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RESUMEN

Como los gobiernos, al diseñar sus políticas macroeconómicas suelen perseguir distintos objetivos que entran en conflicto entre sí, el diseño de las políticas se puede entender como un problema de decisión multicriteria. Siguiendo la propuesta metodológica de André y Cardenete (2005), en este artículo se usa la programación multiobjetivo en combinación con un modelo de equilibrio general computable para obtener un conjunto de las llamadas *políticas eficientes* en una aplicación a una economía regional (concretamente, la de Andalucía). Se ilustra la solución de dos problemas bicriterio (desempleo frente a inflación y crecimiento frente a desempleo) a partir de los cuales se obtiene una nueva lectura de dos resultados clásicos: la curva de Phillips y la ley de Okun. Finalmente, se amplía el alcance de la propuesta presentando un problema de diseño de política con cinco objetivos y se discuten las políticas eficientes que se obtienen en este contexto.

Palabras clave: Políticas públicas, Teoría de la Decisión Multicriterio. Modelo de Equilibrio General Computable, Política Eficiente.

ABSTRACT

Since policy makers usually pursue several conflicting objectives, policy making can be understood as a multicriteria decision problem. Following the methodological proposal in André and Cardenete (2005), we use multiobjective programming in connection with a computable general equilibrium model to represent optimal policy making and to get so-called efficient policies in an application to a regional economy (Andalusia, Spain). We illustrate the solution of two bicriteria problems (unemployment vs. inflation and growth vs. unemployment) from which we get a new reading of two classical results: the Phillips curve and the Okun law. Finally, we enlarge the scope of the exercise by solving a problem with five objectives and discuss the efficient solutions that can be obtained in this context.

Keywords: Public Policy, Multicriteria Decision Making, Computable General Equilibrium Model, Efficient Policy..
JEL classification: C61, C68, D78

1. INTRODUCTION

The design of public policies is an important issue in economics presenting important theoretical and applied challenges. The traditional way to model the design of an optimal economic policy involves assuming that a social planner aims at minimising some social loss function or maximising some social welfare function, typically identified with the utility function of a representative consumer. This approach provides a theoretically elegant tool that links the original economic problem to the operational field of optimisation theory[4]. Nevertheless, this classical approach also presents some important shortcomings concerning its realism and implement ability in practice.

To apply the classical approach, it is crucially needed a suitable utility or welfare function which represents the preferences of society. An intuitive reasoning tells that such a function can be very hard to find, and the intuition is reinforced by the Social Choice line of research pioneered by Arrow (1963), showing that in standard contexts, it is virtually not possible to combine the preferences of all the members of the society in a single social preference relationship, with reasonable properties. On the other hand, direct observation of the usual practice in policy making does not seem consistent with the optimisation of a single specific function. Rather, policy makers appear to be concerned about a bundle of macroeconomic indicators such as the growth rate, inflation rate, unemployment rate, public deficit, public debt or foreign deficit, and they aim at improving the performance of the economy as measured by these indicators. In other words, the government typically faces a decision problem with several goals or objectives and, moreover, these goals usually conflict with each other. For example, an active anti-unemployment policy could foster inflation; increasing economic growth could be harmful for the foreign sector, and so on.

Multicriteria Decision Making (MCDM henceforth) techniques are specifically aimed at dealing with this kind of situations in which there are multiple conflicting

[4] See Ramsey (1927) for a pioneering work.

goals. Several particular techniques, such as multiobjective programming, compromise programming, goal programming and others, have been fruitfully applied to many economic problems in which it is not reasonable or operational to assume the existence of a single goal or objective[5]. André and Cardenete (2005) and André, Cardenete and Romero (2005) proposed to use a multicriteria approach connected to a computable general equilibrium (CGE hereafter). In both of these papers, the concept of *efficient policy* is introduced and applied to a bicriteria policy making problem for the Spanish economy, involving growth and inflation as objectives.

This paper has the following goals: firstly, we seek to apply the mixed MCDM-CGE approach introduced by André and Cardenete (2005) and André, Cardenete and Romero (2005) to a regional economy (Andalusia, Spain). Secondly, we show how this approach, when applied to certain bicriteria problems, provides a new reading of some classical economic results, such as the Phillips curve and the Okun law. Finally, we try to extend the scope of the mentioned approach by addressing policy problems with more than two objectives.

In Section 2, we identify the main elements required to represent policy making as a multicriteria problem and we define the concept of *efficient policies* in this framework. In Section 3 we present the economic model used for the application and the database used to calibrate the model. In section 4 we display the results, which are grouped in three policy making problems. The first one is a bicriteria problem combining unemployment and inflation, which gives a particular version of the classical Phillips curve which we can label *optimal Phillips curve* or *efficient Phillips curve*. The second problem addresses growth and unemployment. Since the same policies aimed at increasing growth also help to reduce unemployment, we arrive at the conclusion that (contrarily to the unemployment-inflation problem) this case does not result to be a

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[5] See Ballestero and Romero (1998) for an introduction to multicriteria techniques and their applications to economic problems.

genuine multicriteria problem given the lack of conflict between objectives. This problem collapses to a mono-criteria one and there is a single efficient policy combination. Nevertheless, by applying the same technique used to obtain efficient policies, we get a set of feasible growth-unemployment combinations from which an Okun-law-type relation can be inferred. Finally, we somewhat enlarge the scope of the analysis by increasing the number of policy objectives to five (including public deficit and compensating variation as a measure of consumers welfare). Using these objectives, we show that the observed policy can be improved in several directions with respect to the observed situation (by improving one or more objectives without worsening any of them). Section 5 summarizes the main findings of the paper.

