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Using compromise programming for macroeconomic policy making in a general equilibrium framework: theory and application to the Spanish economy

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This paper aims to show how Compromise Programming, linked with some results connecting this approach with classic utility optimization, can become a useful analytical tool for designing and assessing macroeconomic policies. The functioning of the method is illustrated through an application to the Spanish economy. In this way, starting from a Computable General Equilibrium Model, a frontier of growth–inflation combinations is determined. After that, several Pareto-efficient policies that represent compromises between economic growth and inflation rate are established and interpreted in economic terms.

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Introduction

A usual exercise in economics, both from a theoretical and an empirical point of view, is that of designing an optimal macroeconomic policy. This exercise is typically modelled as an optimization problem aimed at minimizing some social loss function or maximizing some welfare function, subject to meeting some constraints that define the set of feasible policies (See Ramsey (1927) for a pioneering work).

It can be argued that, in practice, it is difficult to identify a single objective for policy making, but the government is typically concerned about a set of macroeconomic indicators (growth rate, inflation rate, unemployment rate, public deficit, public debt, foreign deficit, etc) and it tries to design policies to improve the performance of the economy as measured by these indicators. Moreover, policy 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. This situation naturally fits in the structure of multiple criteria decision making (MCDM), so that the use of MCDM techniques can be potentially useful to deal with macroeconomic policy-making problems.

André and Cardenete (2005) proposed to model macroeconomic policy making as a multi-criteria problem using a computable general equilibrium (CGE) model. CGE models have been used extensively since the 1980s for the evaluation of public policies and other comparative static exercises both in developed and developing countries. CGE modelling is especially attractive for policy makers because, being consistent with standard economic theory, it allows to measure the effects of a specific decision (typically, a given policy) on the most significant economic variables, such as prices, production levels, tax revenues or income distribution. See a recent revision of this approach in Kehoe *et al* (2006).

In André and Cardenete (2005), a CGE model is combined with a multi-objective programming approach, which allows identifying the set of efficient policies. This is a relevant outcome because a rational policy maker should not select any inefficient policy combination. Nevertheless, the number of efficient policies could be very large, so that it can be convenient to apply some more selective technique in order to reduce the number of eligible policies and get more precise policy recommendations. In this paper, we propose to use compromise programming (CP) in order to identify a smaller set of rational macroeconomic policies. CP was introduced by Yu (1973) and Zeleny (1973, 1974) in the operations research and management science (OR/MS) literature. CP starts by defining the ideal point as a vector whose components are given by the optimum values of the objectives considered. Given the usual conflict among objectives, the ideal point is infeasible, so the 'most suitable' or 'best compromise' solution is defined as the Pareto-efficient solution closest to the ideal point. Depending on the topological metric used, a 'compromise set' is established as the 'most suitable set of solutions'. Some recent applications of CP to economic problems can be found in Ballestero *et al* (2003) and Pérez-Gladish *et al* (2006).

Zeleny and Cochrane (1973) proposed to use the above outlined CP approach to address macroeconomic policy-making

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problems. Their proposal was not very successful in economics, perhaps because of the lack of connection between CP and the traditional utility maximization approaches used in economics. However, some more recent works have tried to approximate the classic utility maximization and CP. Thus, Ballestero and Romero (1991, 1994) show that, under reasonable empirical conditions on the utility function, the compromise set can be interpreted as the piece of the efficient set where the utility function is maximized. By transferring these results to a macroeconomic policy-making scenario, the compromise set can be interpreted as a closed interval where the social preferences are likely to be maximized. Moreover, following Romero (2001), each point of the compromise set can be interpreted as a combination between optimum *policy effectiveness* (ie maximum aggregated achievement of the different macroeconomic objectives) and optimum *policy equity* (ie maximum balance among the achievement of the different macroeconomic objectives).

Summing up, the objectives of this paper are twofold: first, from a methodological point of view, we show how CP can be applied, in connection with a general equilibrium model, to design and assess macroeconomic policies. Second, we apply the proposed methodology to a macroeconomic policy-making problem in Spain, in order to get a specific compromise set and evaluate the observed policy as compared to this compromise set.

