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Is Eco-efficiency the Way to Becoming More Green or is Everything Swept Away by the Jevons Paradox?

The most striking finding of our analysis is the presence of a limited variation across nations in the ecological footprint (EF) per unit of the GDP. EF intensity is lowest (eco-efficiency is highest) in affluent nations, but the level of efficiency in these nations does not appear to be of sufficient magnitude to compensate for their large productive capacities. These results suggest that modernization and economic development alone will be insufficient to bring ecological sustainability to societies.

INTRODUCTION

The concept and the explanation of „sustainability" is one of the most controversial economic phenomena (Kiss, 2011): the expression is used in connection with almost everything; however, its deeper sense is rarely employed. In our study, based on national GDP and ecological footprint data, we examine one of the fundamental questions of sustainability, namely the macro level of eco-efficiency, as well as the Jevons paradox, which brings into doubt the thesis of the above. This approach is a new and so far lesser-studied aspect of this popular topic, since the publications related to eco-efficiency typically examine the company dimension or the energy sector (Tóth, 2002–2006).

LITERATURE

The key question of the complex program of the ecological sustainability is how the dynamics of economic systems can be harmonized with the dynamics of ecological systems (York, 2008). Owing to the influence of consumer trends like

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environmental awareness and ethical consumer behaviour the value of sustainability and the issue of ecological perspective have raised (Fodor et al., 2011). The so-called IPAT equation is widely-known and provides an analytical framework with apparently obvious conclusions for the conceptual sphere of ecological efficiency. The forty year old written concept of its original form (Ehrlich – Holdren, 1971) has provoked significant impact in the international and the national specialized literature (Alcott, 2005; Takács-Sánta, 2008; Kocsis, 2010).

The equation is the following:

$$I = P \times A \times T$$

I = the impact of the human activity on the natural environment (impact),
P = the population (population),
A = the economic performance per capita (affluence),
T = the technology (technology), which indicates how much environmental effect can be accompanied with the production of economic goods (Bajmócy – Málovics, 2011). The most ambiguous part of the IPAT equation is the technology (T), which can be quantified at most indirectly only with the knowledge of the other three parts of the equation (Kocsis, 2010).

In connection with sustainability, in the literature and political and public debates, opinions about the role of general technological changes and innovation are shared widely. In certain approaches, fundamentally, the technological changes make it possible to move towards sustainability. For instance, the precision cultivation has become common in agricultural production nowadays, and with the help of place- specific treatments, they are able to considerably reduce the use of chemicals, which can establish on one hand, the natural sustainability, on the other hand, partly the economical sustainability, as well (Auernhammer, 2001; Szabó – Katonáné, 2008; Takács-György, 2012; Takács-György et al., 2013).

However, according to other opinions, technological change is a part of the problem and not the solution (Bajmócy – Málovics, 2011). William Stanley Jevons (1865) wrote down one of the best known paradoxes of ecological economics in his book of *The Coal Question*. Jevons observed that although industrial coal consumption has became more efficient – the production of more products became feasible from unit coal quantity – the absolute coal consumption increased: „It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth" According to York (2008), its reason is that as a result of more efficient use of the coal, the cost of the coal per capita decreases, which leads to the increased demand for coal, other energy resources are substituted by it, and money is invested in technologies applying coal.

As a fact, it can be laid down generally that the savings gained by the increase of eco-efficiency can almost never be realized completely. Especially in case of

those resources, which can be applied widely it can be expected that the use of a given resource is going to be increased, even more than the absolute resource use of the whole economy. In sense of the rebound effect, it can be assumed that the increase of eco-efficiency in itself is not enough to encourage sustainability; indeed, in a given case, it can produce the contrary effect (Málovics – Bajmócy 2009). Numerous observations reinforce the fact that specific efficiency gain (for instance the increase of eco-efficiency) extends the extent of the change of the biosphere on an absolute level (Málovics 2009). Sebestyénné Szép (2013) confirms that the rebound effect, as an existing phenomenon, can be realized in Hungary as well. So, as the energy efficient arrangements, in parallel with energy efficiency, can contribute to preserve disposable energy resources to a less degree, for this reason, the restriction of the energy use must be enforced.[3] According to Tóth (2003), eco-efficiency has its limits (Laws of Thermodynamics), therefore its increase can be realized only for a certain time. Over and above, the growing population, as well as consumption, can be claimed to be enough to implement sustainable development[4][5].

