is not efficiency.

Policy makers should be better prepared to make decisions leading to sustainable development.

Key words: DEA, efficiency, ecological footprint, scale of return

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Introduction

Sustainable development is analyzed and quantificated already several years. It is considered for a very abstract concept. Efforts of all people is to use natural resources wisest, most effective while also maximizing the economic side of things. So as much to produce and then sell it.

The aim of the paper is to look at the sustainability of the country from the viewpoint of ecological footprint. Ecological footprint is considered one of the most favourite sustainability indicators and include in its calculation, not only environmental but also economic aspects. The aim was to determine whether the country really effective use of their natural resources and also we would like to determine whether the efficient managing with its production. From the viepoint of the methodological approach was used DEA. All calculations were computed in free software MaxDEA.

1 Efficiency and Sustainability Economics

This definition, while pointing to efficiency, emphasizes another idea that is constitutive to modern economics, namely that scarce resources may be used in alternative ways, so that using them in any particular way carries opportunity costs. In this modern understanding, it remains open what the "ends" are to be. Any given end that humans pursue with the help of scarce resources that have alternative uses, in principle, makes an economic issue, and efficiency appears as the goal at which economics is aimed.

Efficiency cannot be taken as a normative goal in itself, it is a secondary goal that is justified by its reference to a primary, elementary normative goal. In order to normatively root and ethically legitimate economics one therefore needs to specify an ethically legitimate end. For instance, the satisfaction of individual human needs and wants typically serves as the normative goal of economics. Sustainability, interpreted as inter- and intragenerational justice and justice towards nature, also specifies such an ethically legitimate end. (Baumgärtner-Quaas,2010)

Some twenty years ago, the international society and the journal of Ecological Economics have been established out of the concern that economics so far had not adequately addressed issues of human–nature relationships and of sustainability. Ecological economics aims to "study how ecosystems and economic activity interrelate" (Proops, 1989; similarly Costanza, 1989). However, ecological economics goes beyond a merely functional and descriptive analysis of this interrelationship, in that it is oriented toward the normative vision of sustainability: it understands itself as "the science and management of sustainability" (Costanza, 1991).

While up to now there exist some contributions of economists — including, but not limited to, ecological economists and environmental and resource economists — to the discussion of specific aspects of sustainability, so far neither a unifying idea (notion, concept) nor coherent structures (scientific community, institutions, curricula, conferences, etc.) of something like sustainability economics do exist — at least not to any significant extent.

Interpreting the existing economic contributions in view of the overall idea of sustainability, we argue that the emerging field of sustainability economics can be defined by four core attributes:

1. Subject focus on the relationship between humans and nature.
2. Orientation towards the long-term and inherently uncertain future.
3. Normative foundation in the idea of justice, between humans of present and future generations as well as between humans and nature.
4. Concern for economic efficiency, understood as non-wastefulness, in the allocation of natural goods and services as well as their human-made substitutes and complements.

Considerations of efficiency in the allocation of scarce resources then refer to three basic alternatives:

(a) scarce resources may be used in alternative ways to achieve one of the normative goals of sustainability economics, say intergenerational justice properly specified;

(b) scarce resources may be used to achieve alternative normative goals of sustainability economics, say intra- and intergenerational justice; and

(c) scarce resources may be used to achieve some normative goal of sustainability economics or alternatively some other legitimate societal goal. As there may be trade-offs and opportunity costs in basically these three ways, "efficiency" means that no scarce resources should be wasted in these respects. While economics has developed a clear, differentiated and operational idea of how to measure efficiency with respect to the satisfaction of the needs and wants of many individuals, it remains to be clarified what "waste" or "non-wasteful" means with respect to the achievement of justice. (Baumgärtner-Quaas,2010)