The remainder has the following structure: in the next section, we outline the representation of policy making as a multi-criteria decision problem. Next, we present an application to the Spanish economy by using a CGE model. We discuss the main features of the model as well as the database used for the calibration and we set up the policy problem to be solved. For the sake of simplicity, we focus on a bi-criteria problem (real growth *vs*. inflation) so that we can show a clear illustration of the methodology proposed. Then, a very general CP model is applied to the Spanish macroeconomic scenario presented. Thus, a Pareto-efficient set between real economic growth and inflation rate is determined. After that, different 'compromise sets' are defined and interpreted in economic terms. In this way, several suitable macroeconomic policies are derived from the CP model. In the last section, the main conclusions obtained are presented.

Basic setting: macroeconomic policy making as a multi-criteria problem

Assume there are m rational agents (consumers and firms) in the economy and each agent h ($h = 1, \ldots, m$) has a vector, denoted as z_h, of decision variables. Agent h decides the value of z_h to

$$\begin{aligned} &\text{maximize} \quad f_h(z_h, z_{-h}, x) \\ &\text{subject to} \quad z_h \in R_h \end{aligned} \tag{1}$$

where R_h is the feasible set of agent h and the objective function of agent h, f_h, may depend on his own decisions represented by vector z_h, the decisions (denoted as z_{-h}) of the rest of agents, and the policy variables denoted as x (which may include different taxes, public expenditure and investment, interest rates, and so on).

Let $\mathbf{z}_h(z_{-h}, x)$ denote the optimal response of agent h, that is the value of his decision variables maximizing f_h, given the value of z_{-h} and x. The interaction among agents provides the *equilibrium* value of all the decision variables for all the agents, denoted as $z^*(x) \equiv (z_1^*(x), \ldots, z_m^*(x))$ in such a way that $z_h^*(x) \in \mathbf{z}_h(z_{-h}^*, x)$ for all $h = 1, \ldots, m$.

After aggregation of z^*, we get the value of the relevant macroeconomic variables in equilibrium which are the typical policy objectives (eg 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 in K macroeconomic aggregates denoted as $Z_1, \ldots, Z_K$, which can be obtained from z^* according to some aggregation rules:

$$\begin{aligned} Z_1 &\equiv Z_1(z^*(x)) \\ &\cdots \\ Z_K &\equiv Z_K(z^*(x)) \end{aligned} \tag{2}$$

If a planner knows the response functions of all the agents, using (2) he can predict the equilibrium of the economy and the policy objectives as a function of x. Since these goals typically conflict with each other, (2) defines a multi-criteria problem. In the fourth section, we illustrate how this problem can be managed by using the CP approach commented in the preceding section. As a first step, we need a structural model to represent the economy under study, see André and Cardenete (2005) for a brief discussion about the need to use a structural, rather than reduced, model. In our case, for illustrative purposes we use a CGE model calibrated for the Spanish economy that is summarized in the next section.

An application for the Spanish economy

The economic model

We use 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 disaggregated 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 maximize their utility and firms maximize their profits (net of taxes), then the CGE model 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.

Table 1 Productive sectors in SAM

No	*Name*
1	Agriculture, cattle, forestry and fishing
2	Extractives
3	Energy and Water
4	Food
5	Chemicals
6	Machinery and transport
7	Manufactures
8	Construction
9	Services

Source: Cardenete and Sancho (2004)

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 (2003) or André *et al* (2005).

The CGE model used in the exercise comprises nine productive sectors (in order to match the aggregated version of the Social Accounting Matrix. See below an explanation about this matrix and 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.

There are nine 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 production technology is described by a rather standard nested production function: the domestic output of sector j $(j = 1, \ldots, 9)$, measured in euros and denoted by Xd_j, is obtained by combining, through a Leontief technology, that is, a fixed coefficient combinations of outputs from the rest of sectors and the value added VA_j:

$$Xd_j = \min\left\{\frac{X_{1j}}{a_{1j}}, \ldots, \frac{X_{9j}}{a_{9j}}, \frac{VA_j}{v_j}\right\} \tag{3}$$

where a_{ij} $(i = 1, \ldots, 9)$ and v_j are fixed technical coefficients. Value added, in turn, is generated from primary inputs (labour, L, and capital, K), combined by the following Cobb–Douglas technology:

$$VA_j = \mu_j L_j^{\gamma_j} K_j^{1-\gamma_j} \tag{4}$$

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:

$$Q_j = \phi_j(Xd_j^{\sigma_j}, Xrow_j^{1-\sigma_j}) \tag{5}$$

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 $j = 1, \ldots, 9$. PD denotes the final balance (surplus or deficit) of the public budget:

$$PD = R - TPS\ cpi - \sum_{j=1}^{9} GD_j p_j \tag{6}$$

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:

$$\begin{aligned} YD = {} & wL + rK + cpi\ TPS + TROW \\ & - DT(rK + cpi\ TPS + TROW) \\ & - DT(wL - WC\ wL) - WC\ wL \end{aligned} \tag{7}$$