2. GENERAL SETTING: MCDM AND POLICY DESIGN

Assume there are *m* economic agents (typically, consumers and firms), indexed by $h=1,...,m$, which are assumed to act rationally in the sense that they choose the values for their decision variables (denoted as a vector $\mathbf{z_h}$) to maximise their objective function f_h. Typically, consumers make consumption and saving decisions to maximise utility and firms decide their factor demand and goods supply to maximise profits. Assume also the government has a vector $\mathbf{x}$ of policy instruments, which may include taxes, public expenditure and investment, interest rates, and so on.

The decision problem of agent *h* can be represented as choosing $\mathbf{z_h}$ to

$$\text{maximise} \quad f_h(\mathbf{z_h}, \mathbf{z_{-h}}, \mathbf{x})$$

$$\text{subject to} \qquad \mathbf{z_h} \in \mathbf{R_h}$$

where $\mathbf{R_h}$ is the feasible set of agent *h* and his objective function f_h may depend on his own decisions $\mathbf{z_h}$, the decisions (denoted as $\mathbf{z_{-h}}$) of the rest of agents, and the policy variables $\mathbf{x}$. For example, the profit of a firm may depend on its own strategy, the competitors' strategy, the consumers' behaviour and the taxes they have to pay.

Let $\mathbf{z}_h^*(\mathbf{z}_{-h}, \mathbf{x})$ denote the optimal response of agent *h*, i.e., the values of his decision variables maximising f_h, given $\mathbf{z}_{-h}$, and $\mathbf{x}$. The interaction among agents provides the *equilibrium* value of all the decision variables for all the agents, denoted as $\mathbf{z}^e(\mathbf{x}) \equiv (\mathbf{z}_1^e(\mathbf{x}), \ldots \mathbf{z}_m^e(\mathbf{x}))$ in such a way that

(1) $$\mathbf{z}_h^e(\mathbf{x}) \in \mathbf{z}_h^*(\mathbf{z}_{-h}, \mathbf{x}), \quad h=1,\ldots,m.$$

Aggregating $\mathbf{z}^e$, we get the value of the relevant macroeconomic variables in equilibrium which are the typical policy objectives (for example, Gross Domestic Product results from the aggregation of outputs from all the firms, the Consumer Price Index results from the weighted average of the prices of goods and services, and so on). Assume the government is interested on *K* macroeconomic aggregates denoted as $Z_1, \ldots, Z_K$, which can be obtained from $\mathbf{z}^*$ according to some aggregation rules:

(2) $$\begin{array}{c} Z_1 \equiv Z_1(\mathbf{z}^*(\mathbf{x})) \\ \ldots \\ Z_K \equiv Z_K(\mathbf{z}^*(\mathbf{x})) \end{array}$$

If a policy maker knows the response functions of all the agents, using (1) he can predict the equilibrium of the economy and, using the aggregation in (2), he can get the values of the policy objectives as a function of $\mathbf{x}$. If there were a single policy objective ($K=1$), the optimal design of the economic policy would result from optimizing Z subject to (1) and (2). In practice, there are typically several policy objectives presenting some trade-off between them, so that the policy makers actually face a multicriteria problem. Following André and Cardenete (2005) we use multiobjective programming, which is a multicriteria technique aimed at determining the set of efficient solutions. In our context, the multiobjective design of policies can be represented by the following problem:

(3) $$\text{Eff } \mathbf{Z} \equiv [Z_1,\ldots,Z_K]$$

$$\text{subject to} \quad (1), (2), \ \mathbf{x} \in \mathbf{X}$$

where Eff means the search for *efficient policies* and **X** represents the feasible set for the policy instruments. A feasible policy (i.e., a value of $\mathbf{x} \in \mathbf{X}$) is said to be efficient if it provides some values of the objective variables such that there is no feasible policy that can achieve the same of better performance for all the policy objectives being strictly better for at least one policy objective. To make this approach operation we also need some description of the economy under study, i.e. some specific contents for the decision variables $\mathbf{z_h}$, the objective functions f_h and the interactions among economic agents. That part of the study is developed in the next section.

3. MODEL, DATA AND POLICY VARIABLES

The Economic Model

We present a CGE model following the basic principles of the walrasian equilibrium -as in Scarf and Shoven (1984), Ballard *et al*, (1985) or Shoven and Whalley (1992)-. Following the CGE tradition, this model performs a structural disaggregate representation of the activity sectors in the economy and the equilibrium of markets, according to basic microeconomic principles. Taxes and the activity of the public sector are taken as exogenous by consumers and firms, while they are considered as decision variables by the government. Assuming that consumers maximise their utility and firms maximise their profits (net of taxes), then the CGE provides an equilibrium solution; that is, a price vector for all goods and inputs, a vector of activity levels and a value for public income. In equilibrium, supply equals demand in all the markets ("markets clearance") and public income equals the total payments from all economic agents. To save some space, we only present some basic features of the model. A more detailed description of the model can be found in Cardenete and Sancho (2003b) or André *et al* (2005).

