Drivers of the change in social welfare

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Abstract

Recent developments in the political, scientific and economic debate on the topic of the project proposal in Area 2: "The impact of ecological sustainability on growth and employment is investigated, as it will have important repercussions on econonmic policy and welfare, many of them not reflected in traditional GDP measures and in economic policy" suggest that it is of critical importance to develop and to use new approaches able to compare policy scenarios for their effectiveness, their efficiency, their enforceability and other dimensions. It is a urgent need for quantitative methodology able to assess the relative performance of different policy scenarios taking into account their long-term economic, social and environmental impacts. The methodology based on Data Envelopment Analysis (DEA) and Multi Criteria Analysis (MCA) provides a promising comparison framework. The objective of this part of research is not solely to discuss and comment on different scenario and policy outcomes provided by WP205, but to extract useful information from the phase where proposed and simulated policy scenarios are compared. In particular, we are interested in incorporating the economic, environmental and social dimensions of the positive and negative impacts of each policy scenario. As shown in the paper by Boseth-Buchner (2009) this methodology allows "to bridge the gap between the simulation phase, in which long-run efects of policies are mimicked, and the valuation phase, in which usually a coherent cost benefit analysis framework is adopted" (p. 1342). In difference to the standard application of DEA for the ex-post performance assessment in the proposed approach DEA can be used for ex-ante assessment of different policy scenarios. DEA models combined with MCA, in particular with Analytic Hierarchy Process (AHP) incorporating human judgements provides an useful instrument to analyse the impact of different policy preferences and strategies that appear to be crucial for the increasing well-being of the population. As a consequence, the proposed approach can provide a very beneficial contribution to the project as a whole and in particular to one of the central questions: "How can the EU guarantee a maximum well-being of its population?"

Contribution to the Project

Following the MS43 with the new concept of measuring the economic performance taking into account simultaneously different outcomes of economic activities, the methodology based on DEA and MCA provides an useful instrument to assess the impact of different policy strategies for the welfare and well-being of the population.

Keywords:

Academic research, Beyond GDP, Challenges for welfare system, Economic strategy, European economic policy, Research, Sustainable growth, Welfare reform, Welfare state

Jel codes:

C61, D69, E01, E61, O11, O47, Q56

Contents

Tables and Figures

1. Introduction

The necessity of having economic performance measured in terms of welfare beyond GDP calls for new approaches capable of simultaneously taking into account economic as well as social and environmental indicators. Data envelopment analysis (DEA) proved to be a proper tool for measuring the economic performance and for assessing efficiency of firms and national economies in the situations of multiple inputs and multiple outputs where the indicators are expressed in different units and some of the outputs are undesirable (like pollutants). In the paper Lábaj et al. (2014), we analysed the economic performance of 30 European countries for the year 2010 in terms of welfare beyond GDP. As the input indicators for GDP (Y) – the output of production activities – capital stock (K) (both measured in PPS) and labour (L) in thousands of persons employed are taken into account. Greenhouse gas (GHG) emissions in thousands of tons and Gini coefficient as the income inequality indicator are considered. The DEA model can be extended by adding further economic as well as social and environmental indicators. Using EUROSTAT data for a year 2010, relative social welfare efficiency was estimated. The results of DEA model yield the set of social eco-efficient countries: Switzerland, Belgium, Norway, Denmark, Germany, United Kingdom, Sweden, Finland, Slovenia and France with the efficiency score equal one (for a complete list see Table 2 in Lábaj et al., 2014). None of the inputs or outputs (as defined above) of these countries could have been improved without worsening at least one of the other inputs or outputs. The remaining countries in our sample are inefficient because they should improve their performance by increasing GDP and/or decreasing Gini coefficient, GHG emissions or the inputs labour and capital stock. For example Austria should increase GDP and Gini coefficient by 3 %, Spain by 6,5 %, Bulgaria by 12 % in order to achieve the level of social eco-efficient countries. In this way the model identifies the potential for increasing social welfare. Deeper insights into strengths and weakness of particular economies and into potentials for improving the efficiency can be obtained looking the multipliers for the inputs and outputs. For illustration we chose six countries: Germany as a country with very strong economy, Greece, a country with weak economic performance, then Finland, Sweden and Austria, countries with high standard of living and Slovakia as a country with rapid economic development. We have showed very strong economic performance of Germany compared to other countries in the sample (the strongest economy in the EU) with the weighted data 1 for GDP and zero for inequality indicator. On the other hand, the main contribution to the efficiency score for Slovakia is provided by the inequality indicator, where the position of the country is much better compared to other countries in the sample – in contrast to the lagging technical efficiency of Slovakia. Similar results can be found for Austria. The weakness of Greece in technical efficiency is not surprising. The results for Sweden and Finland show more balanced contributions of both output factors, confirming the reality that the welfare in these countries is based on all indicators: economic, environmental as well as social. In Sweden, both indicators contributed to the evaluation approximately in the same degree, while in Finland the inequality played a more important part. The resulting weights for particular economic social and environmental indicators indicate the human judgments and priorities of economic policy that appear to be crucial for the social welfare. In other words, they provide the implicit weights for social welfare function (specified for every country) and are closely related to implicit weights of social welfare components discussed in Table 2 of Antal, M. – Van Den Bergh, J. (2015, p. 4).

In this paper, we assess the social welfare and drivers of social welfare over time. We contribute to current research by taking into account simultaneously economic, environmental and social dimensions of overall welfare. The paper is organized as follows. In the following chapter we review the recent contributions to measuring the welfare beyond GDP. We focus strongly to outcomes from WWWforEUROPE project and highlight the interlinkages we our research. In our analysis, we first focus on unrestricted data envelopment models that measure economic, environmental and social efficiency. Then we combine the efficiency scores obtained from these models into overall welfare model. Second, we introduce the restrictions on weights in DEA models and analyse so called assurance region models. In this way we incorporate the policy preferences over different dimensions of social welfare. These weights can be estimated by multi-criteria analysis (MCA) and thus can provide an important decision support for policy makers. In the last section we analyse the drivers of social welfare change over time and conclude.

