THE IMPACT OF ENVIRONMENTAL TAX POLICY ON SUSTAINABLE DEVELOPMENT OF THE EU ECONOMIES. DEA APPROACH

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Abstract

Challenges of climate policy increase the pressure on governments to find ways to reduce environmental damage while minimizing harm to economic growth. Governments have a range of tools at their disposal, including regulations, information programmes, innovation policies, environmental subsidies and environmental taxes. Taxes in particular are a key part of this toolkit. Without governmental intervention, there is no market incentive for firms and households to take into account environmental damage, since its impact is spread across many people and it has little or no direct cost to the polluter. Therefore, protection of the environment generally requires collective action, usually led by the government. Effective implementation of 'green' taxes requires careful consideration of a number of factors. Poorly designed taxes can have a reduced environmental effect and higher economic costs. The paper reviews the theoretical and empirical evidence to assess whether there is consensus on the problem: how ecological taxation affects the sustainable development. A detailed empirical analysis of the environmental tax policy impact on sustainable development in the EU countries concerning economic (the impact on selected economic development variables) and climate (the impact on selected ecological development variables) aspects have been carried out in the subsequent part of the study. The study uses the DEA (Data Envelopment Analysis) methodology, which allows to make a comparative analysis of the relative effectiveness of ecological tax policy in the above mentioned countries.

Keywords: ecological taxes, sustainable development, DEA approach

JEL Classification: H23, Q58

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1. Introduction

Environmental challenges are increasing the pressure on governments to find ways to reduce negative environmental impact while minimising harm to economic growth. There is a range of the green policy tools at governments' disposal, including: regulations, information programmes, innovation policies, environmental subsidies and environmental taxes. These last constitutes a key part of this toolkit. Environmental taxes have many important advantages, such as for example: environmental effectiveness, economic efficiency, the ability to raise public revenue, and transparency. Environmental taxes have been successfully used to address a wide range of issues including waste disposal, water pollution and air emissions. The design of environmental taxes and political economy considerations in their implementation are crucial determinants of their overall economic effects (OECD, 2010). The main goal of paper is to indentify the impact of environmental tax policy on the EU economies sustainable development, using DEA approach. Adopted hypotheses are following: effectiveness of the tax environmental policy is very differentiated between analysed EU countries, as well as between applied types of taxes. That is why adjustment of overall output levels and adjustment of levels of inputs and outputs will enable them to achieve higher efficiency.

2. Ecological policy instruments – types and possible profits from their implementation

Governments have a range of environmental policy tools at their disposal: regulatory (or "command-and-control") instruments, market-based instruments (such as taxes imposed on: energy, pollution, resources and transport) and tradable permits), negotiated agreements, subsidies, environmental management systems and information campaigns. Although no one instrument can be considered best to address every environmental challenge, there has been a growing movement towards environmentally related taxation (and tradable permits) in the EU economies (OECD, 2010). Most environmentally related taxes generate very little revenue. Often, tax bases are quite small, making taxes unlikely to raise much revenue even though the resulting incentives can be quite effective from an environmental perspective. In other cases, tax rates can be quite low. In the medium term, additional revenues from carbon taxes and from the auctioning of tradable permits may increase the role of environmentally related taxation in government budgets (OECD, 2010). The EU governments are increasingly using environmentally related taxes because they are typically one of the most effective policy tools available. Exploring the relationship between environmentally related taxation and innovation is critical to

understanding the full impacts of this policy instrument as well as one potential facet of "green growth" (OECD, 2010). Taxes can directly address the failure of markets to take environmental impacts into account by incorporating these impacts into prices. Environmental pricing through taxation leaves consumers and businesses the flexibility to determine how best to reduce their environmental "footprint". This ensures lowest-cost solutions, provides an incentive for innovation and minimizes the need for government to attempt to "pick winners" (OECD, 2010b).
Environmental tax bases should be targeted to the pollutant or polluting behavior, with few exceptions. Their scope should be as broad as the scope of the environmental damage. The tax rate should be: commensurate with environmental damage, credible, clear, predictable, coordinated and transitional. Environmental tax revenues can assist fiscal consolidation or help to reduce other taxes. Distributional impacts should be addressed through other policy instruments. Environmental taxes may need to be combined with other policy instruments (OECD, 2010b).