The model comprises 25 productive sectors (in order to match the Social Accounting Matrix, see Table 1 for a list of the sectors) with one representative firm in each sector, a single representative consumer, one public sector and one foreign sector. The production technology is described by a nested production function: the domestic output of sector *j*, measured in euros and denoted by Xd_j, is obtained by combining, through a Leontief technology, outputs from the rest of sectors and the value added VA_j. This value added is generated from primary inputs (labour, *L*, and capital, *K*), combined by a Cobb-Douglas technology. Overall output of sector *j*, Q_j, is obtained from a Cobb-Douglas combination of domestic output and imports $Xrow_j$, according to the Armington (1969) hypothesis, in which domestic and imported products are taken as imperfect substitutes.

INSERT TABLE 1 HERE

There are 25 different goods –corresponding to productive sectors- and a representative consumer who demands present consumption goods and saves the remainder of his disposable income after paying taxes. 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 GD_j from each sector $j=1,\ldots,25$. *PD* denotes the final balance (surplus or deficit) of the public budget:

$$PD = R - TPS\ cpi - \sum_{j=1}^{25} GD_j\ p_j$$

cpi being the Consumer Price Index and p_j a production price index before Value Added Tax (*VAT* hereafter) referring to all goods produced by sector *j*. The Consumer Price Index is calculated as a weighted average of the prices of all sectors, according to the participation of each one in the overall consumption of the economy.

Consumer disposable income (*YD* henceforth) equals labour and capital income, plus transfers, minus direct taxes:

$$YD = w\,L + r\,K + cpi\ TPS + TROW - DT\,(r\,K + cpi\ TPS + TROW)$$

$$- DT\ (w\ L - WC\ w\ L) - WC\ w\ L$$

where *w* and *r* denote input (labour and capital) prices and *L* and *K* input quantities sold by the consumer, *TROW* represents transfers received by the consumer from the rest of the world, *DT* is the tax rate of the Income Tax (*IT* hereafter) and *WC* the tax rate corresponding to the payment of the employees to Social Security (*ESS* hereafter). The consumer's objective is to maximise his utility (welfare), subject to his budget constraint. Welfare is obtained from consumption goods CD_j ($j = 1,\dots,25$) and savings *SD*, -according to a Cobb-Douglas utility function, that leads to the following optimisation problem:

$$\text{maximise} \qquad U\ (CD_1,\dots,CD_{25}, SD) = \left(\prod_{j=1}^{25} CD_j^{\alpha_j}\right) SD^{\beta}$$

$$\text{subject to} \qquad \sum_{j=1}^{25} p_j CD_j + p_{inv}\ SD \quad = YD$$

p_{inv} being an investment price index.

Regarding investment and saving, this is a *saving driven* model. The closure rule is defined in such a way that investment is exogenous, savings are determined from the consumer's decision and both variables are related with the public and foreign sectors by the following identity, where INV_j denotes investment in sector *j*:

$$\sum_{j=1}^{25} INV_j\, p_{inv} = SD\ p_{inv} + PD + ROWD$$

Labour and capital demands are computed under the assumption that firms minimise the cost of producing value added. In the capital market we consider that supply is perfectly inelastic. For labour supply, we use the following approach, which shows a feedback between the real wage and the unemployment rate, related to the power of unions or other factors inducing frictions in the labour market (see Kehoe *et al,* 1995):

$$\frac{w}{cpi} = \left(\frac{1-u}{1-\bar{u}}\right)^{\frac{1}{\beta}}$$

where u and $\bar{u}$ are the unemployment rates in the simulation and in the benchmark equilibrium respectively, w/cpi is the real wage and β is a flexibility parameter. This formulation is consistent with an institutional setting where the employers decide the amount of labour demanded and workers decide real wage taking into account the unemployment rate. For the empirical exercises, we take an estimated value for Spain from the econometric literature: β=1.25 Andrés *et al.* (1990).

Real Gross Domestic Product (GDP hereafter) is calculated from the expenditure point of view, by aggregating the values of private consumption, investment, public expenditure and net exports using constant prices.

Databases and Calibration

The main data used in this paper are those contained in the Social Accounting Matrix (SAM hereafter) of Andalusia 1995 (see Cardenete and Sancho, 2003a, for the technical details about the construction of this matrix), which is the more recent available one. The SAM comprises 40 accounts, including 25 productive sectors as shown in Table 1, two inputs (labour and capital), a saving/investment account, a government account, direct taxes (*IT* and *ESS*) and indirect taxes (*VAT*, payroll tax, output tax and tariffs), a foreign sector and a representative consumer.