2. Literature review

Antal (2014) studies two correlations at a global level. The correlation between economic growth and environmental impact and the correlation between the lack of growth and unemployment. He demonstrates that, at a global level, economic growth is strongly correlated with environmental impacts and that low or negative economic growth is highly correlated with increasing unemployment in most market economies. To tackle these issues simultaneously creates a big challenge and trade-offs. To make the environmental goals compatible with full employment, the decoupling of environmental impacts from economic output has to be accompanied by a reduction of dependence on economic growth. Following this empirical observation, Antal and van den Bergh (2014) argue that the focus on decoupling as a main or single strategy to combine economic and environmental aims is very risky and in order to minimize this risk we need to consider reducing our dependence on economic growth. Antal and van den Bergh (2014) point out that developing such strategies is not only a huge challenge but also unattractive in the eyes of many politicians and traditionally trained economists. The alternative, however, comes down to giving little weight to either environmental and climate goals (as is implicit in many political decisions and economic advice) or economic goals (as is implicit in some green proposals). A relatively high risk of the green growth strategy is supported by the analysis of the past development in chosen European countries in Gazheli – Antal – van den Bergh (2015). They considered the relation between carbon dioxide emissions per dollar of output and growth in economic output and labour productivity at the level of production sectors. They show that relatively clean sectors are not more productive than dirtier ones, and neither show higher productivity growth. Additionally, sectors associated with high carbon intensity grew more in absolute terms than those with low carbon intensity. They conclude that at the sectoral production level, there are no indications that something has started that can be regarded as a clear indication of a shift to green growth.

Fischer-Kowalski et al. (2013) prepared generated biophysical scenarios for resource constraints to the supply side of economic activity in Europe up to 2050. These scenarios are based both on natural constraints (resource scarcity) and at politically targeted constraints (e.g. resource use reduction goals, European climate policies, etc.). They suggested four scenarios for European resource use that are aligned with the global resource use scenarios developed by UNEP´s International Resource Panel (2011). The "trend scenario" maintains per capita material consumption in high income countries. The per capita consumption in transitional economies converges to EU 15 levels. The "freezing scenario" prolongs the Europe´s resource use into the future and leads to an average per-capita resource use on the same level as in the early 2000s. The "best practice scenario" generalizes the past success of some European countries (Germany, UK, France) in downsizing their resource use to all European countries up to 2050. The "radical transformation scenario" leads to what is called "absolute decoupling" in halving per capita annual resource use of the European countries. The material boundaries in these scenarios serve as an input to the macroeconomic model developed by Kratena-Sommer (2014). They incorporated the biophysical constraints into a disaggregated dynamic New Keynesian model using the example of two different policy scenarios of resource use in Europe. They explicitly link the physical energy and material flow data to production and consumption activities and model different sources of technical change that are relevant for decoupling of resource use from economic growth. The "baseline scenario" in the model is based on "trend scenario" in Fischer-Kowalski et al. (2013). Then, "best practice" and "radical transformation" scenarios are compared with the baseline scenario up to 2050. These scenarios differ a lot in economic, social and environmental impacts. We can illustrate remarkable differences in the outcomes even by the year 2020. In the "best practice" scenario, the difference to "baseline" scenario is 1,5 % for GDP in constant prices, 6,6 % for employment in persons, -5,6 p.p. for unemployment rate and 4,4 % for total GHG emissions. Real disposable income is 2 % higher with higher income inequality between the first and fifth quintile but relatively strong increase in the middle-class income. On the other side, the "radical transformation" scenario leads to -0,8 % difference in GDP in constant prices, 0,7 % in employment, - 0,6 p.p in unemployment and -20 % decrease in total GHG emissions. There is higher income inequality in real disposable income than in the "best practice" with 1,6 % lower absolute value of disposable income. Its obvious that in order to evaluate these scenarios one need to take into account the social, political, preferences represented by the weights in the social welfare function. Further limitation for an evaluation of these scenarios is recognized in Wiedenhofer - Fischer-Kowalski (2015). The comparison and evaluation of each scenario and policy instrument has to counteract the built-in relationships of the baseline scenario. Thus the modelling exercise in Kratena-Sommer (2014) implicitly assumes that this baseline scenario is actually feasible and realistic in itself. In Wiedenhofer - Fischer-Kowalski (2015) the results have been checked against an expert judgement of plausibility. Some biophysical assumptions have been reformulated or removed to secure consistency and some other economic functions have been adjusted to take care of adequacy and plausibility of outcomes and model specifications. The outcomes of the macroeconomic modelling should thus be taken with cautious. On the other hand it highlights the limitations of existing economic models to incorporate certain biophysical functional interdependencies.

Kettner et al. (2012) prepared a list of social welfare indicators that go beyond the narrow concepts of national economic accounts and are relevant for the evaluation of well-being in Europe. Even though the necessity of measuring the welfare beyond GDP is widely recognized is far from obvious which indicators, indexes, or a set of indicators, should replace it. The review of rather standard obstacles for macroeconomic modelling is presented by Kettner et a. (2014). However, modelling the welfare beyond GDP and its policy implications aim at changing the behaviour associated with carbon-intensive goods. This is often subject to bounded rationality and social preferences and therefore it is necessary to go beyond the representative rational agent models. Rengs et al. (2015) address distributional impacts of climate policies in a multi-agent macroeconomic model and test the effect of various policies on environmental and economic performance. Composite indicators that include a broader array of information than production into an index are quick to communicate and can be relatively easy integrated in model. The main disadvantage of composite indicators is that the weights for the particular indicators have to be chosen a priory and impose a subjective valuation of different aspects of well-being by a researcher. The approach proposed in this paper tackles this problem directly. The weights are not chosen a priory but they are the result of optimizing procedure and in this way determined in the model itself. Furthermore, the weights obtained from the model can be interpreted as a revealed implicit weights of decision making units.