3. The impact of ecological taxes on sustainable development – review of theoretical and empirical literature

So far most of the environmental and growth literature has been theory based, either using environmental taxes in an endogenous growth framework as in Bovenberg & De Mooij (1997) or as a general measure of environmental policy as in Ricci (2007).

The empirical literature on this issue has mainly concentrated on the use of simulation exercises rather than the use of econometric modelling, due to the lack of suitable macro-data so far.

The approach to environmental taxation in the EU has concentrated on the use of taxes to improve the environment, using the revenue raised to reduce the distortionary taxation on labour and production. This policy is often regarded as creating the double dividend whereby the environment is improved and at the same time the economy benefits through the reduction in these distortionary taxes (Bosquet, 2000). However other studies (Myles, 2000) state that for the double dividend to occur, the tax system must be inefficient, in which case a better policy would be to improve the system, rather than tax the pollutants. Fisher & van Marrewijk (1998) used a theoretical model which suggests that pollution taxes can result in a double dividend.

The main empirical work on environmental taxation and economic growth has centred around the use of simulations on the impact on environment, use of natural resources and the whole economy. Leiter et al. (2009) have used the EU environmental tax data as a determinant of investment. In their study they find that environmental tax revenue has a positive but diminishing effect on investment. In one study on the EU (Andersen, 2007) the energy-environment-economy (E3) model was used to calculate the effect of a carbon-energy tax on economic growth where a positive contribution of such taxes for both the environment and the economy was found. In consequence the 'double dividend' theory holds because energy is used efficiently and it results in increased economic growth, as long as the energy taxes were used to reduce distortionary taxes, such as labour. Studies like Patuelli et al. (2005) and Anger et al. (2010) focused on a meta-analytical approach in analyzing the impact of environmental taxes on the economy and phenomena of double dividend, which involves the use of regression techniques to determine the effects from simulation studies within the current literature on the double dividend. There have been no econometric studies in general or Granger non-causality studies in particular on the relationship between environmental taxes and economic growth. Interesting example of this kind of analysis was presented in paper of Morley & Abdullah (2010). They investigated the impact of some environmental taxes on economic growth for 23 EU countries in 1995-2006. Authors concluded that there is a little evidence that an expansion of environmentally policies will enhance economic growth through the double dividend. The environmental tax policy interpretation is that more smart approaches for efficient instruments to promote sustainable economic growth and managing the natural resources as well as controlling pollution levels efficiently is required.

Pearce (1991) referred to the 'double dividend' theory, where there are two benefits of environmental taxes: increased environment protection and reduced distortionary impact of taxes on the economy. This theory has on the one hand won over environmentalists who support taxes on environmental externalities and claiming that revenue recycling of this tax in the economy offsets distortionary taxes for labour and firms. On the other hand, economists have argued environmental or pollution taxes affect economic development by reducing the competitiveness of firms.

In addition to the double dividend approach, other studies have suggested further justifications for a positive causal effect from environmental policies to economic growth. Ricci (2007) suggests a number of ways in which measures to improve the environment can enhance economic growth, such as the prospect of a better environment may encourage saving. Pautrel (2009) suggests when the reduced effects of pollution on health are taken into account, the effects of the environmental policy can be positive on the economy.

