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Obtaining Efficient Economic and Environmental Policies for the Spanish Economy

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Abstract: In this paper we propose an analytical approach to obtain so-called *efficient* policies in terms of environmental and economic objectives. A policy is said to be efficient if any environmental or economic achievement is obtained with the minimum possible detriment to other relevant objectives. We apply this concept obtain the minimum possible environmental impact for a given growth rate or, symmetrically, the maximum economic growth for a given amount of polluting emissions. We present an application to Spanish economy with 2000 data using a Computable General Equilibrium model. We evaluate the efficiency of the observed policy and give some policy recommendations. Finally, we give an idea about how to enlarge the analysis by including additional objectives.

Keywords: Environmental Policies, Applied General Equilibrium Models, Multicriteria Decision Making

JEL Classification Number: C68, D58, Q58.

1. Introduction

Together with traditional economic policy objectives, such as controlling unemployment, inflation or public deficit, nowadays public policies need to pay more attention to environmental protection. Moreover, both groups of objectives (environmental and economic) are likely to conflict with each other in the sense that pursuing one objective might harm the other.

In this framework, we claim that environmental goals will be easier to defend if they do not imply very large losses in terms of economic objectives. And the other way around: economic policies will be better seen by society if they do not entail very large environmental impacts. In other words, policy makers should aim to design *efficient policies* in the sense introduced by André and Cardenete (2008, 2009a, 2009b) and André, Cardenete and Romero (2008, 2009) in a recent line of research addressing public policies as a multicriteria decision making (MCDM) problem[2]. A policy (a combination of policy instruments) is said to be efficient if it is not possible to find another policy providing the

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[2] MCDM is an analytical approach to address problems with several conflicting objectives. See Ballestero and Romero (1998) for an introduction.

same or better outcome for all the policy objectives being strictly better for some objective. Efficiency guarantees that the observed level of achievement for any objective is reached with the minimum possible cost in terms of other objectives.

The aim of this paper is to apply the notion of efficient policy to a setting in which the policy makers are concerned about economic and environmental objectives and to provide an approach to identify efficient policies in practice. Our approach is illustrated with data from Spain 2000.

Section 2 summarizes our methodological approach, the model and the data used for the analysis. Section 3 presents a policy design exercise with one economic criterion (real growth) and one environmental criterion (CO_2 emissions). Section 4 briefly advances how to enlarge the scope of the research by including additional economic objectives. Section 5 concludes.

2. Data and Methodology

We describe the economic system using a Computable General Equilibrium (CGE) model following the basic principles of Walrasian equilibrium. The model includes a representative consumer and 26 productive sectors to match the database structure (see André and Cardenete 2008 for details), each sector with a single representative producer. Taxes and the activity of the public sector are taken as exogenous by consumers and firms, while they are considered as decision variables (i.e., policy instruments) by the government. The equilibrium of the economy is a price vector for all goods and inputs and a vector of activity levels such that the consumer is maximising her utility, producers are maximising their profits and supply equals demand in all markets. To save some space, we just present some of the main elements of the model. Some additional details can be found in André et al. (2005). See Kehoe and others (2005) for an overview of CGE models.

The production technology is given by a nested production function. The domestic output of sector j ($j = 1,...,26$) is obtained by combining, through a Leontief technology, outputs from the rest of sectors and the value added. In turn, value added is generated from primary inputs (labor and capital), combined by a Cobb-Douglas technology. Overall output of sector j is obtained from a Cobb-Douglas combination of domestic output and imports according to the Armington hypothesis (1969).

The government raises taxes to obtain public revenue, R, as well as it gives transfers to the private sector, TPS, and demands goods and services from each sector, GD_j. PB denotes the final balance (surplus or deficit) of the public budget:

$$PB = R - TPS.cpi - \sum_{j=1}^{26} GD_j.p_j \qquad (1)$$

cpi being the Consumer Price Index and p_j the price, before Value Added Tax (VAT hereafter), of good j.