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 maximize his utility (welfare), subject to his budget constraint. Welfare is obtained from consumption goods CD_j $(j = 1, \ldots, 9)$ and savings *SD*, according to a Cobb–Douglas utility function, which leads to the following optimization problem:

$$\begin{aligned} &\text{maximize } U(CD_1, \ldots, CD_9, SD) = \left(\prod_{j=1}^{9} CD_j^{\alpha_j}\right) SD^{\beta} \\ &\text{subject to } \sum_{j=1}^{9} p_j CD_j + p_{\text{inv}} SD = YD \end{aligned} \tag{8}$$

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*:

$$\sum_{j=1}^{9} INV_j p_{\text{inv}} = SD p_{\text{inv}} + PD + ROWD \tag{9}$$

Labour and capital demands are computed under the assumption that firms minimize 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):

$$\frac{w}{cpi} = \left(\frac{1-u}{1-\overline{u}}\right)^{\frac{1}{\beta}} \tag{10}$$

where u and $\overline{u}$ 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: $\beta = 1.25$ (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 come from the aggregated 1995 social accounting matrix for Spain (SAM hereafter, see Cardenete and Sancho, 2006 for the technical details about the construction of this matrix). A SAM is a square matrix—based on the Input–Output table— that captures the relations of production and income distribution among the productive factors, the consumers and all the economic institutions, and therefore, represents the circular flow of income. As explained below, this matrix is essential for the calibration of the model. Currently, the 1995 SAM is the more recent one that is officially available and henceforth the only one we can use for our study. The SAM used in this work comprises 21 accounts, including nine productive sectors as shown in Table 1 (A more disaggregate version is available but we decided to stick to this simpler version since we do not attempt to capture any distributional impact but to focus on aggregate effects), 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, eg Mansur and Whalley, 1984). Specifically, the following parameters are calibrated: all the technical coefficients of the production functions, all the (average) 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 optimization exercises, the wage is taken as numeraire ($w = 1$) and the rest of prices are allowed to vary as required to meet equilibrium conditions.

Policy variables, policy objectives and efficient policies

We focus on fiscal policy and we take as policy variables (x) the public expenditure in each activity sector (g_j) and the average tax rates applied to every economic sector, including indirect taxes: Social Security contributions paid by employers (EC_j), Tariffs (T_j), Value Added Tax (VAT_j); and 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 3% with respect to their values in the benchmark situation (denoted as x_0), that is the following constraints are imposed to the model:

$$0.97\ x_0 \leqslant x \leqslant 1.03\ x_0$$

(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 must be equal to their values in the benchmark situation.

For the sake of simplicity, we stick to a bi-criteria setting (K=2) assuming that the government only cares about economic growth and inflation. This allows us to get clear-cut results, which are easy to interpret and to illustrate graphically. A larger number of objectives could be handled in a similar way (of course, at the cost of a higher computational burden). Economic growth is calculated by the annual rate of change of real *GDP* and the inflation rate is measured by the annual rate of change of the *cpi*:

$$\gamma = \frac{GDP_{1995} - GDP_{1994}}{GDP_{1994}} \times 100$$
$$\pi = \frac{cpi_{1995} - cpi_{1994}}{cpi_{1994}} \times 100 \qquad (11)$$

where the subscript denotes the year. The values of *GDP* and *cpi* for 1994 are exogenously given and the values for 1995 are equilibrium values endogenously determined in the optimization exercise.