The popularity of this issue can be well realized by several summing studies (Alcott, 2005; Missemer, 2012; Sorrel, 2009) and book (Polimeni et al., 2008), that describe the appearing forms, validity and solving possibilities of both the Jevons paradox and the rebound effect, too. The studies tend to typically examine the issue from the perspective of energy-saving – energy- efficiency (Sebestyénné Szép, 2013); however, it can be justified with the help of the example of water consumption (Dumont et al., 2013). Daly (2013) mentions the Jevons paradox among the most important economic development-related contradictions. According to Jaeger (1995), the dissenting perspectives of economists and environmentalists regarding sustainability as well as economic development can be well shown by Jevons theory.

Based on the studies of Bunker (1996), the whole world economy can be characterized as a set of resources – in which efficiency significantly improves (the economic output per unit of natural resources); however, the complete resource-consumption of the global world is continuously increasing. Similarly, York and his colleagues (2004) have showed that on a national level, the considerable material abundance can go both with higher eco-efficiency of the whole economy (GDP release of unit „ecological footprint") and with higher ecological

[3] It is also worth to thinking about to what extent the not sufficiently utilized efficiency development can be explained by the legal and institutional environment. It is possible to read about the power of different lobbies influencing the rules of law in the research of Pintér (2014).
[4] The problem can be examined in the field of tourism as well; besides it can also be discovered that the fundamental principles related to sustainability are enhanced comparing to other fields in several cases (Szabó 2014a).
[5] The terms of eco-efficiency as well as sustainability are closely connected to the concept of social responsibility and participation (Reisinger, 2009, Reisinger, 2013); a citizen who is active on local level can do much more about increasing efficiency.

footprint per capita. It suggests that the empiric circumstances characteristic of the Jevons paradox can often be applied to higher levels. The strategic importance, the restrictions, and the applicability of the ecological footprint index have been reinforced by a number of studies (Csutora, 2011; Csutora – Zsóka, 2011). One of the most important objections against the GDP is that it considers every kind of economic activity identically, not taking into account its effect on consumption or its social benefits (Márki-Zay, 2005). The economic subsystem is not almighty and unlimited and if we forget about it, it can cause unforeseeable social and ecological dangers (Győri, 2010). For this reason, connecting diverse data (macro-economic, budget, etc.) to the GDP will result in a number of distortions (Csiszárik-Kocsir – Fodor, 2013).[6]This situation is worsened by the crisis (Csiszárik-Kocsir, 2013). The spatial densifications, which apply GDP as one of its indicators, can also show significant spatial differences (Szabó, 2014b). According to Varga (2013) the economic situation of a nation cannot be measured by its GDP, because competitiveness or welfare mean a lot more than material wealth.

At the same time, in spite of several critics and suggestions for development, to the present day, it is seen as the most accepted indicator.

MATERIAL AND METHOD

In the first part of our study, we present the results of literature research, which we have done with the help of the free ScienceDirect database of one of the biggest scientific journals published by the Dutch company, the Elsevier. This publisher mainly deals with issuing the well respected magazines in the field of natural science, besides publishing hundreds of magazines dealing with economy and management, including the determinative alternative economical magazines, such as *Ecological Economics (IF: 2,855)* and *Ecological Indicators (IF: 2,89)*. In the ScienceDirect 2500 journals, 20000 books and more than 12 million scientific articles can be found and downloaded. The articles can be found based on different dates or the most often downloaded publications can be seen according to a field of science and journals. A variety of options are available; we can search with simple or combined search using the name of the author, the title of the article or to keywords, which can be narrowed down by giving the language, the name of the magazine, the topic or the date of the publication. The frequent filtering options and the user-friendly interface of the searching site give grounds for our choice of ScienceDirect in our examination. Within the scope of the examination, we were looking for those articles that include