Final demand comes from investment, exports and consumption demand from households. There are 26 different goods –corresponding to productive sectors- and a representative consumer who pays taxes, demands consumption goods and saves the remainder of her disposable income in order to maximize a Cobb-Douglas utility function.

Concerning pollution, we focus on CO_2 emissions and we adopt a short-term approach. The production technology is assumed to be fixed and so is the pollution intensity of all the sectors, according to the following linear relationship:

$$E_j = \alpha_j.Q_j \qquad (2)$$

where E_j and Q_j denote respectively emissions and output of sector j and α_j is a sector-specific technical parameter measuring emissions per unit of output. There is an environmental tax of t euros per unit of emissions, due to which sector j pays T_j:

$$T_j = t \cdot E_j \qquad (3)$$

The same tax on pollution implies a different economic burden in terms of output. Substituting (7) into (8), we get:

$$T_j = \beta_j \cdot Q_j \qquad (4)$$

where $\beta_j \equiv t.\alpha_j$ is the tax rate of sector j in terms of output. Total emissions are given by:

$$E = \sum_{j=1}^{26} E_j \qquad (5)$$

The model is callibrated using the aggregated 2000 social accounting matrix for Spain (see Cardenete and Fuentes, 2007 for details) and the Spanish national statistical institute (INE).

We approach policy design by assuming that the government solves a MCDM problem choosing the optimal value of the policy instruments in order to achieve efficient results in terms of the policy objectives. All the equations of the CGE model are included as constraints in the policy-design exercise as a representation of the economic system and, hence, of the relationship between objectives and instruments.

We consider as *policy instruments* taxes and public expenditure. Concerning taxes, we take the average rate of direct taxes -income tax and the social security contribution of employees- and indirect taxes -value added tax (VAT) and payroll tax, allowing for a different tax rate in each activity sector-, as well as the emissions charge. For the sake of realism, we include the following constraints: first, all the instruments (except the emissions charge) cannot vary more than 5% with respect to the observed value. Second, although public expenditure can vary 5% by sector, total expenditure must remain equal to the observed value. Concerning the emissions charge, we set a lower bound of 0 (pollution cannot be subsidized) and an upper bound equal to 0.02 euros per kton/year of CO_2 emissions, to avoid an unrealistically high tax burden[3].

3. Determining Efficient Policies in terms of Growth and Emissions

Assume that the government is concerned about two *policy objectives*: the first one is to increase economic growth as measured by the one-year growth rate of total output, denoted by g_Q. The second objective is to reduce CO_2 emissions. We take as an indicator the growth rate of emissions with respect to the observed value in 2000, denoted as g_E.

Table 1 is the so-called *payoff matrix*, which is obtained by optimizing each objective separately. The first row shows that the maximum attainable growth is 4.94%, which would imply, as a side-effect, a 0.59% increase in emissions.

Table 1: Growth-CO_2 Emissions Payoff Matrix

	g_Q (%)	g_E (%)
$Max\ g_Q$	4.94	0.59
$Min\ g_E$	3.45	-2.01

The second row shows that it would be possible to reduce emissions about 2% with respect to the observed value. The economic consequence of this policy would be an economic growth rate of 3.45 %, about 1.5 below the maximum.

[3] Specifically, when the environmental tax rate is set at its highest rate, the most polluting sector (which is sector 7, "Production and distribution of electricity") has an average tax rate of 8% in terms of output.

Regarding the optimal values of policy instruments, maximizing growth is consistent with no emissions charge, while minimizing emissions entails the highest possible value for this tax. Maximizing growth also requires reducing all indirect taxes whereas minimizing emissions requires increasing them. Both solutions entail increasing direct taxes. Maximizing growth requires shifting public expenditures to sector 17 ("vehicles") and minimizing emissions is consistent with increasing public expenditure in Sector 25 ("other services"), which is one of the less polluting.