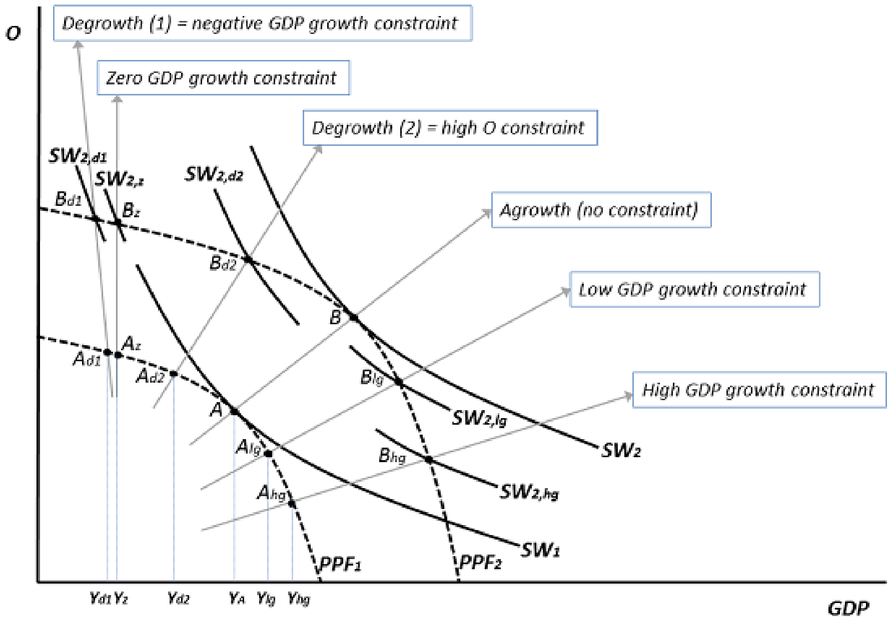
Four different categories of indicators as an alternative to GDP are evaluated in Antal – van den Bergh (2014). The first type represents adjustments to GDP, such as the Index of Sustainable Economic Welfare (ISEW) or Genuine Progress Indicator (GPI). They correct the regular GDP by adding or subtracting certain partially-calculated money amounts to/from GDP. The second type of indicators also starts from GDP but focuses entirely on natural resource depletion and environmental externalities, e.g. Heuting´s Sustainable National Income. The third category of indicators distinguishes between measures of current well-being and measures of well-being over time. This category includes the net present value, discounted utilitarian inter-temporal or multigenerational welfare functions. The fourth type is a composite index that combines a set of indicators that are considered to capture relevant aspects of well-being. This type of indexes does not to be expressed in monetary units but there are two sources of arbitrariness in their construction. First, in the sense of selecting arbitrary components and second, arbitrary aggregation procedure. Human Development Index that aggregates GDP per capita in PPP, life expectancy at birth, adult literacy rate and enrolment ratios is a representative example in this category. As discussed before, the second disadvantage of this type of indicators can be get over by data envelopment analysis that assigns the weights for different indicators within the model and therefore they are not chosen arbitrarily. This has been recognized in the concept of eco-efficiency, first introduced by Schaltegger and Sturm (1989), and later identified by the OECD as one of the major strategic elements in its work on sustainability (OECD, 1998).

Data envelopment analysis (DEA) is a non-parametric production-frontier approach based on mathematical programming and it is suitable for a multiple input/multiple output production system analysis. With DEA, multiple goals of economic policy can be taken into account simultaneously and the potential trade-offs systematically explored. In contrast to neoclassical growth accounting, DEA does not require information about factor prices. The weights required for aggregation of inputs and outputs are obtained as an integral part of the optimization process. This frontier approach allows decomposing productivity growth into a movement of the economy towards the efficiency frontier and a shift of the frontier. Another advantage of DEA is that it enables us to measure efficiency in a system with inputs and output in different units. It does not require having all the variables expressed in monetary units and thus extend the analysis for environmental and social aspects that are usually not expressed in monetary terms.

First DEA models with undesirable outputs were developed by Färe et al (1989), Färe at al (1996), followed by Tyteca (1996), Tyteca (1997), Dyckhoff – Allen (2001) and others. Korhonen and Luptacik (2004) proposed different variants of DEA models for the evaluation of eco-efficiency in a single period. They show that the set of (strongly) efficient decision making units (DMUs) is the same for all the models. However, the different variants provide deeper insights into the underlying sources of eco-efficiency differential across DMUs and therefore show different ways of increasing eco-efficiency. Rao and Coelli (1999) analyze the social welfare encompassing growth in GDP as well as the changes in the distribution of income. They use a non-parametric method to measure productivity growth in different countries and generalize the approach to include both inequality and level of income as joint determinants of total welfare resulting from economic activity. Economic, environmental and social indicators where introduced into the DEA models by our contribution in Lábaj et al (2014). The static approach to eco-efficiency was extend to an intertemporal setting by Caves et al. (1982) as s theoretical index called Malmquist productivity index. It was developed and popularized later by Fare et al. (1994a and 1994b). Malmquist productivity index measures total factor productivity change and allows us to decompose it into the change in efficiency on the one hand side and to change in the frontier technology on the other. In this way, Malmquist productivity index can be used to identify the drivers of social welfare change and permits us to decompose the overall change to change in economic (technical) change, environmental change and social change.