The numerical values for the parameters in the model are obtained by the usual procedure of calibration (see, for example, Mansur and Whalley, 1984). Specifically, the following parameters are calibrated: all the technical coefficients of the production functions, all the tax rates and the coefficients of the utility function. The calibration criterion is that of reproducing the 1995 SAM as an initial equilibrium for the economy, which is used as a benchmark for all the simulations. In such an equilibrium, all the prices and the activity levels are set equal to one, so that, after the simulation, it is possible to observe directly the change rate of relative prices and activity levels. When finding the economic equilibrium corresponding to the policy combinations obtained from the optimisation exercises, the interest rate is taken as numeraire and the rest of prices are allowed to vary as required to meet equilibrium conditions.

Policy variables

We focus on fiscal policy. The vector of policy variables (**x**) includes the public expenditure in goods and services of each activity sector (g_j, $i=1,\ldots,25$) and the average tax rates applied to every economic sector, including indirect taxes: Social Security contributions paid by employers (EC_j) and Value Added Tax (VAT_j), as well as direct taxes: Social Security contributions paid by employees (W_j) and Income Tax (TD). Concerning the feasible set for these policy variables we impose the following constraints to increase the realism of the exercise:

a) We take as a benchmark the values of public expenditure and tax rates observed in the SAM and obtained in the calibration procedure. We restrict all the policy variables to vary less than five percent with respect to their values in the benchmark situation (denoted as $\mathbf{x_0}$), that is the following constraints are imposed to the model:

$$0.95\ \mathbf{x_0} \leq \mathbf{x} \leq 1.05\ \mathbf{x_0}$$

b) Furthermore, to avoid obtaining policies that could affect drastically the public budget, we impose the condition that both the overall tax revenue and the overall public expenditure in goods and services must be equal to their values in the benchmark situation, although the composition by sectors may change[6].

[6] For the tax revenue, we impose that the condition that it must be constant in current value terms. Nevertheless, for the total public expenditure, we found more natural to

4. RESULTS: SOLVING MULTICRITERIA POLICY MAKING PROBLEMS[7]

For the policy making problem to be fully described, we need to select the policy objectives. In this next section we address several specific problems by selecting different sets of policy objectives. We analyze two problems with two objectives and one problem with five objectives.

Bicriteria Problem 1: Unemployment vs. Inflation

Assume, first, that the policy maker only cares about two economic indicators: the unemployment rate (u) and the inflation rate, as measured by the annual rate of change of the *cpi*:

$$\pi = \frac{cpi_{1995} - cpi_{1994}}{cpi_{1994}} \cdot 100$$

where the subscript denotes the year. The value of *cpi* for 1994 is exogenously given[8] and the value for 1995 is endogenously determined, as an equilibrium result, in the optimisation exercise.

The equilibrium of the model gives, as a result, the unemployment rate u and the inflation rate π as (implicit) functions of the policy variables x, that is, we have $u = u(x)$ and $\pi = \pi(x)$. Once we have identified the policy objectives, the (multicriteria) policy making problem is fully described. The first step to address this problem is to asses the degree of conflict between the policy objectives by computing the so-called payoff matrix. This is done by solving two mono-criteria problems which consists of

impose that it must be constant in real terms, since the public sectors is usually obliged to make some expenditures independently of their monetary costs.

[7] All the calculations are made using GAMS software, with solve CONOP.

[8] Source: IEA, Regional (Andalusia) Statistical Institute.

optimising each objective separately disregarding the other one: firstly, we find the minimum feasible value of unemployment (subject to the specified constraints on the policy variables and all the equations of the model). This minimum value is refereed to as *ideal* value of unemployment and denoted as u^*. By plugging the optimal values of the policy variables $x_u = arg\ max\ u$ in the relevant equations of the model, we obtain an associated value of inflation. Both of these values conform the first row of the pay-off (Table 2). In the same way we obtain the ideal (= minimum) value of inflation, π^* and an associated value of unemployment. The worst (= maximum) value of each column is the anti-ideal (or nadir) value for the associated objective: u_* and π_*, which correspond to the achievement of each objective, when the other one is optimised.

INSERT TABLE 2 HERE

The first row of Table 2 shows that it would be possible to obtain an unemployment rate u^*=33.1%, together with a high inflation rate π_*=3.6%. Similarly, (as the result of an opposite policy) the second row shows another feasible combination with a low inflation rate (indeed, a deflation) π^*=-0.1 % compatible with a higher unemployment rate u_*=34.5%. The values in the main diagonal (the minimum unemployment rate and the minimum inflation rate) give the *ideal point* and the vector with the worst element of each row (in this case, the maximum unemployment rate and the maximum inflation rate) gives the *anti-ideal* or *nadir point*.

From Table 2 we can draw the following conclusions: first, there is a clear conflict between both objectives, in the sense that it is not possible to get at the same time the minimum feasible unemployment and the minimum inflation rate, since minimizing unemployment implies accepting a higher degree of inflation and the other way round. This conflict is an essential element to have a genuine multicriteria (in this case, bicriteria) problem. The second observation is that, whereas inflation displays a rather wide range of variation, the unemployment in Andalusia, (at least in the period under analysis) seems to show a low degree of sensitivity with respect to any macroeconomic policy, since the range of variation of u is very small. This result is coherent with other existing studies for Andalusia in the literature (see, for example, Cardenete and Sancho, 2003b).