2 Material and Methods

2.1 Ecological Footprint

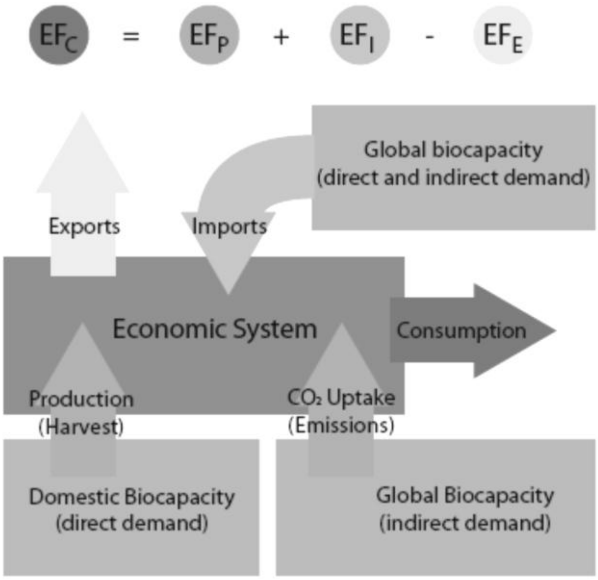
The Ecological Footprint measures appropriated biocapacity, expressed in global average bioproductive hectares, across five distinct land use types, in addition to one category of indirect demand for biocapacity in the form of absorptive capacity for carbon dioxide emissions.

In order to keep track of both the direct and indirect biocapacity needed to support people's consumption patterns, the Ecological Footprint methodology uses a consumer-based approach; for each land use type, the Ecological Footprint of consumption (EFC) is thus calculated as

$$EF_{consumption} = EF_{production} + EF_{import} – EF_{export} \quad (1)$$

where EFP is the Ecological Footprint of production and EFI and EFE are the Footprints embodied in imported and exported commodity flows, respectively. The National Footprint Accounts calculate the Footprint of apparent consumption, as data on stock changes for various commodities are generally not available. One of the advantages of calculating Ecological Footprints at the national level is that this is the level of aggregation at which detailed and consistent production and trade data are most readily available. Such information is essential in properly allocating the Footprints of traded goods to their final consumers.

Figure 1 Schematic of Direct and Indirect Demand for Domestic and Global Biocapacity.



Source: www.footprintnetwork.org

As you can see for our computation we needed obtain two datasets from two different websites. Firstly, we obtain Ecological Footprint from the the datasets National Footprint Accounts, available on the www.footprintnetwork.org and followed we gained data abour international trade from the Eurostat. Each item of the international trade we recomputed on the global hectars. After adjustments we approached to analysis of efficiency by using DEA methodology.

2.2 DEA

Data envelopment analysis or DEA is a linear programming technique developed in the work of Charnes, Cooper and Rhodes (1978). It is a non-parametric technique used in the estimation of production functions and has been used extensively to estimate measures of technical efficiency in a range of industries (Cooper, Seiford and Tone, 2000)

DEA is commonly used to evaluate the efficiency of a number of producers. A typical statistical approach is characterized as a central tendency approach and it evaluates producers relative to an average producer. In contrast, DEA is an extreme point method and compares each producer with only the "best" producers. By the way, in the DEA literature, a producer is usually referred to as a decision making unit or DMU. Extreme point methods are not always the right tool for a problem but are appropriate in certain cases.

Figure 2 DEA Input-Oriented Primal Formulation

$$\min \quad \Theta,$$
$$s.t. \quad Y\lambda \geq Y_0,$$
$$\Theta X_0 - X\lambda \geq 0,$$
$$\Theta \quad free, \quad \lambda \geq 0.$$

Source: www.etm.pdx.edu/dea/homedea.html

The procedure of finding the best virtual producer can be formulated as a linear program. Analyzing the efficiency of n producers is then a set of n linear programming problems. The following formulation is one of the standard forms for DEA. lambda is a vector describing the percentages of other producers used to construct the virtual producer. lambda X and lambda Y and are the input and output vectors for the analyzed producer. Therefore X and Y describe the virtual inputs and outputs respectively. The value of theta is the producer's efficiency.

The inputs-oriented technical efficiency rate responds to the question: "What quantities of the inputs may be proportionally reduced without altering the produced output?". To this question there is perhaps another question: How can be proportionally larger output, without the changes necessary of other inputs.