Results

Pay-off matrix and Pareto-efficient frontier

The equilibrium of the model gives, as a result, the economic growth γ and the inflation rate π as (implicit) functions of the policy variables x; that is, we have $\gamma = \gamma(x)$ and $\pi = \pi(x)$. As a first step in our search for an optimum policy (ie optimum mix real growth–inflation rate) for the Spanish economy, let us introduce the ideal values γ^* and π^* for economic growth and inflation rate, respectively. The former represents the maximum feasible value for economic growth while the latter represents the minimum value for the inflation rate. In the same way, the anti-ideal (or nadir) values γ^* and π^* are introduced. These values represent the achievement of each macroeconomic objective, when the other one has been

Table 2 Pay-off matrix for the two criteria considered

	Growth (%) γ	*Inflation (%)* π
Growth (%) γ	**3.07**	3.77
Inflation (%) π	2.38	**2.36**

Bold figures denote ideal values and underlined figures anti-ideal values

optimized. These ideal and anti-ideal values conform the pay-off matrix shown in Table 2.

In our exercise the first row of the pay-off matrix shows the values of growth and inflation obtained from the growth maximization exercise and the second row the values of the same variables obtained when minimizing inflation, so that the conflict between both objectives can be noticed. Thus, it would be possible to obtain a high growth rate $\gamma^* = 3.07\%$ compatible with a high inflation rate $\pi^* = 3.77\%$. Similarly, as an opposite policy, it would be possible to obtain a low inflation rate $\pi^*=2.36\%$ compatible with a growth rate of only $\gamma^* = 2.38\%$. The values in the main diagonal (the maximum growth rate and the minimum inflation rate) give the *ideal point* and the vector with the worst element of each row (in this case, the minimum growth rate and the maximum inflation rate) gives the *anti-ideal* or *nadir point*. These values serve as anchor to measure the distance from any feasible combination of policy goals to the ideal point.

Let us now introduce the concept of Pareto-efficient policy. A policy is said to be efficient if there is no other feasible policy that can achieve the same or better performance for all the policy objectives being strictly better for at least one objective. In our case, a policy combination x providing the objective values (γ, π) is efficient if there is not any feasible policy x' providing (γ', π') such that $\gamma' \geqslant \gamma$ and $\pi' < \pi$ or $\gamma' > \gamma$ and $\pi' \leqslant \pi$. Within the context of our exercise, the set of Pareto-efficient points can be interpreted as a kind of 'short-run Philips curve'; that is, a curve that represents a trade-off between employment (linked to economic growth) and inflation. Within a multi-criteria context, this type of Pareto-efficient frontier can be determined by resorting to several generating techniques (see Steuer, 1989). In this exercise, we have resorted to the constraint method. This method proposes to optimize one of the objectives, while the other (or in general the others) is placed as a parametric constraint. Through the parameterization of the right-hand side of the objective(s) placed as a constraint, the efficient set is approximated. By applying this method, the Pareto-efficient frontier shown in Figure 1 was obtained (for more details about this exercise see André and Cardenete, 2005).

Obtaining the compromise set

According to the rationality underlying CP, an efficient alternative is preferred to another one if and only if the first one is closer than the second one to the ideal point. In this way, several solutions (efficient macroeconomic policies in our context) can be obtained for different metrics p, by solving the following optimization problem:

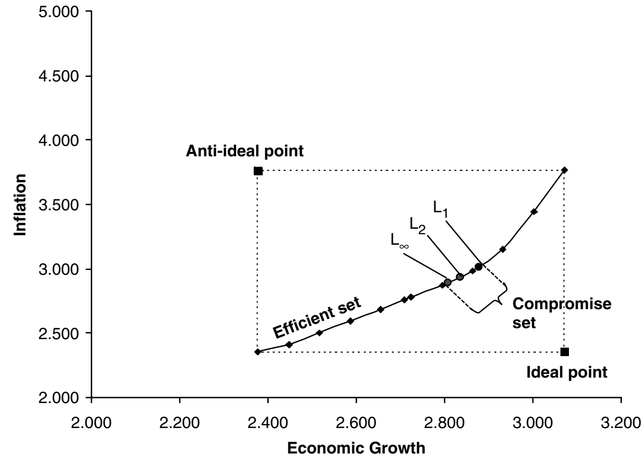

Figure 1 Efficient policies and CP.