The second step is to determine the efficient set of policies. In this case, a policy combination x providing the objective values (u, π) is said to be efficient if there is not another feasible policy x' providing (u', π') such that, either $u' \leq u$ and $\pi' < \pi$, or $u' < u$ and $\pi' \leq \pi$. We obtain (an approximation to) the efficient set using the so-called *constraint method*, which consists of optimising one of the objectives, while the other one is placed as a parametric constraint. In our case, we make a grid for the feasible values of π, from π= -0.1 to π=3.6. Let π_n denote one specific value of π in the grid. For each one of these values we solve the problem *min u* subject to the constraint $\pi \leq \pi_n$ and all the equations in the model (it is arbitrary to decide which objective is parameterized and which is optimized in every point).

Figure 1 shows the result of these calculations. It can be seen that, in the set of efficient policies, there is a monotonic relationship between unemployment and inflation but the trade-off between both rates, as measured by the slope of the frontier, is not necessarily constant. Note that the resulting curve can be interpreted as the classical (short-run) “Philips curve”, initially reported by Phillips (1958), which trade-offs employment against inflation and was initially interpreted as a “policy menu” in the sense that the government, by applying expansive or contractive policies, could choose among different combinations of inflation and unemployment (Samuelson and Solow 1960).

INSERT FIGURE 1

Three important remarks apply to the so-obtained Phillips curve as compared with some traditional practices in the literature: first, it is important to note that the curve shown in Figure 1 is not exogenously imposed but endogenously obtained from the model as an equilibrium result. Secondly, the classical approach in the empirical literature is to look for a Phillips curve by plotting together pair-wise observations of unemployment and inflation for different years and perhaps adjusting some statistical regression (Phillips 1958, Lipsey 1960, Samuelson and Solow 1960). Since the dots in these graphs corresponds to different years, some structural elements of the economy may change across years so that these results can not be clearly interpreted as a policy trade-off, since it may not be possible to move from one unemployment-inflation combination to another one just by changing the economic policy. The Phillips-like curve shown in Figure 1 is obtained under different policy scenarios for a given economy in the same period of time, so that the underlying fundamentals are constant. In this sense, this curve can be more properly interpreted as a pure policy trade-off. Finally, a subtle remark for his curve should be made when it is to be interpreted as a Phillips curve: since the government can, in principle implement a wide variety of policy combinations, it is also possible that some of these policies result in unemployment-inflation combinations strictly above (and to the right of) the curve in Figure 2, meaning that the implemented policy is not efficient. From this point of view, the curve obtained in Figure 2 can be labeled as "optimal Phillips curve" or "efficient Phillips curve" in the sense that all the points result from efficient policies.

Bicriteria problem 2: growth vs. unemployment

Assume now the policy makers care just about unemployment and economic growth, as measured by the annual rate of change of the *GDP*:

$$\gamma = \frac{GDP_{1995} - GDP_{1994}}{GDP_{1994}} \cdot 100$$

where the data for 1994 is exogenously given. When optimising each objective separately, we get a new payoff matrix which is shown in Table 2. It can be seen that in this case, both mono-criteria problems have exactly the same solution, meaning that the same kind of policies aimed at increasing growth also help to reduce unemployment. It is interesting to compare this case with the one in the previous problem: since there is no conflict between the objectives, we come up with the result that this is basically not a true multicriteria problem, since it collapses to a single mono-criteria one (either maximising growth or minimising unemployment will give the same solution). The ideal point of the problem is given by any of the rows of Table 3: $\gamma^{*}=3.4$, $u^{*}=33.1$. Since any movement from this point will imply reducing growth and/or increasing unemployment we conclude that this is the only efficient combination.

INSERT TABLE 3

Nevertheless, it is interesting to use the same method applied before to construct efficient policies. Using this approach, we come up with a "frontier" of feasible growth-unemployment combinations by doing the following steps: First, find the minimum value of growth (by solving the associated minimisation problem), which turns out to be γ=2.1. Second, make a partition in the range for the feasible growth values: [2.1, 3.4]. Third, solve a number of problems of the type *min u subject to* $\gamma \geq \gamma_n$, where γ_n refers to every specific value in the partition. The result of this exercise is illustrated in Figure 2.

INSERT FIGURE 2

Note that the interpretation of this figure is crucially different to the one given for Figure 1. In this case, the curve can not be interpreted as a set of efficient combinations since only one of them is efficient. Rather it can be taken as an estimation of the relationship between growth and unemployment in the same fashion as predicted by the classical Okun law (Okun, 1962). By comparing the minimum and maximum values for growth and unemployment, we observe that growth has a feasible range equal to 3.4 – 2.1 = 1.3 and unemployment has a range 34.7 – 33.1 = 1.6. Dividing the second amount by the first one, we obtain that, on average, an additional percentage point of growth seems to imply a reduction of 1.2 points in unemployment. Once again, it should be remarked that this is a particular type of Okun law: it does not attempt to capture the effect on unemployment when output grows across years, but it is obtained as the different feasible growth-unemployment combinations that can be obtained for a given economy in a given period of time across different policy combinations.