3 Results and Discussion

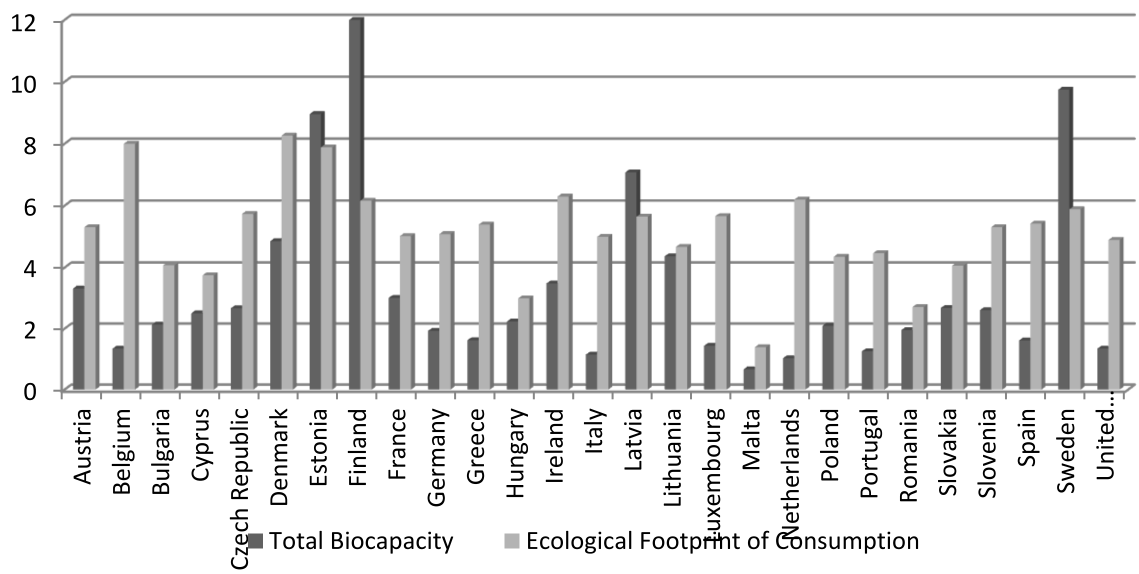
In the our research we focused on calculating the ecological footprint (consumption) for the foreign trade of 27 countries of the European Union. As the foreign trade directly affects the consumption rate of the population in the country, we decided to focus their attention on just this fact.

The aim was to determine whether the country effectively manage its production, and thus make effective use of import and export so that their decisions lead to a sustainable foreign trade. For the calculation we had to normalized the value of production, import and export to the global hectares, which we then compared with the ecological footprint of the acquired datasets from the National Footprint Accounts.

To better understanding of the situation we would like to view the situation in the countries analyzed by a graph showing the ecological footprint and biocapacity of the 27 european countries.

Biocapacity is the capacity of ecosystems for producing useful biological materials and for absorbing carbon dioxide generated by humans, using current management schemes and extraction technologies. (www.footprintnetwork.org).

Figure 2 Ecological Footprint and Biocapacity of EU countries in 2007



Source: www.footprintnetwork.org

As we can observe in Figure 2 biocapacity with the higher level in comparison with ecological consumption has only four countries Finland, Estonia, Latvia and Sweden - the Nordic countries. Other countries have an ecological deficit.

Their natural conditions and population, which the country should ensure its production appear to be ecologically sustainable. One of the reasons why it is so, that the countries do not have suitable natural conditions for intensive agriculture, but sooner organic farming. The second factor is the lower level of population compared to countries such as Germany or France.

The selected environmentally sustainable country must ensure food for people and another way to import from countries where natural conditions allow more efficient production.

For this reason, we focused on foreign trade of 27 countries of the European Union. Indeed, the country is environmentally sustainable and efficient from the viewpoint of foreign trade?. First, be aware of what we actually know about the sustainable consumption is to maintain a given consumption. We know the country should to minimize inputs, in this case, footprint export, import and production. After the initial considerations, we decided to apply inputs oriented DEA model, which represents an amount of inputs that can be proportionally reduce without reducing output.