Environmental taxes can affect the economy in different ways, but if the double dividend holds, we could expect the environmental taxes to have a positive and significant effect on the economic growth, whether measured by GDP or adjusted net savings[2]. Although causality could also run in the opposite direction from GDP to taxes, because an increase in the income and wealth of a country raises its ability and inclination to pay the higher environmental taxes (Morley & Abdullah, 2010). Some authors (see for example: Lee & Gordon, 2005) found a negative relationship between taxes and economic growth, although it depends on the form of the taxation. The most distortionary taxes are usually considered to be taxes on labour and capital.

4. Methodology and data description

4.1. DEA method and its usefulness for conducted analysis

DEA is a non-parametric frontier methodology developed by Charnes et al. (1978). Selection of the most appropriate DEA model is one of the most crucial tasks before carrying out the DEA analysis. There are two basic models of DEA: the CCR and the BCC models.

CCR also known as the constant returns to scale (CSR) model is the original DEA model developed by Charnes et al. (1978). According to CSR assumption the scale of operation of a DMU has no impact on productivity. It is appropriate when all DMUs operate at an optimal scale. In contrast to the CCR model, the BCC model developed by Banker et al. (1984) takes into account possible returns-to-scale evaluations (increasing, constant or decreasing) and therefore is called the variable returns to scale (VRS) model.

Each DMU consumes varying amounts of m different inputs to produce s different outputs. Specifically DMU_j consumes x_{ij} of input i and produces amount y_{rj} of output r. Envelopment BCC model (output oriented) is stated as follows (Thanassoulis, 2001):

$$Max\ z + \varepsilon\left[\sum_{i=1}^{m=1} I_i + \sum_{r=1}^{s} O_r\right], \qquad (1)$$

subject to:

[2]Adjusted net savings (ANS) measure the true rate of savings in an economy after taking into account investments in human capital, depletion of natural resources and damages caused by pollution. Adjusted net savings, known informally as genuine savings, is an indicator that aims to assess an economy's sustainability based on the concepts of extended national accounts, see: http://data.worldbank.org/indicator/NY.ADJ.SVNG.GN.ZS.

$$\sum_{j=1}^{N} \alpha_j x_{ij} = x_{ij_0} - I_i \qquad i = 1.......m, \tag{2}$$

$$\sum_{j=1}^{N} \alpha_j y_{rj} = O_r - z y_{rj_0} \qquad r = 1.......s, \tag{3}$$

$$\sum_{j=1}^{N} \alpha_j = 1, \tag{4}$$

$$\alpha_j \geq 0,1...N, I_i \qquad O_r \geq 0 \forall \quad i \quad and \quad r, z \quad free, \tag{5}$$

where

ε - is a non-Archimedean infinitesimal

I_i, O_r - represent additional output augmentations and/or input reductions (slacks)

The optimal value $z_{j_0}^*$ of z is the maximum factor by which the output levels of DMU j_0 can be radially expanded without detriment to its input levels. Thus by definition $1/z_{j_0}^*$ is the measure of efficiency of DMU j_0 and a measure of the pure technical output efficiency DMU j_0. Slacks represent the leftover portion of inefficiencies. After a proportional increase in outputs, if a DMU cannot reach the efficient frontier, slacks are needed to push the DMU to the frontier (Kumar & Gulati, 2008).

A notion pure is to signal that technical efficiencies are "net" of any scale effect (Thanassoulis, 2001). The impact of scale size on efficiency is measured by scale efficiency. It measures the divergence between the efficiency rating of a DMU under CRS and VRS respectively. The CRS technical efficiency measure is decomposed into "pure" technical efficiency and scale efficiency. Scale output efficiency is defined as follows:

$$\frac{Technical\ output\ efficiency\ of\ DMU_{j0}}{Pure\ technical\ output\ efficiency\ of\ DMU_{j0}}. \tag{6}$$