We approximate the set of efficient policies using so-called *constraint method* (Marglin 1967): we made a partition in the feasible range of g_E, (from -2.01% to 0.59%) and, denoting by g_{E_n} the *n*-th value in this partition, we maximize growth imposing that emissions are not greater than g_{E_n}:

$$\begin{aligned} &Max\ g_Q \\ &s.t. \quad g_E \le g_{E\_n} \end{aligned} \tag{6}$$

Figure 1: Efficient (Growth v.s. Emissions) Policies

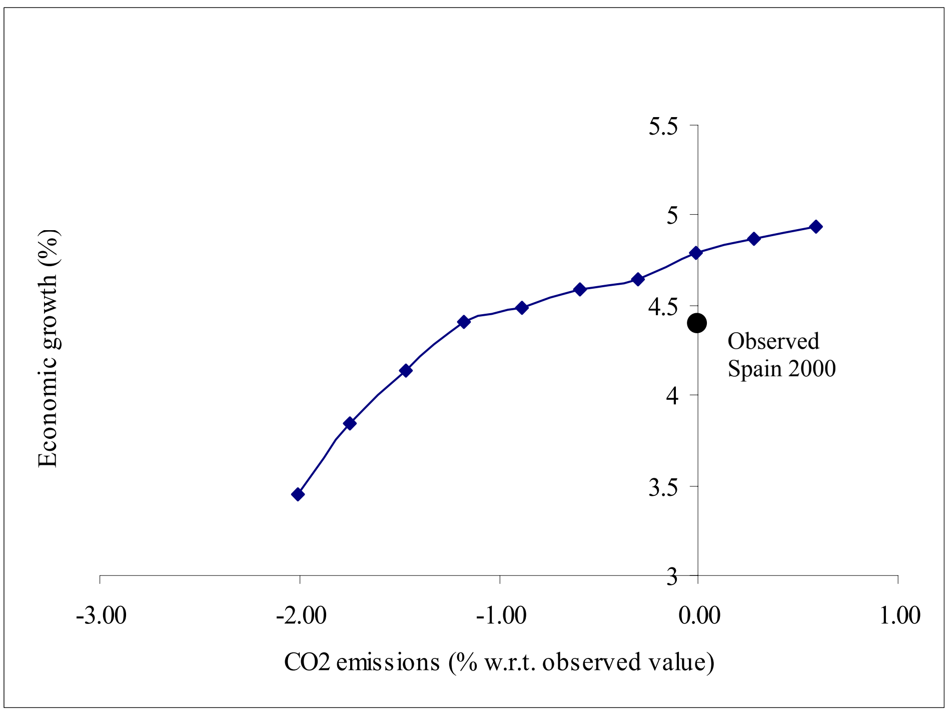

Figure 1 shows the results of these calculations. Tougher environmental targets always imply lower growth rates but the slope of the efficient frontier is higher for low values of emissions than for higher values. Therefore, as the government pursues tougher environmental objectives, the marginal cost in terms of foregone growth is increasing. The observed combination in Spain 2000 ($g_E = 0$, $g_Q = 4.4$. Source: INE) is below the frontier. We conclude that the policy followed by the government could be improved in terms of efficiency. Indeed, alternative policies could provide about 0.4 additional points of growth with the same emissions or, alternatively, the same growth rate while reducing emissions about 1%.

4. Efficient Policies with More Than Two Criteria

Assume that, apart from growth and emissions, the government is also concerned about reducing unemployment, u, public deficit, PD and fiscal pressure, FP (total tax collections as a percentage of GDP).

Table 2 represents the new payoff matrix. Maximizing growth and minimizing unemployment are fully consistent with each other, since both problems provide essentially the same solution. Therefore, the same conflict between emissions and growth also exists between emissions and unemployment. Minimizing unemployment entails 0.56% more emissions while minimizing emissions leads to the worst value of unemployment, 2 points above its minimum. Indeed, emission minimization displays a strong conflict with all economic objectives since all of them achieve their worst values.