Tab. 1: Input oriented DEA

NO	DMU	Technical Efficiency Score(CRS)	Pure Technical Efficiency Score(VRS)	Scale Efficiency Score	RTS
1	Austria	0,909	0,918	0,990	Increasing
2	Belgium	0,836	0,839	0,996	Increasing
3	Bulgaria	1	1	1	Constant
4	Cyprus	1	1	1	Constant
5	Czech Republic	1	1	1	Constant
6	Denmark	0,986	0,989	0,997	Increasing
7	Estonia	0,857	1	0,857	Increasing
8	Finland	1	1	1	Constant
9	France	1	1	1	Constant
10	Germany	1	1	1	Constant
11	Greece	0,986	0,987	0,999	Decreasing
12	Hungary	1	1	1	Constant
13	Ireland	1	1	1	Constant
14	Italy	1	1	1	Constant
15	Latvia	0,823	0,904	0,911	Increasing
16	Lithuania	0,855	0,899	0,951	Increasing
17	Luxembourg	0,689	1	0,689	Increasing
18	Malta	1	1	1	Constant
19	Netherlands	1	1	1	Constant
20	Poland	1	1	1	Constant
21	Portugal	1	1	1	Constant
22	Romania	0,995	0,997	0,997	Increasing
23	Slovakia	0,977	1	0,977	Increasing
24	Slovenia	0,982	0,985	0,997	Increasing
25	Spain	1	1	1	Constant
26	Sweden	0,947	0,964	0,983	Increasing
27	United Kingdom	1	1	1	Constant

Source: Own calculation

Firstly, we focus on first column values of technical efficiency. Countries with a value equal to 1, showing the technical efficiency. There belong: Bulgaria, Cyprus, Greece, Finland, France, Germany, Hungary, Ireland, Italy, Malta, Netherlands, Poland, Portugal, Spain and United Kingdom. These countries use their resources efficiently and in the adequate rate of use for its consumption and imports from other countries. From the viewpoint of returns to scale, these countries show constant returns to scale, so do not reduce their level of input level or expand their output.

Until now we have considered only constant returns to scale. Pure technical efficiency is calculated assuming economies of scale variable.

DMU is also effective for the variable assuming constant returns to scale, is a fully efficient DMU, DMU thus operates in the most sizing.

If DMU is efficient only under conditions of variable returns to scale and is not effective for conditions of constant returns to scale, it is a local DMU efficient. This moment occurred in Estonia, Luxembourg and Slovakia.

Based on the previous informations we continue to analysis of the scale efficiency, which is given by the ratio of technical efficiency CRS and VRS.

According to effieciency scale are countries with efficiency score = 1. Other countries are ineffective either due to inefficient operations or because of unfavorable conditions. In the returns to scale can distinguish three cases: constant returns to scale, increasing returns to scale and decreasing returns to scale.

Constant returns to scale reflect that changes of inputs result in the same change in output. This situation shows the country that took the value of effectiveness = 1: Bulgaria, Cyprus, Greece, Finland, France, Germany, Hungary, Ireland, Italy, Malta, Netherlands, Poland, Portugal, Spain and United Kingdom. They are, effectively using all instruments of foreign trade.

Decrease returns to scale occur when a proportional increase in all inputs leads to a proportional reduction in output. This group includes only Greece. The country has inefficient spread of the individual foreign trade such as import, export and own production. Greece is a country with high ecological deficits, as well showing a high degree of inefficiency in the economic area of the country, the country seems to be highly deficient.

The last group is increasing returns to scale. Proportional increase in inputs leads to an increase proportional outputs. These include: Austria, Belgium, Denmark, Estonia, Latvia, Lithuania, Luxembourg, Romania, Slovenia, Slovakia and Sweden. Countries have not yet reached its peak in treated its inputs such as import, export and production, thus showing even in terms of foreign trade economic reserves. While in the viewpoint of ecological function are some countries already in deep deficit.

Conclusion

We came to the fact that the assessment of countries in terms of ecological and economic point of view is diametrically opposed. This struggle was led several decades and still not found a consensus between these two aspects. Was appeared the ecological footprint, which includes not only the calculation of environmental but also economic items of the country, but on the other hand, a deeper analysis suggests contradictory results. A country which appears as environmentally effective and economically may not be effective and vice versa.

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