DEA method has been applied in this paper in order to assess the effectiveness of environmental tax policy of the EU countries on sustainable development of their economies. Using the above method let extract the countries with the maximum level of efficiency and deviating from this level and to determine the degree of these deviations. The DEA also allows you to extract the most strategic, specific inputs and effects (called: *outputs*), which include in particular act in order to increase the efficiency of the impact of climate and energy policy in individual countries, which have a different determinants. In case of this kind of analysis it is important to determine the benefits of scale. An approach based on intuition research suggests that there should be economies of scale variables, primarily due to: differences in the size of objects (countries), different societies environmental awareness in the countries concerned, as well as different traditions in the use of climate and energy policy and the different composition of the economy. Although there are also close, econometric methods of verification of the type of economies of scale, based on statistical tests. It should be noted that in some cases the choice of these advantages does not have very significant effect on the results obtained in efficiency, which in these cases also reinforces the argument for the use of variable economies of scale. The assumption variables economies of scale in terms of ex-ante evaluation is also necessary if at a later stage of analyzes we want to determine differences in the nature of those benefits to individual countries.

In this study 24 EU member states were analysed, four countries: Croatia, Cyprus, Luxembourg and Malta were excluded due to the lack of data for them. As mentioned above there was no justification for CRS, a VRS model was developed. The goal of the paper is to analyse the impact of tax ecological policy on the sustainable development of the EU countries, output oriented VRS model was applied in the analysis.

4.2. Description of variables

For the analysis were chosen, on the base of literature review, variables representative of the environmental tax policy and sustainable development. Proposed input variables illustrate the characteristics of different kinds of environmental taxes imposed on: energy (ET), pollution (TOP) and on transport (TT)) which should influence analysed sustainable development indicators: GDP per capita – based on Purchasing Power Standard (PPS) (GDP_PC), greenhouse gas emissions per capita (EPC) and the share of the renewable energy in gross final energy consumption (REN_EN). All kinds of analysed were taken from Eurostat database. Taxes imposed on resources were not included to the analysis because of lack of data. The relative values of all the analysed variables were used to compensate for the differences in size of countries. All tested types of environmental taxes are referenced to total taxes. The value of GDP is expressed in terms of per capita (based on purchasing power standard – PPS), the volume of greenhouse gas emissions is also calculated in terms of per capita, while the volume of consumption of renewable energy were related to total energy consumption. All analysed data are for the year 2012.

5. Results and discussion

Table 1 presents output efficiency of 24 EU member states under assumption of variable returns to scale. 10 member states are technically efficient and together they define the best practice or an efficient frontier. The remaining countries have a score bigger than 1 which means that they are technically inefficient.

Table 1. Output Efficiency Scores under Variable Returns of Scale (VRS) (analysed year: 2012)

DMU	Output Efficiency Scores (OES_VRS)	Benchmark(Lambda)	Times as a benchmark for another DMU
Austria	1	Austria(1.000000)	8
Belgium	1	Belgium(1.000000)	0
Bulgaria	1.469529	Lithuania(0.129450); Spain(0.250332); Sweden(0.620218)	0
Czech Republic	1	Czech Republic(1.000000)	0
Denmark	1.361341	Latvia(0.222620); Portugal(0.182929); Austria(0.594451)	0
Estonia	1.073111	Lithuania(0.984848); Spain(0.015152)	0
Finland	1.507145	Latvia(0.097860); Austria(0.902140)	0
France	1	France(1.000000)	1
Germany	1.295513	Spain(0.896907); Austria(0.103093)	0
Greece	1.384781	Portugal(1.000000)	0
Hungary	1.209073	Latvia(0.406775); Romania(0.160712); France(0.432513)	0
Ireland	1.217698	Latvia(0.114760); Austria(0.885240)	0
Italy	1.18672	Latvia(0.070618); Portugal(0.142578); Sweden(0.315365); Austria(0.471439)	0
Latvia	1	Latvia(1.000000)	7
Lithuania	1	Lithuania(1.000000)	4
Netherlands	1.377096	Latvia(0.031259); Austria(0.968741)	0
Poland	1.346027	Lithuania(0.363636); Spain(0.636364)	0
Portugal	1	Portugal(1.000000)	3
Romania	1	Romania(1.000000)	1
Slovakia	1.339251	Lithuania(0.283011); Spain(0.500594); Sweden(0.216395)	0
Slovenia	1.308517	Spain(0.519046); Sweden(0.283157); Austria(0.197797)	0
Spain	1	Spain(1.000000)	6
Sweden	1	Sweden(1.000000)	5
United Kingdom	1.345301	Latvia(0.308771); Sweden(0.046886); Austria(0.644343)	0

Source: own calculations based on Eurostat data.