Van den Bergh argues that we should not be obliged to choose between the two polarized opinions in the debate on growth versus the environment. He proposed a third option, the so called “agrowth strategy” that the policy constraints given either by strong preferences for high economic growth or by zero- or de-growth strategies.

Figure 1 **Social welfare implications of an agrowth strategy**



Source: van den Bergh, 2015, Figure 1, p. 8.

He shows that strong focus on GDP per capita growth implies very high weight for average income and medium to high weight for employment in the social welfare function. On the other side, the implicit weight for equity is low and the weights for environment/climate and leisure are extremely low. Figure 1 shows that very strong focus on any particular indicator in production possibility frontiers leads to social welfare function below the optimum. Constraints imposed by high GDP growth scenario and "degrowth" or zero GDP growth scenario do not allow to reach the highest social welfare function and thus are not an optimal strategies. These aspects were not taken into account explicitly in previous DEA models discussed before. On the other side, they can be incorporated in the DEA model through constraints on weights for particular indicators. Upper and lower bounds for relative weights can be estimated by interactive methods of multi-criteria analysis, in particular by methodology known as Analytic Hierarchy Process. Thus, human judgments and priorities that appear to be crucial for an increase of the well-being of population may be taken into account.

3. Assessing the social welfare and drivers of social welfare change over time

First, we analyse the social welfare taking into account simultaneously economic, environmental and social performance of European countries (Models I - IV). Second, we restrict the weights in DEA models (AR models). These restrictions represent the policy preferences. In the last section, we analyse the drivers of social welfare change over time (Model V). An overview of models employed is in Table 1. The analysis is performed for the year 2012 and covers 25

European Union countries. The intertemporal analysis identifies drivers of change over 2003 – 2012 time period.

Table 1 **Overview of social welfare models**

Model	Description	Type	Inputs			Outputs		
I	technical	SBM-V	capital	labor		GDP		
II	ecological	SBM-V	material	energy	emissions	GDP		
III	social	SBM-V	1			income	employment	1 - Gini
IV	welfare (composed)	CCR-O	1			score I	score II	score III
ARx	welfare (restricted weights)	AR-O-C	1			score I	score II	score III
V	welfare	SBM-V	capital	labor		GDP		
			material	energy	emissions	income	employment	1 - Gini

Source: Authors´.

In sections 3.1 to 3.3 we first describe DEA models and then present empirical results.

3.1 Social welfare with unrestricted weights

In DEA modelling, a considerable amount of data is processed. Subjects under evaluation called DMUs (Decision Making Units) are considered as transforming *m* inputs into *s* outputs. Denoting *n* number of DMUs, the data are arranged in the input matrix X and output matrix Y with elements x_{ij}, and y_{rj} respectively. In more technical detail, the approach to modelling social welfare is described in Lábaj et al. (2014). Instead of proposed radial measures of efficiency, the slack-based measure of efficiency (Tone, 2001) is employed in this analysis to capture all sources of inefficiency that could be omitted in radial models.

SBM measure of efficiency is defined by the function $\rho = \dfrac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{i0}}{1+\frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{r0}}$ meeting the requirements of the both, moreover, it can be shown that $0 < \rho \le 1$ (Cooper et al, 2007, p.100).Evaluation of efficiency thus takes the form of a fractional program:

$$\min_{\lambda, s^+, s^-} \quad \rho = \frac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{i0}}{1+\frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{r0}} \tag{1}$$

$$\text{s.t.} \quad \mathbf{x}_0 = X\boldsymbol{\lambda} + \mathbf{s}^- \tag{2}$$

$$\mathbf{y}_0 = Y\boldsymbol{\lambda} - \mathbf{s}^+$$

$$\boldsymbol{\lambda} \geq 0,\ \mathbf{s}^- \geq 0,\ \mathbf{s}^+ \geq 0.$$

Using substitution $t = \dfrac{1}{1 + \frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{r0}}$ the fractional program can be linearized into conveniently computable form (Charnes – Cooper, 1962). Variable returns to scale assumption can be imposed by the additional constraint $\sum_{j=1}^{n} \lambda_j = 1$ on variables **λ** which are used to define production possibility set in the constraints (2). SBM measure with variable returns to scale is denoted SBM-V type of model.

Output-oriented radial measure of efficiency (CCR-O model) is used to integrate three dimensions of social welfare into one single indicator. Primal and dual pair of linear programs where (3)-(4) represent *envelope* program is given below. Formulations (5)-(6) define *multiplier* program yielding shadow prices for individual outputs.

CCR-O: *primal and dual program*

max	θ	(3)	min	$\mathbf{vx_0}$	(5)
s.t.	$\mathbf{x}_0 - \boldsymbol{\lambda}\mathbf{X} \geq \mathbf{0}$	(4)	s.t.	$-\mathbf{vX} + \mathbf{uY} \leq 0$	(6)
	$\mathbf{Y}\boldsymbol{\lambda} - \theta\mathbf{y}_0 \geq \mathbf{0}$			$\mathbf{uy}_0 = 1$	
	$\boldsymbol{\lambda}, \mathbf{s}^-, \mathbf{s}^+ \geq \mathbf{0}$			$\mathbf{u}, \mathbf{v} \geq \mathbf{0}$	

Model I measures the technical efficiency of European countries. Capital and labour are used as inputs to production process and gross domestic product measures the output. By Model II we measure the ecological efficiency. Material and energy consumption as inputs are transformed to output (GDP). We treat emissions, undesirable output, as an input variable. Social efficiency is measured in Model III. It is determined by three indicators of social welfare, that is income, employment and Gini coefficient. We have transformed the Gini coefficient that measures the income inequality to 1 – Gini coefficient that measures the income inequality. In this way, higher coefficient represent a better outcome (more equal income distribution). Model IV measures the overall welfare taking into account the efficiency scores from Model I – Model III. The results are presented in Table 2.