[6] Outcomes distortion interrelated with data collection, meaning, application is observed and pronounced phenomenon even the cleverest in other fields of economic research. (e.g. Farkas–Kovács 2010, Kovács 2011, 2013, Koppány–Kovács–Szabó 2013, 2014)

the Jevons paradox as well as eco-efficiency (eco- efficiency expressions). The number of the articles and essays have been classified based on their publication year and they have been described in a rectangular coordinate system in the following way: the numerical values of certain years show the number of the article containing the requested expression published by that publisher in a given year.

In the second stage of our study, according to the research of York et al (2004), we were trying to find an answer to the question, whether the connection described by the author can be observed 10 years after the first examination: on a national level, considerable material abundance is entitled both by the higher eco-efficiency of the whole economy and by a higher ecological footprint per capita. We applied the data table of 2012 of Global Footprint Network (in the following: GFN) for our study, which includes the data of the ecological footprint of countries all over the world between 1961 and 2008 by categories. The GDP data originate from the database of 2008 of the Maddison project (Maddison, 2008), which consists of GDP data calculated with the help of Geary-Khamis (in the following: G-K) for the years of 2011 and 2008 in a national break down. In the database, altogether with the summarizing lines, the data of 188 countries for the year of 2008 can be found. The database of the year of 2011 of the GFN, the data of 234 countries are available.

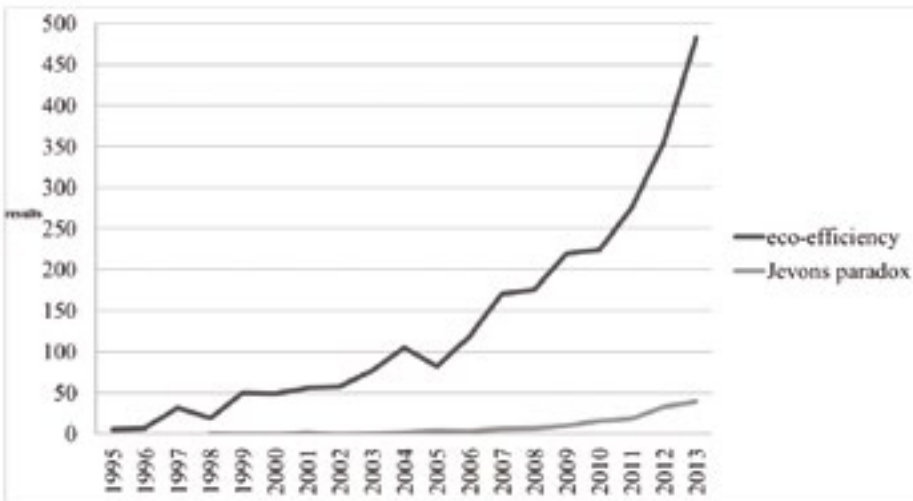
The eco-efficiency was calculated by the ratio of the GDP and the ecological footprint by countries and the calculated results were described in a rectangular coordinate system (scatter plot diagram). The ratio can be calculated on 111 countries since incomplete ecological footprint data are given for several countries presented in the chart. Based on the figures, the tightness of the possibly positive relation was examined with correlation calculation. As we are examining two metrical variables (the GDP and EF), we counted the correlation coefficient of Pearson with a two-tailed test.

We compared the countries possessing the highest ratio with literature data (York 2004) and then we scrutinized the data of the time series of eco-efficiency and the ecological footprint of the most favourable eco-efficient country.

RESULTS

According to literature data, the popularity of eco-efficiency seems to be clearly one of the key terms of sustainability. Nowadays, every year hundreds of articles are published, which include this expression. The concept (Jevons paradox) of the most important critic of the theory is a significantly less used term (Figure 1).