Table 3 Best-compromise solutions, for metrics 1,2 and $\propto$

	Growth (%) γ	*Inflation (%)* π
L_1	2.88	3.01
L_2	2.84	2.94
L_∞	2.81	2.89

$$\text{Min } L_p = \left[\left(\frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} \right)^p + \left(\frac{\pi(x) - \pi^*}{\pi_* - \pi^*} \right)^p \right]^{1/p}$$
$$\text{Subject to the constraint set} \tag{12}$$

where we have implicitly assumed that the government is equally concerned about growth and inflation deviating from its ideal value, so that both deviations are equally weighted when computing the distance. At any case preferential weights can be attached to the two criteria considered. By minimizing the distance function L_p, different best compromise policies can be obtained. Figure 1 displays the best-compromise policies for metrics 1, 2 and $\propto$. Table 3 shows the numerical values of these three macroeconomic policies.

Interpreting the compromise set

For bi-criteria cases, the L_p solutions enjoy some properties that are especially relevant within our macroeconomic context. Thus, we have:

(a) Metrics $p = 1$ and $p = \propto$ define a subset on the Pareto-efficient frontier called compromise set, where the other best-compromise solutions (policies) fall (see Yu, 1973). This boundness of the efficient set is very suitable for computational purposes.

(b) The L_1 solution represents the compromise that maximizes the aggregated achievement (or minimizes the aggregated disagreement) of the two criteria considered (economic growth and inflation); that is, L_1 represents the solution of maximum effectiveness. The $L_\propto$ solution represents the compromise that maximizes the balance among the criteria considered. For the bi-criteria case, the degree of achievement is the same for both criteria; that is, $L_\propto$ represents the solution of maximum equity (Ballestero and Romero, 1991, 1998). Thus, for our exercise the following results were obtained:

$$\begin{aligned} L_1 \Rightarrow\ & 0.28(\text{disagreement for growth}) \\ & + 0.46(\text{disagreement for inflation}) \\ & = 0.74(\text{total disagreement}) \end{aligned}$$

$$\begin{aligned} L_\propto \Rightarrow\ & 0.38(\text{disagreement for growth}) \\ & + 0.38(\text{disagreement for inflation}) \\ & = 0.76(\text{total disagreement}) \end{aligned}$$

Thus, the L_1 compromise policy is better from an aggregated point of view, whereas the $L_\propto$compromise policy guarantee the same degree of discrepancy or achievement (perfect balance) for the two macroeconomic objectives considered.

(c) The compromise set is a good surrogate of the utility optimum. To justify this statement, we resort to a theorem (see Ballestero and Romero, 1991), that adapted to our context reads as follows:

With any utility function $u(\gamma, \pi)$, the condition under which the maximum of u over the feasible set always belongs to the compromise set is:

$$MRS(\gamma, \pi) = u_1/u_2 = 1 \text{ on the } L_\propto \text{ path:}$$
$$\frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} = \frac{\pi(x) - \pi^*}{\pi_* - \pi^*} \tag{13}$$

where MRS represents the marginal rate of substitution between economic growth and inflation, and u_1 and u_2 the corresponding partial derivatives. The above condition seems empirically plausible since it simply implies a behaviour coherent with the diminishing MRS law. More details about the economic soundness of the condition can be seen in Ballestero and Romero (1994). Moreover, Morón *et al* (1996) proved the existence of a large family of utility functions holding the above condition, what reinforces the character of the compromise set as a good surrogate of the utility optimum.

(d) The interpretation given to the two bounds L_1 and L_∞ of the compromise set as policies of maximum effectiveness and maximum equity, respectively leads to the idea of joining both solutions through a convex combination that represents a utility or social welfare function (Romero, 2001). Thus, the following utility function for our macroeconomic exercise is obtained:

Table 4 Compromise policies for different values of control parameter λ

	Growth (%) γ	*Inflation (%)* π
$\lambda \in [0\ 0.73)$ $(L_\propto)$	2.81	2.89
$\lambda \in [0.73\ 0.83)$	2.84	2.95
$\lambda \in [0.83\ 0.84)$	2.87	2.99
$\lambda \in [0.84\ 1)$ (L_1)	2.88	3.01