In the rows labelled I, II and III, scores from models I, II and III respectively are displayed. Within the set of analysed countries, eight technically efficient countries with the unit score determine efficiency frontier – Belgium, Germany, Ireland, France, Cyprus, Latvia, Poland, and Slovakia. Lithuania is considerably lagging behind. The detailed results of optimization would be involved to determine specific sources of inefficiency.

Table 2 **Efficiency scores for models I - IV**

DMU	Model			
	I	II	III	IV
Belgium	1	0,780	0,930	1
Bulgaria	0,806	0,392	0,559	0,806
Czech Republic	0,826	0,531	0,810	0,826
Denmark	0,856	1	0,931	1
Germany	1	1	1	1
Estonia	0,838	0,390	0,683	0,838
Ireland	1	1	0,830	1
Greece	0,702	0,677	0,708	0,708
Spain	0,918	1	0,786	1
France	1	1	0,921	1
Croatia	0,937	0,811	0,643	0,937
Italy	0,992	1	0,829	1
Cyprus	1	1	0,847	1
Latvia	1	1	0,541	1
Lithuania	0,263	0,221	0,732	0,732
Hungary	0,928	0,765	0,701	0,928
Netherlands	0,959	1	1	1
Austria	0,833	0,873	0,986	0,986
Poland	1	0,507	0,716	1
Portugal	0,764	0,804	0,765	0,804
Slovenia	0,932	0,758	1	1
Slovakia	1	0,688	0,776	1
Finland	0,812	0,551	0,967	0,967
Sweden	0,761	1	1	1
United Kingdom	0,976	1	0,910	1

Source: Authors´ computations.

Environmentally oriented assessment is given by model II yielding other set of efficient countries – German, Ireland, Spain, France, Italy, Cyprus, Latvia, Netherlands, Sweden, and United Kingdom. It is thus obvious that viewing GDP as a product of differently defined transformation processes results in different values of efficiency providing additional dimension of assessment.

The third model III only focuses on social indicators without regarding any inputs accounted for in previous two models. Germany, Netherlands, and Sweden appear efficient with this respect apparently in line with common view of having successfully implemented welfare state policies. Completing list of efficient countries from model III, Slovenia gains advantage from the lowest level of inequality contributing massively to its model III unit score. Greece and Lithuania appear to be performing countries with this regard achieving scores of 0,708 and 0,732 respectively.

The scores from the three models are used to obtain overall social welfare measure in model IV. In line with conceptual DEA model, DMUs are allowed to ascribe weights in the most favourable manner so that to achieve the maximal possible value of the resulting overall score IV. Obviously, this approach drives countries efficient in at least one dimension to give it the maximum weight neglecting their poor performance in the other dimensions. Thus all the efficient DMUs listed above form a set of efficient countries in model IV. For other countries, the best value from I, II or III scores is picked up to represent the social welfare efficiency. This approach does though not reflect the fact that in evaluating welfare no dimension should be allowed to be completely ignored which leads to imposing weight restrictions as a possible solution to the problem.

3.2 Social welfare with restricted weights

An overall welfare measured in Model IV neglects the problems discussed in van den Bergh, 2015. In unrestricted DEA models, countries can achieve high efficiency score simply by focusing on the strongest aspect of overall welfare and by neglecting all other dimensions. These corner solutions are not optimal from social welfare function perspective as described above. We can get over these obstacles by imposing restrictions on weights in DEA models. In this way we can compute the overall welfare with assurance region model (see Cooper et al, 2007 for detailed description of assurance region method).

We have employed three different versions of restricted DEA model. In the first assurance region model, Model AR1, the weight on economic performance should be higher than the weight on ecological efficiency. There are no restrictions on social efficiency in this model. So, the policy preferences are indifferent with respect to social welfare and they value the economic performance more than environmental performance. The weights chosen in the second model, Model AR2, follow the description of implicit weights for social welfare function with focus on gross domestic product in van den Bergh (2015). Weights for economic performance should be higher than weights for social performance and these should be higher than weights for environment. Restrictions in Model AR3 allow different preferences over economic, environmental and social welfare. Economic efficiency can be preferred to environmental efficiency and vice versa, but weights should be in “reasonable” proportions. It means that they should be far away from corner solutions that neglect some dimension of overall welfare. The ratio between environmental and economic weights should be higher than 0,5 but lower than 2. Similar restriction holds for social and economic weights. The overview of these models is in Table 3.

Table 3 **Overview of assurance region models**

Model	Description	Restrictions
AR1	Low preferences for environment performance and indifference with respect to social aspects	Weight I > Weight II
AR2	Focus on economic performance	Weight I > Weight III > Weight II
AR3	“No corner solutions” preferences	0,5 < Weight II / Weight I <2 0,5 < Weight III / Weight I <2

Source: Authors´.

Complete results that are obtained from Models AR1 to AR3 are shown in Annex in Table 6, 7 and 8. In Table 4 below we highlight the result for chosen European countries and compare them with unrestricted Model IV.