Figure 1: Results in ScienceDirect

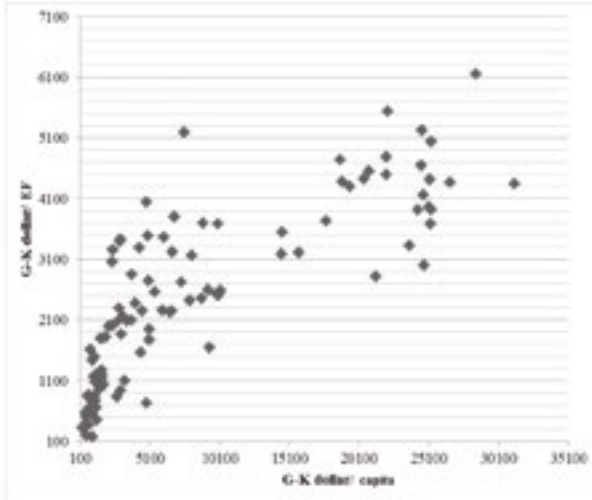


Source: own research (2014).

In Figure 2, a scatter plot diagram (eco-efficiency) can be seen, which shows the relation between the GDP and the GDP / ecological footprint ratio, which is called eco-efficiency. The correlation coefficient of the two metrical variables is 0.821, which refers to a strong positive relation. The correlation under 1 percent in this case is also significant.

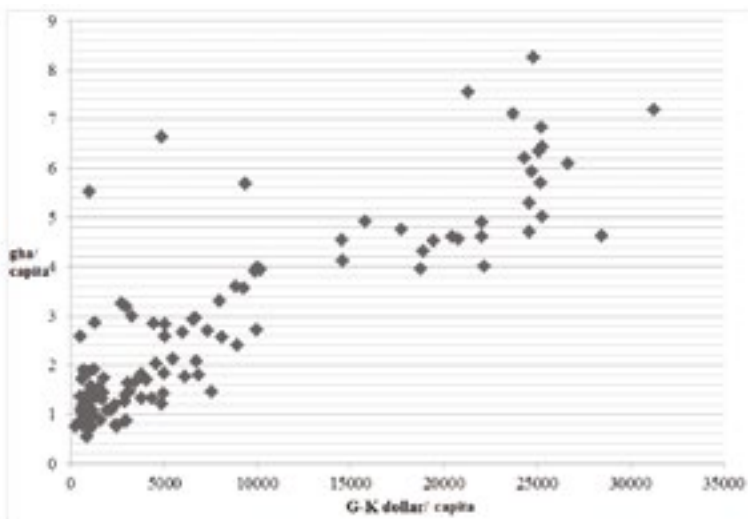
The probable connection between the extent of economic development and the environmental impact has been proved by a wide range of examinations; it is higher than the medium based on the correlation between the ecological footprint and the GDP (York et al., 2004). The relation can be assumed, by realizing that the ecological footprint of an environmental conscious consumer is higher than that of a less environmental conscious person; however, it is lower than the one with lower income (Csutora – Kerekes, 2004). The scatter plot diagram in Figure 3 confirms the results of previous studies, with a probability of a positive relation between the ecological footprint per capita and the GDP. Based on our study, the correlation coefficient of the ecological footprint per capita and the GDP is 0.868 referring to a strong positive relation. The correlation under 1 percent is also significant.

Figure 2: Scatter plot diagram (eco-efficiency)



Source: own research based on Maddison 2008 and GFN 2012.

Figure 3: Scatter plot diagram (EF and GDP)



Source: Based on Maddison 2008 and GFN 2012 own research.

Based on our study, the three countries having the highest GDP / EF ratio were Norway, Japan, and the United Kingdom in 2008 (Table 1). Based on their

data of 1998 , according to the studies of York, these three countries belong to the most favourable quantile. The ecological footprint of all of the three countries was over 4 gha/person in 2008, significantly exceeding the international average of 2.7 gha/person, which was the double of their disposable bio-capacity. The ecological footprint of the year of 2008 of the three countries presented in the former study was also over 4 gha / person.