To discriminate 10 efficient EU member states the author employed methodology applied by Kumar & Gulati (2008). For discrimination purposes, use was made of the frequency in the "benchmark set". The frequency which an efficient country shows up in the benchmark set of inefficient countries represents the extent of robustness of that country relative to another efficient country. Efficient countries that appear seldom as a benchmark are likely to possess a very uncommon input/output mix. An efficient country with zero frequency in the benchmark set is termed as "efficient by default" because it does not have characteristics which must be followed by other inefficient countries (Kumar & Gulati, 2008).

Austria, Latvia, Spain, Sweden, Lithuania and Portugal may be regarded as global leaders of the EU. There are 2 countries (Belgium and Czech Republic) which may be regarded as "efficient by default".

Pure Technical Efficiency (efficiency under VRS assumption) scores provide that all inefficiencies directly result from managerial underperformance. Inefficiency is a combination of both pure technical inefficiency and inefficiency that is due to scale of operations (scale inefficiency). Table 2 includes scores of technical efficiency, scale efficiency and kind of returns to scale for analysed EU countries.

Table 2. Scale efficiency and returns-to-scale (analysed year: 2012)

DMU	Technical Efficiency Score (TES_CRS)	Pure Technical Efficiency Score (PTES_VRS)	Scale Efficiency (SE)	Returns of Scale (RTS)
Austria	1	1	1	constant
Belgium	1.119248044	1	1.119248044	decreasing
Bulgaria	2.371449643	1.46952931	1.613747768	decreasing
Czech Republic	1	1	1	constant
Denmark	1.585735988	1.361340648	1.164834084	decreasing
Estonia	1.126104568	1.073111056	1.049383064	decreasing
Finland	1.785456032	1.507145376	1.18466079	decreasing
France	1	1	1	constant
Germany	1.433249966	1.295512991	1.106318482	decreasing
Greece	1.384780706	1.384780706	1	constant
Hungary	1.390043397	1.209072883	1.149677093	decreasing
Ireland	1.480062814	1.217697529	1.215460144	decreasing
Italy	1.316373181	1.186719658	1.109253709	decreasing
Latvia	1.259401432	1	1.259401432	decreasing
Lithuania	1	1	1	constant

Netherlands	1.787076932	1.377095595	1.297714507	decreasing
Poland	1.600752994	1.346027268	1.18924262	decreasing
Portugal	1	1	1	constant
Romania	1	1	1	constant
Slovakia	1.406483608	1.339251037	1.050201619	decreasing
Slovenia	1.767696409	1.308516875	1.35091602	decreasing
Spain	1	1	1	constant
Sweden	1	1	1	constant
United Kingdom	1.639005714	1.345301132	1.218318839	decreasing

Source: own calculations based on Eurostat data.

Based on the results from table 2 it can be stated that overall technical inefficiency of Belgium and Latvia, is not caused by managerial inefficiency but by inappropriate scale size. Greece's situation is the opposite, because overall technical inefficiency is caused by managerial inefficiency. In the remaining countries both pure technical inefficiency and scale inefficiency exist, because these states have both pure technical efficiency and scale efficiency scores more than 1. Only Bulgaria and Slovenia have pure technical efficiency score less than scale efficiency score which implies that their inefficiency is primarily attributable to the scale inefficiency rather than the managerial inefficiency. Remaining countries, besides Ireland, are in opposite situation, because they have pure technical efficiency score more than scale efficiency score. That is why their overall technical inefficiency is mainly caused by managerial inefficiency. In the case of Ireland the both scores are almost equal.