Table 4 **Efficiency score and weights for Model IV and Models AR1 – AR3**

	Model IV				Model AR1				Model AR2				Model AR3			
	Score	U(1)	U(2)	U(3)	Score	U(1)	U(2)	U(3)	Score	U(1)	U(2)	U(3)	Score	U(1)	U(2)	U(3)
Germany	1				1	0,99	0,01	0	1	0,98	0,01	0,01	1	0,29	0,57	0,14
Sweden	1				1	0	0	1,00	0,92	0,36	0,36	0,36	0,95	0,21	0,42	0,42
Austria	0,99				0,99	0	0	1,01	0,91	0,55	0,01	0,55	0,93	0,31	0,15	0,62
Slovakia	1				1	0,99	0,01	0	1	0,99	0	0,01	0,87	0,58	0,29	0,29
Finland	0,97				0,97	0	0	1,03	0,89	0,56	0,01	0,56	0,86	0,33	0,17	0,66
Greece	0,71				0,71	0,00	0	1,41	0,71	0,71	0,01	0,71	0,70	0,41	0,20	0,81
Lithuania	0,73				0,73	0	0	1,37	0,50	1	0,01	1,00	0,52	0,54	0,27	1,09

Source: Authors´ computations.

The results in Table 4 demonstrate the main drawback of DEA models with unrestricted weights as well as of models with one-hand side restrictions. The highest efficiency score in these models can be achieved in a way that attaches zero or negligible small weights for one or more dimensions of overall welfare. Thus, it identifies the production possibility frontier but it can lead to sub-optimal results from social welfare function perspective. For example, the efficiency score in Model IV is obtained solely by choosing very high weight for economic performance in Germany and Slovakia while neglecting environmental and social dimensions. Neither Model AR1 nor Model AR3 solve this problem, even though they restrict the weights in favour of economic dimension. The possibility to achieve high efficiency via unbalanced weights is ruled out in Model AR3 where we have imposed the lower and upper bound on weights´ ratios. Slovakia was very strong in economic dimension in 2012 and defined the production possibility frontier in Model IV, AR1 and AR2. But this efficiency was achieved with zero (or very low) weights on environmental and social dimensions. With imposed restrictions in Model AR3, the efficiency score of Slovakia dropped down to 0,87. Constraints imposed on weights in this model for Slovakia are binding in both cases. The weights for Slovakia are thus 0,58 for economic dimension and 0,29 for environmental and social dimensions. Germany is the only country that is efficient in all models presented in Table 4. This suggests that although the Germany is strongest in economic performance, it can be considered efficient even after imposing restrictions on weights. Sweden is a country with very good performance in social dimension (Model IV and Model AR1). The restriction imposed in Model AR2 lead to equal weights for each dimension in Sweden while the Model AR3 reveals strong performance of Sweden in social and environmental dimensions of social welfare. This is reflected in relatively low weight on economic performance.

3.3 Drivers of social welfare change

To account for the social welfare efficiency change over time the static approach elaborated in previous section must be augmented. For intertemporal setting, we utilize productivity index which would present total factor productivity (TFP) change. We are also interested in decomposing the improvement in performance into individual country´s effort and the general technology progress. DEA provides a method for measuring productivity and efficiency change over time. Intertemporal change of productivity is assessed by the Malmquist productivity index (MI) given by

$$MI = C \times F = \frac{d_o^2(\mathbf{x}_0, \mathbf{y}_0)^2}{d_o^1(\mathbf{x}_0, \mathbf{y}_0)^1} \times \left[\frac{d_o^1(\mathbf{x}_0, \mathbf{y}_0)^1}{d_o^2(\mathbf{x}_0, \mathbf{y}_0)^1} \cdot \frac{d_o^1(\mathbf{x}_0, \mathbf{y}_0)^2}{d_o^2(\mathbf{x}_0, \mathbf{y}_0)^2} \right]^{1/2} \quad (7)$$

where d_o denotes efficiency score related to activity (**x**,**y**) of DMU under consideration in specific time period and within the production set of specific period of time. Malmquist index is expressed in (7) as a product of two subindices C and F. The former stands for efficiency change over time, the latter representing improvement in productivity ascribed to technological progress defined by DMUs performing at *best practice* level. Thus, in terms of DEA analysis, C and F represent two movements – one towards the efficiency frontier (catch-up effect) and the other movement of the frontier itself (frontier-shift). Computation of (7) involves solving four auxiliary optimizations of the type (3) – (6) for each DMU. Values of Malmquist index as well as the component terms allow to infer on the type of technology change.

Efficiency change over time was analysed by Mahlberg et al. (2011) who conducted an analysis of eco-efficiency of EU-15 countries to identify drivers of technological change. Borrowing the idea of Mahlberg et al. (2011), we used three social welfare dimensions described individually by models I, II and III to compute TFP change as well as components C and F for each country. Finally, the MI and composite indices based on the compound Model V embracing all the variables (see Table 1) is determined. The results are displayed in Table 5.

A comprehensive picture of productivity change involving all inputs and outputs defining social welfare is provided by Malmquist index from model V (the rightmost column of the Table 5). On average, social welfare increased by 9,7%. Austria, Slovakia, Sweden, Denmark were the most successful in increasing the welfare. Taking a look at the outcomes of models I, II and III describing constituent parts of the welfare, it can be inferred that the most significant contribution to the total welfare was on the part of ecology – 28,1% on average while pure technical change or improvement in social sphere only went up by 4,3% and 3,8% respectively. Comparing countries individually, one can clearly see that the social welfare improvement was qualitatively different in Slovakia (driven mostly by ecology – 58% while just 5,4% from social model) and Austria (25,8% ecology and 13,3% social conditions).

Decomposition of Malmquist index into catch-up and frontier-shift terms provides information on whether the improvement should be ascribed to individual country´s better performance or it was driven by the overall technology shift. Columns labelled C and F corresponding to models I, II, III and V contain values of MI subindices. Taking a look on average values, one can state that the social welfare improvement (model V) was by most part due to technological shift (8,2%) rather than cathing up (1,4%)by individual countries. Qualitatively same results is obtained from component models for technical, ecological and social dimensions where the increase in productivity is on average mainly technologically driven (F exceeds C).

