MEASURING MACROECONOMIC TECHNICAL EFFICIENCY WITH DESIRABLE AND UNDESIRABLE OUTPUTS

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ABSTRACT

Purpose - This paper focuses on environmental performance at a macro level in the construction of (environmental) efficiency indices for the European Economic Area (EEA) 32 countries. We consider five components of production: outputs - GDP and greenhouse emission, inputs- capital stock, employment and energy use, from 2006 to 2011.

Methodology framework - The issue is to treat the undesirable output in a production function framework. The approach assumes the production of desirable outputs comes jointly with a set of polluting wastes and weak disposability on undesirable output constraint by environmental protection. Färe et al. (1989) propose a hyperbolic technical efficiency measurement under strong and weak disposability of bad output and computes a hyperbolic environmental efficiency index.

Following the same methodology, we compute the opportunity costs for environmental regulations measures in terms of a lower feasible expansion of desirable outputs. Data are processed sequentially. This means that each observation for a given year is compared to the all other observations in the same year and to the observations in previous years.

Findings - The results show that East and South regions seem more inefficient, and the gap increases over the period. Developing economies seem to be less efficient than those advanced. In addition, if the disposability for pollutants were strictly restricted as a result of an environmental regulation, the total value of output loss to the GDP countries would correspond between 2% and 3% of the hyperbolic environmental efficiency for the six years. We can conclude that the opportunity cost of imposing environmental regulations is not very high.

Keywords: macroeconomic efficiency, undesirable outputs, Data Envelopment Analysis.

JEL classification: C61, D24, O52

1. Method

Two assumptions are becoming commonly accepted: null jointness and weak disposability.

In the null jointness assumption bad outputs are considered as a sort of byproduct of the main production process at producing desirable outputs. Therefore, it is impossible to observe a positive amount of good outputs without observing also a positive amount of bad outputs.

Weak disposability is the notion that there is a cost associated with disposing of undesirable outputs. With environmental protection, bad output reduction cannot occur for free because it is costly in technological terms.

According to joint production of desirable and undesirable outputs and the weak disposability hypothesis, the environmental non-parametric technology, associated with the observed data *K* that exhibits constant returns to scale (CRS), can be expressed as

$$P^{w}(\mathbf{x}) = \Big\{ (\mathbf{y},\mathbf{b}) : \sum_{k=1}^{K} z_k y_{mk} \geq y_m \,, \quad m = 1,2,...M$$
$$\sum_{k=1}^{K} z_k b_{jk} = b_j \,, \quad j = 1,2,..,J$$
$$\sum_{k=1}^{K} z_k x_{nk} \leq x_n \,, \quad n = 1,2,...,N$$
$$z_k \geq 0, \quad k = 1,2,...K \Big\}$$

where z_k indicates the intensity variables, and $\mathbf{x}_k$, $\mathbf{y}_k$, $\mathbf{b}_k$ respectively the vectors of inputs, desirable outputs and undesirable output.

The constraints state that the desirable outputs are strongly disposable (their quantities can be reduced at no cost), while the equality $\sum_{k=1}^{K} z_k b_{jk} = b_j$ allows a weak disposability of undesirable outputs (their production can be reduced only at the cost of a reduction in the other outputs or an increase in inputs).

In contrast to weak disposability, the concept of strong disposability allows any output to be disposed without imposing any private costs

$$P^{S}(\mathbf{x}) = \Big\{ (\mathbf{y},\mathbf{b}) : \sum_{k=1}^{K} z_k y_{mk} \geq y_m \,, \quad m = 1,2,...M$$
$$\sum_{k=1}^{K} z_k b_{jk} \geq b_j \,, \quad j = 1,2,..,J$$
$$\sum_{k=1}^{K} z_k x_{nk} \leq x_n \,, \quad n = 1,2,...,N$$
$$z_k \geq 0, \quad k = 1,2,...K \Big\}$$

The inequality $\sum_{k=1}^{K} z_k b_{jk} \geq b_j$ allows a strong disposability of undesirable outputs.

Following the work of Pittman (1983), that offered a framework for assessing productivity when some outputs are undesirable and cannot be freely disposed, Färe et al. (1989) developed the notion of hyperbolic output efficiency measures under weak (***H^W***) and strong disposability (***H^S***), providing an asymmetric treatment of desirable and undesirable outputs. The hyperbolic environmental efficiency measurement $HEE = \left(H^S / H^W\right)$ is considered a measure of regulatory impact, conceived in terms of reduced productivity due to a forced departure from strong disposability of undesirable outputs. The output loss is given as $y_{mk}(H^S - H^W)$.

2. Empirical analyses

According to the model outlined above, we employ EEA32 over the period from 2006 to 2011 in a sequential frontier. This means that, each observation for a given year is compared to all other observations in the same year and to the observations in previous years[162].

With respect to imposing weak disposability of GHGE, on average, we distinguish the $\boldsymbol{H^W}$ efficiency score in three clusters.

The first cluster is the most efficient and is made up of the advanced countries in the North and West, excepting Turkey. The third cluster is the least efficient, and is comprised both of advanced and emerging countries, all found in Eastern and Southern Europe, excepting Iceland.

[162] Thus, starting with a reference sample of 32 observations for the year 2006, the frontier is built by the next enlargements that include the observations for all the years. In this manner, the efficiency for the observations in the last year, 2011, is estimated by constructing the frontier based on all observations between 2006 and 2011

Table - Average of: hyperbolic efficiency index, environmental efficiency and GDP loss.

Sub region	market classification	cluster	country	H^W	H^S	HEE	GDP loss (in mil. 2005US$)
N	A	1	IRL	1.000	1.000	1.000	0
W	A	1	CHE	1.001	1.063	1.062	19,258
N	A	1	NOR	1.002	1.025	1.023	6,589
N	A	1	SWE	1.006	1.145	1.138	43,177
E	E	1	TUR	1.063	1.063	1.000	0
W	A	1	LUX	1.082	1.082	1.000	0
N	A	1	EST	1.083	1.083	1.000	0
N	A	1	GBR	1.084	1.153	1.064	138,484
E	E	2	BGR	1.110	1.110	1.000	0
S	A	2	ITA	1.119	1.163	1.039	73,739
S	A	2	MLT	1.125	1.145	1.018	174
N	E	2	LTU	1.125	1.147	1.020	1,125
W	A	2	AUT	1.132	1.180	1.043	14,359
N	A	2	DNK	1.140	1.168	1.025	5,271
S	A	2	ESP	1.152	1.200	1.042	57,480
W	A	2	NLD	1.158	1.184	1.022	16,306
W	A	2	BEL	1.161	1.161	1.000	0
W	A	2	DEU	1.162	1.198	1.031	100,547
S	A	2	PRT	1.169	1.198	1.025	6,386
W	A	2	FRA	1.182	1.212	1.026	57,416
S	A	2	GRC	1.189	1.194	1.004	1,307
N	E	2	LVA	1.190	1.279	1.075	2,711
E	E	2	POL	1.195	1.196	1.001	441
N	A	2	FIN	1.216	1.216	1.000	0
E	A	3	SVK	1.227	1.278	1.042	5,161
E	E	3	HUN	1.235	1.314	1.064	12,851
S	E	3	HRV	1.242	1.271	1.023	1,985
E	E	3	ROU	1.248	1.274	1.021	6,011
S	A	3	SVN	1.280	1.334	1.042	2,593
S	A	3	CYP	1.283	1.292	1.006	142
N	A	3	ISL	1.312	1.312	1.000	0
E	A	3	CZE	1.329	1.364	1.027	8,366

References

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