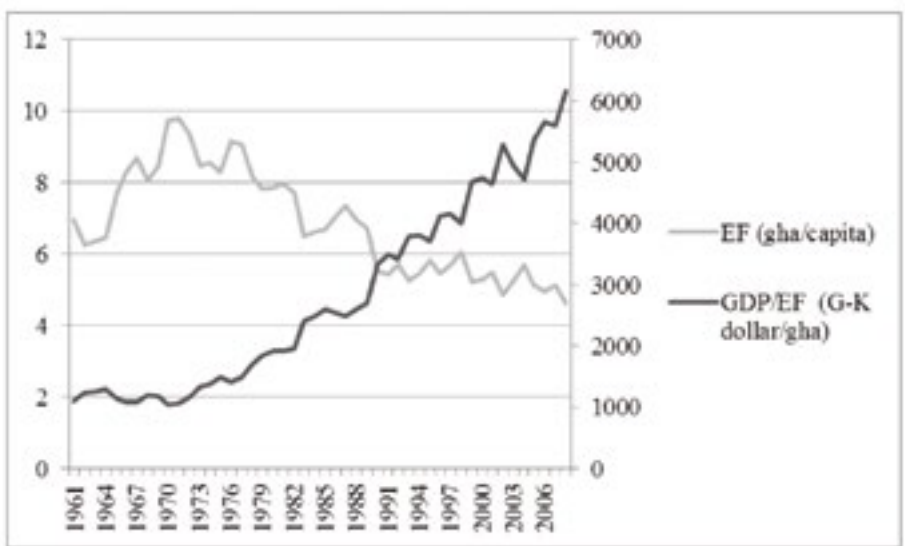
Table 1: Top of eco-efficiency

	1.	2.	3.
York (2004)	Switzerland	Mauritius	Italy
own research	Norway	Japan	UK

Source: Based on York 2004; Maddison 2008 and GFN 2012 own research.

The sample of Norway is informative from other perspective as well, since not only can its eco-efficiency be seen as outstanding, but it is also the only European country with a ecological footprint decrease exceeding 30% continuously since 1961. In the right axis of the Figure 4, the GDP per gha ('eco-efficiency') can be seen, in its left axis, the level of the ecological footprint can be realized (gha/person).

Figure 4: The ecological footprint and eco-efficiency of Norway (1961–2008)



Source: Based on Maddison 2008 and GFN 2012 own research.

CONCLUSIONS

The fashion of eco-efficiency can be clearly observed in scientific publications; however, regrettably, much less scientific attention is paid to its critics. It seems to be promising that the wealthier countries tend to be more eco-efficient (Figure 3). In other words, the GDP per unit ecological footprint is higher than in poorer countries. Nevertheless, we cannot expect a full solution from this result due to two reasons:

1. the higher GDP probably goes with a higher ecological footprint,
2. the ecological footprint of the outstandingly eco-efficient and environmentally decreasingly loaded Norway is more than double the sustainable ones after a significant decrease.

In sum the Jevons paradox appears on a national level as well, although there are some exceptional countries (e.g. Norway), where the developing eco-efficiency is accompanied with decreasing environmental impact.

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HUNGARIAN SUMMARY

Tanulmányunkban bemutatjuk, hogy az ökohatékonyság divatja egyértelműen megjelenik a tudományos publikációkban is, míg ennek kritikájára, a Jevons paradoxonra jóval kevesebb kutatói figyelem irányul. Biztatónak látjuk, hogy a gazdagabb országok jellemzően ökohatékonyabbak, vagyis nagyobb náluk az egységnyi ökológiai lábnyomra jutó GDP, mint a szegényebbeknél. Ugyanakkor ettől az eredménytől nem várhatunk teljes körű megoldást, mert a magasabb GDP nagy valószínűséggel nagyobb ökológiai lábnyommal is jár. Vizsgálataink alapján a Jevons paradoxon az országok szintjén is megjelenik, de vannak kivételes országok (pl. Norvégia) ahol a javuló ökohatékonyság csökkenő környezetterheléssel jár.