Concentrating thus on the frontier-shift effect one can see that improvement in process involving transformation of the inputs into outputs relevant to social welfare presents average of 8,2% resulting from model V. All the countries but Lithuania and Estonia experienced growth of social welfare productivity indicated by MI, Slovakia, Austria, Denmark, and Sweden were also the most pushed-forward by technology which contributed to their overall productivity increase.

A disaggregate look at the constituent dimensions reveals sources of improvement. A frontier-shift index from model I reflects growth of productivity due to more efficient use of technical inputs while values from the column II describe productivity growth while saving environmentally-related inputs or reducing pollution. Thus the relative size of the effects can distinguish between input- or environment-saving technological progress. It is obvious that the latter took place without exception since values of II are greater than of I. The technological change was clearly environmentally biased. The same conclusion can be derived from the comparison of frontier-shift indices from models II and III. On average, 4,4% improvement due to technical input saving (model I) and 3,8% gain in the "social efficiency" (model III) are outperformed by 20,1% increase from the model II. Specifically, Estonia and Lithuania experienced overall deterioration mainly due to worsening in the social part which represented their strengths as determined by static evaluation via I, II and III scores.

It can be concluded that the social welfare in Europe in the span of 2003 – 2012 increased. This was mostly contributed by the change of technology that was for the most part environment-saving rather than technical-input-saving or social-conditions-improving.

Table 5 **Malmquist index and decomposition terms**

	I			II			III			V		
	C	F	MI	C	F	MI	C	F	MI	C	F	MI
Belgium	0,959	1,058	1,014	1,043	1,222	1,275	1,005	1,118	1,124	1	1,046	1,046
Bulgaria	0,916	1,077	0,986	1,193	1,174	1,401	0,897	0,980	0,879	0,916	1,077	0,986
Czech Republic	1,123	1,016	1,141	1,178	1,159	1,366	0,996	0,981	0,977	1,108	1,059	1,174
Denmark	1,001	1,029	1,029	1,072	1,200	1,286	0,970	1,051	1,020	1,043	1,186	1,237
Germany	1,040	0,999	1,039	1,025	1,172	1,201	1,005	1,198	1,204	1,074	1,005	1,080
Estonia	1,003	1,055	1,059	1,020	1,164	1,188	1,048	0,988	1,035	0,990	0,841	0,832
Ireland	1	1,028	1,028	1	1,238	1,238	1,016	1,025	1,041	1	1,097	1,097
Greece	0,933	1,040	0,971	0,859	1,164	1	1,019	0,989	1,008	0,890	1,125	1,002
Spain	0,981	0,998	0,979	1,099	1,210	1,330	0,954	1,043	0,995	1,048	1,130	1,184
France	0,959	1,073	1,028	1	1,219	1,219	0,957	1,148	1,098	1	1,140	1,140
Croatia	0,947	1,050	0,995	1,023	1,164	1,191	0,995	0,979	0,974	1	1,083	1,083
Italy	0,890	1,045	0,930	1	1,179	1,179	0,985	1,119	1,102	1	1,097	1,097
Cyprus	0,914	0,992	0,906	1,098	1,173	1,289	0,963	1,018	0,980	1	1,031	1,031
Latvia	1	1,020	1,020	1,035	1,237	1,280	1,027	0,986	1,013	1	0,929	0,929
Lithuania	1,072	1,128	1,209	1,229	1,194	1,467	1,072	0,980	1,051	1,022	0,796	0,813
Hungary	0,948	1,068	1,012	1,115	1,198	1,336	1,024	0,978	1,001	1	1,180	1,180
Netherlands	1,051	1,002	1,053	1	1,168	1,168	1	1,049	1,049	1	1,123	1,123
Austria	0,939	1,114	1,046	1,028	1,223	1,258	0,991	1,143	1,133	1,021	1,175	1,200
Poland	1,055	1,095	1,155	1,112	1,196	1,330	1,089	0,980	1,067	1,066	1,089	1,161
Portugal	1,003	0,998	1,001	1	1,170	1,170	0,958	1,001	0,958	1	1,105	1,105
Slovenia	0,997	1,032	1,029	0,992	1,221	1,211	1	0,983	0,983	1,043	1,095	1,141
Slovakia	1,203	1,070	1,288	1,300	1,220	1,586	1,075	0,981	1,054	1,050	1,176	1,235
Finland	1,001	1,040	1,042	1,123	1,254	1,408	1,032	1,073	1,108	1,071	1,063	1,138
Sweden	0,980	1,123	1,100	1	1,320	1,320	1	1,067	1,067	1	1,288	1,288
United Kingdom	1,058	0,954	1,008	1,106	1,197	1,324	0,942	1,101	1,037	1,011	1,121	1,133
Average	**0,999**	**1,044**	**1,043**	**1,066**	**1,201**	**1,281**	**1,001**	**1,038**	**1,038**	**1,014**	**1,082**	**1,097**

Source: Authors´ computations.

4. Conclusions

In this study, a social welfare measures in several variants were presented. The basic model assessed three dimensions of social welfare – economic, environmental and social – individually to integrate them subsequently into a single social welfare indicator. Weight restrictions were introduced to prevent excluding of unfavourable performance in any dimensions from affecting the overall score. The approach is applicable in any case when preferences of policy makers should be taken into account in the process of evaluating performance outcomes. Such preferences can be estimated by multi-criteria analysis and thus provide an important support for policy makers.