Policies with More than Two Criteria

In order to enlarge the scope of the discussion made so far, we consider now the possibility that the government is concerned about a larger number of criteria. To illustrate the way to deal with this kind of settings, we show, as an illustration, a problem in which the government is concerned about five objectives: the first three of them are those discussed above: growth, inflation and unemployment. We also include as an objective minimizing Public Deficit (*PD*) which is an important political concern in practice in many countries and regions. Finally, since the policy makers are supposed to aim at increasing social welfare, we include as an objective (the maximization of) Compensating Variation (*CV*) which is a conventional welfare measure in monetary terms (see, for example, Mass-Colell et al. 1995, p. 82). We arbitrarily set as zero the *CV* in the observed situation, in such a way that $CV > 0$ (<0) means that, after implementing the analyzed policy combination, the consumers are better off (worse off) than before implementing it. Summing up, we have two “more is better” objectives (which must be maximised): growth and compensating variation, and three “less is better” objectives (to be maximised): unemployment, public deficit and inflation.

By solving five mono-criteria problems, we get the pay-off matrix for this policy problem, which is shown in Table 3. As in the previous exercises, the values in the main diagonal, which are displayed with bold characters, conform de ideal point, whereas the worst value for each column (displayed underlined) conform the anti-ideal point. A visual inspection of the matrix show that we have the following conflicts among objectives: as discussed above, growth and unemployment have a joint behaviour in the sense that there is no conflict between them, but both of them strongly conflict with inflation and public deficit. Public deficit, in turn, behaves almost exactly the same as inflation. The reason for this is the particular way in which the policy exercises are designed: public deficit is measured in nominal terms (current monetary units) so that its value can vary, on the one hand, because of real shifts in public income or expenditure, and on the other hand, because of changes in prices. As documented in the previous section (see footnote 4), the policy exercises are constrained to give the same (nominal) value for public income, whereas public expenditure is restricted to be constant in real terms. Given these constraints, the only way to reduce (nominal) public deficit is to reduce prices, so that the nominal value of public expenditure will decrease (while the nominal value of public income is fixed). Finally, the compensating variation seems to display a moderate degree of conflict with growth and unemployment and a strong degree of conflict with inflation and public deficit[9].

We illustrate now two alternative ways to obtain efficient policies: the previously used *constraint method* and the *weighting method*. To apply the **constraint method**, we need to optimise one single objective while keeping the rest as parametric constraints. The way to fix these constraints depends on the specific problem. To illustrate the technique, we force all objectives except the one being optimized to have an equal or better value than that in the observed situation. The observed values (taken from the databases reported in section 3) are the following:

(4) $\gamma = 2.79 \qquad \pi = 4.4 \qquad u = 33.9 \qquad PD = 110800.7 \qquad \mathrm{CV} = 0$

where PD and CV are measured in 10^6 euros. Thus, the first candidate point is obtained by solving the following problem:

(5)
$$\begin{aligned} &Max\ \gamma \\ \text{subject to}\quad &\pi \le 4.4,\ u \le 33.9,\ PD \le 110800.7,\ CV \ge 0 \\ &\textit{all the equations of the model} \end{aligned}$$

[9] Given the joint behavior of some objectives, an operational way to deal with this problem could be to group them so that we end up with a problem with less than five objectives. Nevertheless, for illustrative purposes, we find useful to keep all five objectives in the analysis.

The solution of problem (5) is given by

$\gamma = 3.4$ $\pi = 3.6$ $u = 33.1$ $PD = 108605,4$ CV = 2243.5

Note that this combination Pareto-dominates the observed situation (4), since not only the growth rate is larger than the observed one, but also the CV is larger and inflation, unemployment and public deficit are lower. So, we conclude that, according to our setting, the observed policy displays some degree of inefficiency and it could be unambiguously improved with respect to the five objectives considered here.

By doing similar calculations for each objective, we obtain five points which are displayed in the rows of Table 5. Note that some rows of this matrix are the same as those in Table 4. Specifically, the solution for growth, unemployment and the compensating variation are the same as in the respective mono-criteria problems. The reason is simply that the constraints imposed are not binding since the unconstrained optima shown in Table 4 dominate the observed situation for all the objectives. Nevertheless, the situation is different for inflation and public deficit, since the unconstrained optimal values (those in Table 4) violate the constraints for growth and unemployment. This makes the constrained optima being different from the unconstrained ones. Nevertheless, observe that, in the optimal solution found, some constraints are unbinding.

A sufficient condition for the constraint method to provide efficient solutions is that the parametric constraints are binding. This means that we can not be sure that the solutions found up to now are efficient, although any of them Pareto-dominates the observed situation. At this point, to find solutions that are efficient for sure, we have two possibilities: the first one is using still the *constraint method* and making the parametric constraints tougher, by increasing the value of the “more is better objectives” (growth and CV) and/or decreasing the value of the “less is better” objectives (inflation, unemployment and public deficit) until we find a solution when all of them are binding at the same time.