Slacks exist for all DMUs which are inefficient. They provide information regarding which areas should be improved by particular countries to make them efficient. Slacks were identified in table 3.

Table 3. Input and output slacks of inefficient countries (analysed year: 2012)

DMU	**Pure Technical Efficiency Score (PTES_VRS**	**Slacks (energy taxes/total Taxes) ET**	**Slacks (taxes on pollution/total taxes) TOP**	**Slacks (transport taxes/total taxes) TT**	**Slacks (GDP per capita, PPS) GDP_PC**	**Slacks (emisions per capita) EPC**	**Slacks (share of renewable energy in total energy) REN_EN**
Bulgaria	0.693758	-3.344664	-0.247738	0	0	0	6.154067
Denmark	0.96568	-0.556268	0	-1.127497	0	0	1.965942
Finland	0.903055	-0.511155	0	-0.680109	0	0.028793	0
Germany	0.995698	-0.351702	-0.033191	0	0	0.06932	33.362612

Greece	0.975124	-0.92	0	-0.27	0	0.046519	11.258163
Hungary	0.965042	0	-0.122041	-0.087429	10638.11225	0	36.82199
Ireland	0.991676	-0.468022	0	-0.815495	0	0.018082	13.516746
Italy	0.835499	-0.309362	0	-0.387564	0	0	28.381379
Poland	0.659334	-1.543848	-0.496134	0	0	0	17.330295
Slovakia	0.802654	-0.263083	-0.02105	0	0	0	23.088805
Slovenia	0.677414	-2.776814	-0.512597	-0.015181	0	0	19.949412
United Kingdom	0.836524	-0.783926	0	-0.090267	0	0	31.690984

Source: own calculations based on Eurostat data.

In terms of input variables 11 countries have non-zero slacks for ET, 6 countries have non-zero slacks for TOP and 8 countries have non-zero slacks for TT. Regarding output variables: 1 country have non-zero slacks for GDP_PC, 4 have non-zero slack for EPC and 11 has non-zero slacks for REN_EN. These results show that besides the proportional increase in outputs by the level observed by pure technical efficiency most of the inefficient countries need to reduce input levels to become Pareto efficient.

6. Conclusions

The aim of the article was to analyze the environmental impact of EU tax policy for the sustainable development of member countries. The study used the DEA approach to assess the degree of effectiveness of the policy. Adopted hypotheses for varying effectiveness of the tax environmental policy, both between individual countries, as well as between applied types of taxes have been positively verified. On the background of analysis following conclusions can be formulated:

- there are areas for improvement in analysed EU countries: adjustment of their overall output levels and adjustment of levels of particular inputs and outputs that enable them to achieve efficiency,
- more detailed investigation of Slovak, Spanish, Belgian and Danish environmental tax policies should be carried out to identify best practices allowing these countries to serve as benchmarks for inefficient countries,
- implementation of best practices by the EU countries with worse performing environmental taxes would contribute to supporting their economies in terms of sustainable development indicators improvement,

- there is a strong necessity to concentrate on choosing relevant input and mainly output variables, which would be the most representative for sustainable development (DEA method doesn't let to take into account too many variables),
- it is worth to consider the possibility to analyse other tools of environmental policy, like for example: emission permits, spending on environmental protection, regulatory instruments, etc.,
- extremely useful could be analysis of the differentiation of tax rates levels and share of various taxes (environmental, imposed on work and on capital) in total tax revenues, in order to optimize the efficiency of tax systems in the analyzed countries,
- the results obtained in this analysis should be treated with caution. The proposed DEA approach should be possibly verified against alternative variable measures. It would be very difficult task to formulate policy detailed recommendations for particular countries because of their economic, political, social and ecological specifics.

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