The inter-temporal analysis using Malmquist productivity index revealed the prevailing role of technology in improving overall social welfare as well as its three constituent dimensions. Making use of the productivity indices derived from constituent models it was possible to expose environment-saving bias of social welfare performance change in technology, i.e. that the technology in Europe has for the most part been environment-saving rather than technical-input-saving or social-conditions-improving.

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Annex

Table 6 **Efficiency score and weights form Model AR1**

	Model AR1			
	Score	U(1)	U(2)	U(3)
Belgium	0,998	0,992	0,010	0,000
Bulgaria	0,802	1,235	0,012	0,000
Czech Republic	0,823	1,203	0,012	0,000
Denmark	0,931	0,000	0,000	1,074
Germany	1,000	0,990	0,010	0,000
Estonia	0,833	1,188	0,012	0,000
Ireland	1,000	0,990	0,010	0,000
Greece	0,708	0,000	0,000	1,412
Spain	0,959	0,521	0,521	0,000
France	1,000	0,990	0,010	0,000
Croatia	0,936	1,058	0,011	0,000
Italy	0,996	0,502	0,502	0,000
Cyprus	1,000	0,990	0,010	0,000
Latvia	1,000	0,990	0,010	0,000
Lithuania	0,732	0,000	0,000	1,367
Hungary	0,926	1,069	0,011	0,000
Netherlands	1,000	0,000	0,000	1,000
Austria	0,986	0,000	0,000	1,014
Poland	0,995	0,995	0,010	0,000
Portugal	0,784	0,638	0,638	0,000
Slovenia	1,000	0,000	0,000	1,000
Slovakia	0,997	0,993	0,010	0,000
Finland	0,967	0,000	0,000	1,034
Sweden	1,000	0,000	0,000	1,000
United Kingdom	0,988	0,506	0,506	0,000

Source: Authors´ computations.

Table 7 **Efficiency score and weights form Model AR2**

	Model AR2			
	Score	U(1)	U(2)	U(3)
Belgium	0,999	0,991	0,000	0,010
Bulgaria	0,803	1,233	0,000	0,012
Czech Republic	0,826	1,199	0,000	0,012
Denmark	0,929	0,359	0,359	0,359
Germany	1,000	0,980	0,010	0,010
Estonia	0,836	1,184	0,000	0,012
Ireland	0,998	0,982	0,010	0,010
Greece	0,705	0,706	0,007	0,706
Spain	0,918	1,068	0,011	0,011
France	0,999	0,981	0,010	0,010
Croatia	0,934	1,060	0,000	0,011
Italy	0,991	0,990	0,010	0,010
Cyprus	0,998	0,982	0,010	0,010
Latvia	0,996	0,985	0,010	0,010
Lithuania	0,496	1,003	0,010	1,003
Hungary	0,926	1,070	0,000	0,011
Netherlands	0,986	0,338	0,338	0,338
Austria	0,909	0,547	0,005	0,547
Poland	0,997	0,993	0,000	0,010
Portugal	0,778	0,429	0,429	0,429
Slovenia	0,965	0,515	0,005	0,515
Slovakia	0,998	0,992	0,000	0,010
Finland	0,888	0,560	0,006	0,560
Sweden	0,920	0,362	0,362	0,362
United Kingdom	0,976	1,005	0,010	0,010

Source: Authors´ computations.

Table 8 **Efficiency score and weights form Model AR3**

	Model AR3			
	Score	U(1)	U(2)	U(3)
Belgium	0,928	0,308	0,154	0,616
Bulgaria	0,641	0,781	0,390	0,390
Czech Republic	0,775	0,369	0,184	0,737
Denmark	0,949	0,301	0,602	0,151
Germany	1,000	0,286	0,571	0,143
Estonia	0,687	0,728	0,364	0,364
Ireland	0,976	0,293	0,586	0,146
Greece	0,702	0,407	0,203	0,814
Spain	0,946	0,302	0,604	0,151
France	0,989	0,289	0,578	0,144
Croatia	0,832	0,601	0,300	0,300
Italy	0,973	0,294	0,587	0,147
Cyprus	0,978	0,292	0,584	0,146
Latvia	0,934	0,306	0,612	0,153
Lithuania	0,525	0,545	0,272	1,089
Hungary	0,830	0,602	0,301	0,301
Netherlands	0,992	0,202	0,403	0,403
Austria	0,926	0,308	0,154	0,617
Poland	0,806	0,621	0,310	0,310
Portugal	0,787	0,363	0,726	0,182
Slovenia	0,946	0,302	0,151	0,604
Slovakia	0,866	0,577	0,289	0,289
Finland	0,863	0,331	0,165	0,662
Sweden	0,952	0,210	0,420	0,420
United Kingdom	0,980	0,291	0,583	0,146

Source: Authors´ computations.

Project Information

Welfare, Wealth and Work for Europe

A European research consortium is working on the analytical foundations for a socio-ecological transition

Abstract

Europe needs change. The financial crisis has exposed long-neglected deficiencies in the present growth path, most visibly in the areas of unemployment and public debt. At the same time, Europe has to cope with new challenges, ranging from globalisation and demographic shifts to new technologies and ecological challenges. Under the title of Welfare, Wealth and Work for Europe – WWWforEurope – a European research consortium is laying the analytical foundation for a new development strategy that will enable a socio-ecological transition to high levels of employment, social inclusion, gender equity and environmental sustainability. The four-year research project within the 7th Framework Programme funded by the European Commission was launched in April 2012. The consortium brings together researchers from 34 scientific institutions in 12 European countries and is coordinated by the Austrian Institute of Economic Research (WIFO). The project coordinator is Karl Aiginger, director of WIFO.

For details on WWWforEurope see: www.foreurope.eu

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