Table 2: Payoff Matrix with 5 Objectives

	g_Q(%)	g_E(%)	u(%)	PD (10^6€)	FP(%)
Max g_Q	**4,94**	<u>0,59</u>	13,10	17.59	33,06
Min g_E	<u>3.45</u>	**-2,01**	<u>15,28</u>	<u>24.55</u>	<u>34,84</u>
Min u	4,94	0,56	**13,09**	17.68	33,05
Min PD	4,05	-0,79	14,41	**13.82**	<u>34,84</u>
Min FP	4,44	0,16	13,83	16.02	**32,96**

Note: **bold** (<u>underlined</u>) figures represent ideal (anti-ideal) values.

But the conflict between emissions and public deficit is not as straightforward as one may think. While minimizing deficit is compatible with a noticeable reduction of emissions (-0.79 %), reducing emissions from this point to their minimum would bring a strong increase of deficit, 70% above its minimum. These results suggest the existence of a non-monotonic relationship between both variables. A similar conclusion can be obtained about emissions and fiscal pressure. There is also some conflict among economic objectives: minimizing public deficit involves almost 1 point below the ideal value of growth, more than one additional point of unemployment with respect to the minimum and a high value of fiscal pressure.

The enlarged problem can be tackled by different computational techniques (see Evans, 1984), a systematic exploration of which is beyond the scope of this paper. As an illustration, we present the so-called *weighting method* (Zadeh, 1963), which works by maximizing the following weighted average of the normalized objectives:

$$\omega_Q \frac{g_Q - g_{Q*}}{g_Q^* - g_{Q*}} + \omega_E \frac{g_{E*} - g_Q}{g_{E*} - g_E^*} + \omega_u \frac{g_{u*} - g_u}{g_{u*} - g_u^*} + \omega_{PD} \frac{g_{PD*} - g_{PD}}{g_{PD*} - g_{PD}^*} + \omega_{FP} \frac{g_{FP*} - g_{FP}}{g_{FP*} - g_{FP}^*} \qquad (7)$$

where X^* represents the ideal value and X_* the anti-ideal value of objective X. Each objective is normalized and bounded between zero (when X_* is reached) and one (when X^* is attained). The weighting coefficients ω are preference parameters measuring the importance of objectives. Alternative combinations of ω provide different efficient policies corresponding to different preferences. As an example, assume that the policy maker considers that all the objectives are equally important:

$$\omega_Q = \omega_E = \omega_u = \omega_{PD} = \omega_{FP}$$

Then, maximizing (7) provides the following solution:

$$g_Q = 4.42\% \quad g_E = -0.9\% \quad u = 13.83\% \qquad PD = 14552 \cdot 10^6 € \quad FP = 32.69\%$$

The observed values in Spain 2000 are the following:

$$g_Q = 4.4\% \qquad g_E = 0\% \qquad u = 14.0\% \qquad PD = 15957 \cdot 10^6 € \qquad FP = 33\%$$

The solution given by the weighting method (which is efficient by construction) Pareto-dominates the observed one since it provides the same or better values for all the objectives. Therefore, the observed policy could be improved in terms of efficiency if we restrict to the selected criteria and given the feasible set of policy instruments.

5. Conclusions

Both economic and environmental objectives are relevant for public polices. The concept of *efficient policies* allows us to represent the aim to get a certain result for each objective with the lowest possible detriment for other objectives. We apply this concept to a setting in which the government is assumed to be concerned about economic and environmental objectives with data from Spain, 2000.

Our approach provides an approximation of the set of efficient policies as well as an estimation of the sacrifice that environmental goals entail in terms of foregone growth. It is also possible to determine in which directions the policy mixed should be reformulated to get efficient combinations of economic activity and environmental impact. The model can be enlarged to include more than two objectives to get a higher degree of realism at the cost of more complicated computations.

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