The second approach is to use the **weighting method**. This method consists of maximizing the following sum of normalized value of objectives:

$$\text{(6)} \qquad \omega_{\gamma}\frac{\gamma-\gamma_*}{\gamma^*-\gamma_*}+\omega_{\pi}\frac{\pi-\pi_*}{\pi^*-\pi_*}+\omega_{\mathrm{u}}\frac{\mathrm{u}-\mathrm{u}_*}{\mathrm{u}^*-\mathrm{u}_*}+\omega_{\mathrm{DP}}\frac{\mathrm{DP}-\mathrm{DP}_*}{\mathrm{DP}^*-\mathrm{DP}_*}+\omega_{\mathrm{CV}}\frac{\mathrm{CV}-\mathrm{CV}_*}{\mathrm{CV}^*-\mathrm{CV}_*}$$

where each objective is normalized by subtracting the anti-ideal value and dividing by the difference between the ideal and the anti-ideal value (both of them being given in Table 4), so that the resulting quotient is bounded by construction between zero (when the objective is equal to the anti-ideal) and one (when it is equal to the ideal)[10]. This normalization eliminates units of measurement and allows the addition having mathematical and economic sense. The coefficients ω_i are preference parameters representing how concerned the policy maker is about each objective *i*. We illustrate the policy combination obtained with $\omega_\gamma = \omega_\pi = \omega_u = \omega_{PD} = \omega_{CV} = 1$, meaning that the policy maker is equally concerned about all the objectives. The maximization of (6) with this set of weights gives the following solution:

$$\gamma = 3.4 \qquad \pi = 3.5 \qquad u = 33.1 \qquad PD = 109131.1 \qquad CV = 2643.1$$

which Pareto-dominates the observed situation (4) and provides an alternative efficient policy combination. By testing different combinations of weights we obtain different efficient solutions which may respond to different preference configurations of the policy maker. As an extreme case, if we fix ω_i=1 for a specific objective and ω_j=1 for the rest, meaning that the policy maker is concerned only about objective *i*, we would get the i-th row of the pay-off matrix

5. DISCUSSION AND CONCLUDING REMARKS

[10] Note that, for the "more is better" ("less is better") objectives, i.e., γ and *CV* (π, *u* and *PD*), the denominator is positive (negative), so that the function depends positively (negatively) on the value of the objective.

Model policy making can be suitably represented as a multicriteria problem for a double reason. Firstly, from a conceptual perspective, it seems a sensible way to understand and represent the concerns and the procedures actually followed by policy makers. Secondly, from an empirical perspective, MCDM techniques can be of considerable help to get operative policy recommendations and, therefore, to decide how to use policy instruments in practice.

A CGE model properly calibrated for the Andalusian economy allows us to solve some policy making problems with different properties: Firstly, when addressing unemployment and inflation as policy objectives, we obtain a set of efficient policies that can be interpreted as a particular version of the classical Phillips curve which we can label *optimal Phillips curve* or *efficient Phillips curve*. Secondly, when considering growth and unemployment as policy objectives, we arrive at the conclusion that this combination collapses to a mono-criteria one and there is a single efficient policy combination. By applying the same technique used to obtain efficient policies, we get a set of feasible growth-unemployment combinations from which a particular type of Okun law can be obtained.

Enlarging the number of objectives makes the problem computationally more demanding but also more interesting and realistic. By including five policy objectives we have shown that the observed policy could have been unambiguously improved in a number of ways depending on the weight given by the policymaker to each objective.

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TABLE 1: Productive Sectors in SAM

1. Agriculture	14. Vehicles
2. Cattle and Forestry	15. Transport
3. Fishing	16. Food
4. Extractives	17. Manufacturing of Textil and Leather
5. Refine	18.Manufacturing of Wood
6. Electricity	19. Other Manufactures
7. Gas	20. Construction
8. Water	21. Commerce
9. Minery	22.Transport y Communications
10. Manufacturing of Construction Material	23. Other Services
11. Chemicals	24.Sales Services
12. Manufacturing of Metal Products	25.Non Sales Services
13. Machinery	

Source: Cardenete and Sancho (2003a).

TABLE 2: Pay-off matrix unemployment vs. inflation

	u *Unemployment* (%)	**π *Inflation* (%)**
Min u	**33.1**	3.6
Min π	34.5	**-0.1**

Source: own elaboration.

TABLE 3: Pay-off matrix growth against Unemployment

	γ *growth* (%)	**u *Unemployment* (%)**
Max γ	3.4	33.1
Min u	3.4	33.1

Source: own elaboration.

TABLE 4: Pay-off matrix of the problem with five objectives

	γ (%)	**π (%)**	***u* (%)**	***PD* (*10[6] euros*)**	***CV* (*10[6] euros*)**
Max γ	**3.4**	3.6	33.1	108605.4	2243.5
Min π	2.4	**-0.1**	<u>34.5</u>	100586.1	-7642.7
Min u	3.4	3.6	**33.1**	108547.7	2177.4
Min PD	<u>2.3</u>	-0.1	<u>34.5</u>	**100564.5**	<u>-7903.9</u>
Max CV	3.2	<u>3.9</u>	33.4	<u>110723.8</u>	**3049.0**

Source: own elaboration.