(e)

$$\text{Max } \mathbf{U} = -\left\{(1-\lambda)\text{Max}\left[\frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*}, \frac{\pi(x) - \pi^*}{\pi_* - \pi^*}\right] + \lambda\left[\frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} + \frac{\pi(x) - \pi^*}{\pi_* - \pi^*}\right]\right\}$$

for $\lambda = 1$, we have the L_1 solution and for $\lambda = 0$ the $L_\propto$ solution. For intermediate values of the control parameter λ belonging to the open interval (0,1) compromise policies, if they exist, can be obtained. The above model is not computable; however, it has been proved elsewhere that it is equivalent to the following computational mathematical programming problem (Steuer, 1989, Chapters 14 and 15)

$$\text{Min}(1-\lambda)D + \lambda\left[\frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} + \frac{\pi(x) - \pi^*}{\pi_* - \pi^*}\right] \tag{14}$$

subject to

$$\frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} - D \leqslant 0$$

$$\frac{\pi(x) - \pi^*}{\pi_* - \pi^*} - D \leqslant 0$$

where D is an auxiliary variable introduced in the problem to represent the maximum deviation from the ideal value of each objective.

The application of the above model to our problem leads to the compromise policies displayed in Table 4. For $\lambda = 1$ the solution of maximum aggregated achievement (maximum effectiveness) is obtained. According to reductions in the value of control parameter λ, the equity of the macroeconomic policy is improved in detriment of its effectiveness. 'The most balanced' policy is obtained when the value of control parameter λ is less than 0.73. In short, this procedure allows to determine and to interpret several compromise policies. Moreover, to some extent, it also allows tracing out the whole compromise set.

Reducing the size of the compromise set

Assume the government finds that the compromise set obtained above is still too wide to be useful as a policy guide. In that case, this set can be reduced by including some information in terms of additional constraints in order

Table 5 Pay-off matrix of restricted problem

	Growth (%) γ	*Inflation (%)* π
Growth (%) γ	**3.07**	<u>3.77</u>
Inflation (%) π	<u>2.71</u>	**2.76**

Bold figures denote ideal values and underlined figures anti-ideal values

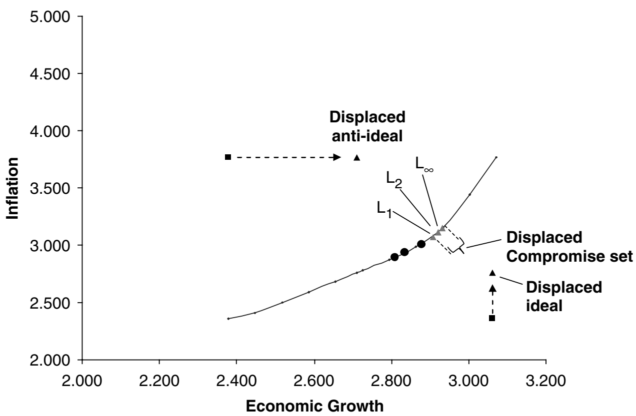

Figure 2 Compromise set and displaced compromise set.

Table 6 Best-compromises policies when the ideal is displaced

	Growth (%) γ	*Inflation (%)* π
L_1	2.91	3.07
L_2	2.92	3.11
L_∞	2.93	3.15

to get the so-called *displaced ideal* point which will be used as an anchor to get a new *displaced compromise* set (see Zeleny, 1974, 1976 for technical details about this method). To illustrate this procedure, assume the government requires that the growth rate be, at least, 2.71% (which is exactly the observed growth rate in Spain in 1995). If we solve the resulting CP problem including the constraint $\gamma \geqslant 2.71$, we obtain the new payoff matrix shown in Table 5. Thus, the new displaced ideal point is given by $\gamma^* = 3.07$ $\pi^* = 2.76$ and the new displaced anti-ideal point is given by $\gamma^* = 2.71$ and $\pi^* = 3.77$. These results, together with the new displaced compromise set, are illustrated in Figure 2 and Table 6.

It can be seen that the new compromise set has moved upwards and rightwards with respect to the original one and its size is smaller. Moreover, if we work with a single decimal precision, the new compromise set reduces to a single point. The uniqueness of the compromise set is very suitable from a policy making point of view; however, its determination has required additional information that in many cases the public decision-maker cannot provide with easiness.