TABLE 5: Using the constraint method with respect to the observed situation					
	γ (%)	**π (%)**	***u* (%)**	***PD*** ***(10^6 euros)***	***CV*** ***(10^6 euros)***
Max γ	3.4	3.6	33.1	108605.4	2243.5
Min π	3.2	1.7	33.4	105427.3	0.0
Min u	3.4	3.6	33.1	108547.7	2177.4
Min PD	3.2	1.7	33.4	105401.9	0.0
Max CV	3.2	3.9	33.4	110723.8	3049.0
Source: own elaboration.					

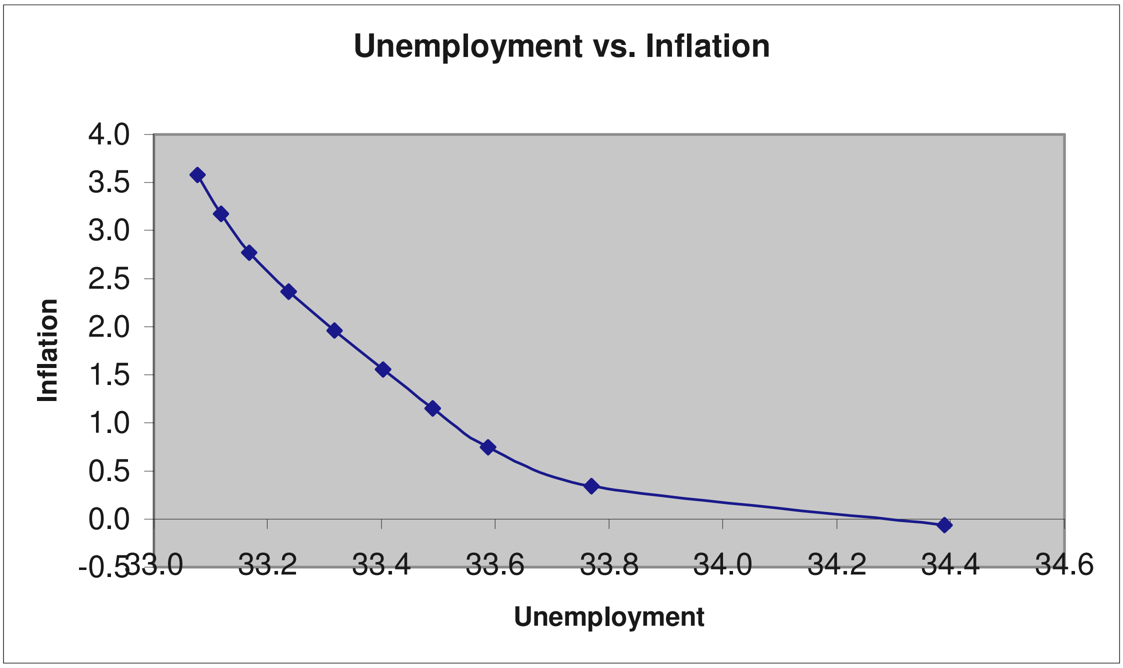

FIGURE 1: Trade-off between unemployment and Inflation

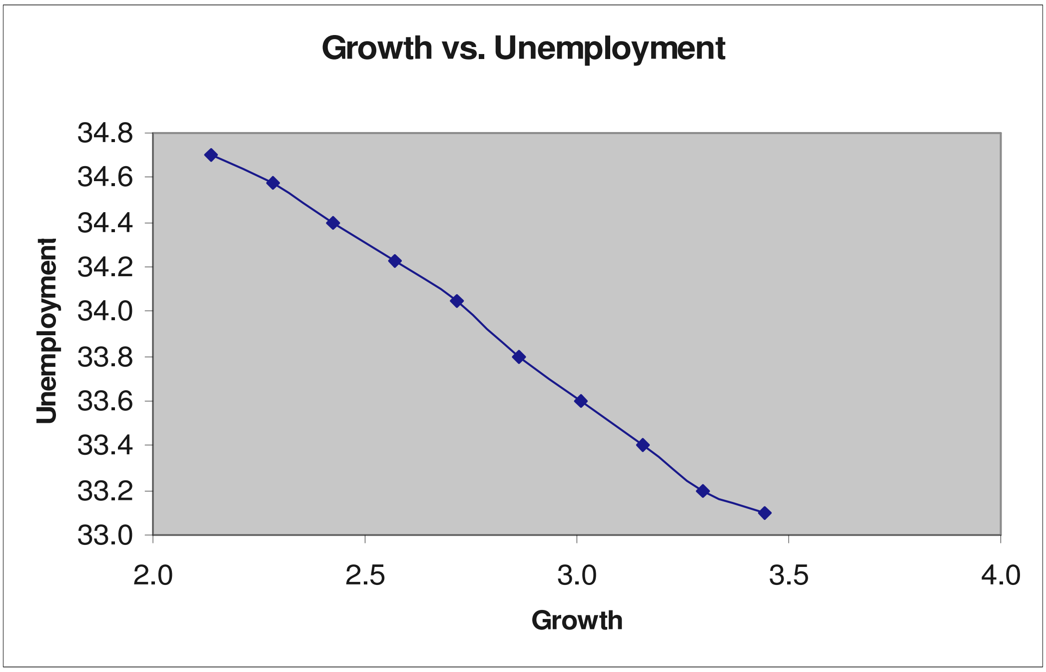

FIGURE 2: Relationship between unemployment and growth