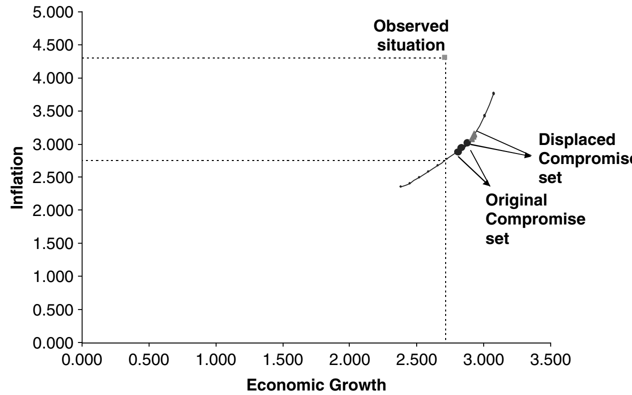

Figure 3 Evaluating the observed situation.

Evaluating the observed policy

Each point of the Pareto frontier (ie every growth–inflation combination) that we have discussed so far is obtained as an equilibrium of the Spanish economy resulting from a given hypothetical policy combination. Similarly, the combination of growth and inflation observed in reality can be interpreted as the result of the policy actually followed by the government, so that we can get some intuition about how the economic policy is being designed in practice.

The real situation of the Spanish economy in 1995, is given by an economic growth of 2.71% and an inflation rate of 4.30%, as represented in Figure 3. At first sight we can make two crucial remarks: first of all, the observed situation is not Pareto–efficient, since the model indicates that the same growth rate (2.71%) could be compatible with a much smaller inflation rate (2.76%); in other words, the observed policy is dominated by several policies placed on the frontier.

Moreover, and perhaps more importantly, the observed situation appears to be very far from the compromise set and the displaced compromise set, so that the Spanish policy do not appear to be easily justifiable according to sensible preferences attached to both growth and inflation. Rather it is seems to be the case that the policy was almost exclusively aimed at maximizing growth disregarding the consequences on inflation. The historical experience seems to corroborate this interpretation. In fact, after the Spanish dictatorship (1936–1975) regime, the situation of underdevelopment with respect to the rest of Europe made growth and development the main priority, causing very high rates of inflation for many years, although it is fair to point out that, apart from the effect of macroeconomic policy, these high rates of inflation are partly due to the effect of the oil crises. This inflationary trend still continues for the early 1990s, as it is illustrated in Figure 4.

Conclusions and further research

This paper is addressed to two types of readers: first, to OR people interested in economics in general and in designing

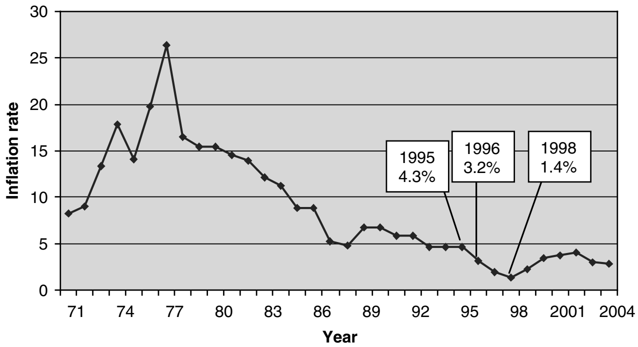

Figure 4 Inflation rate in Spain.

macroeconomic policies in particular. Second, it is addressed to policy makers who may be interested in having some operational tool to design rational macroeconomic policies in practice. Specifically, we have argued that the process of designing optimal policies can be suitably understood as a multi-criteria decision problem from the point of view of the government. The proposed methodology can be a useful device for policy making in order to design sensible macroeconomic policies. Thus, this paper has clearly shown how the joint use of CP, utility optimization and CGE models, makes up a useful theoretical and operational framework for designing and assessing macroeconomic policies. Moreover, the application of this theoretical approach to the Spanish economy has provided useful insights for the understanding and designing of basic macroeconomic policies illustrated the functioning of the methodology.

A useful line of future research will consist in extending the proposed framework to macroeconomic policy problems involving more than two objectives. In fact, it is well known, that for more than three objectives some of the nice properties underlying the CP approach vanish (Yu, 1985, chapter 4). Thus, the boundedness of the compromise set or the utility optimality of the compromise solutions, do not necessarily hold for more than two objectives. In this sense, it seems especially interesting to find conditions, justifiable from an economic perspective, that validate the proposed methodological framework for more general macroeconomic policy problems.

Another potential line of future research has an applied character. Thus, it would be useful to apply the theory developed in this paper, to the assessing of the anti-inflationist policies followed for several countries in different periods of time, in order to elucidate their Pareto-efficient character as well as the potential optimality underlying these policies.

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