

**USING COMPROMISE PROGRAMMING FOR MACROECONOMIC  
POLICY MAKING IN A GENERAL EQUILIBRIUM FRAMEWORK:  
THEORY AND APPLICATION TO THE SPANISH ECONOMY**

**Francisco J. André  
M. Alejandro Cardenete  
Carlos Romero**

De conformidad con la base quinta de la convocatoria del Programa de Estímulo a la Investigación, este trabajo ha sido sometido a evaluación externa anónima de especialistas cualificados a fin de contrastar su nivel técnico.

ISBN: 84-89116-07-5

La serie **DOCUMENTOS DE TRABAJO** incluye avances y resultados de investigaciones dentro de los programas de la Fundación de las Cajas de Ahorros.

Las opiniones son responsabilidad de los autores.

# **Using Compromise Programming for Macroeconomic Policy Making in a General Equilibrium Framework: Theory and Application to the Spanish Economy**

**Francisco J. André**

Univ. Pablo de Olavide

**M. Alejandro Cardenete**

**Carlos Romero**

Univ. Politécnica de Madrid

## **ABSTRACT**

This paper has a twofold purpose. First, to show how Compromise Programming, linked with some results connecting this approach with classic utility optimisation, can become a useful analytical tool for designing and assessing macroeconomic policies. Second, to apply the proposed methodology to a macroeconomic policy making problem in Spain. In this way, starting from a Computable General Equilibrium Model, a frontier of growth-inflation combinations for the Spanish economy is determined. After that, several Pareto-efficient policies that represent compromises between economic growth and inflation rate are established and interpreted in economic terms.

December 12<sup>th</sup>, 2005

***Keywords:* Compromise Programming, Economics, Computable General Equilibrium Model, Optimisation, Multi-objective.**

## **Acknowledgements**

Francisco J. André thanks European research project EFIMAS and project SEJ2005-0508/Econ from the Spanish Ministry of Science and Technology. M. Alejandro Cardenete thanks SEC2003-05112 from Spanish Ministry of Science and Technology and XT0095-2004 from Generalitat de Catalunya. Carlos Romero thanks project SEJ2005-04392 from the Spanish Ministry of Education and Science.

## 1. 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 optimisation problem aimed at minimizing some social loss function or maximizing some welfare function, subjected to meet 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...) 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) propose to model macroeconomic policy making as a multi-criteria problem and use a multi-objective programming approach combined with a Computable General Equilibrium (CGE) model, 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 Compromise Programming 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 problems. The absence of echo of their proposal was perhaps due to the lack of connection between CP and the traditional utility maximisation approaches used in economics. However, some works have tried to approximate the classic utility maximisation and CP. Thus, Ballestero and Romero (1991 and 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 maximised. 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 maximised. Moreover, following Romero (2001), each point of the compromise set can be interpreted as a combination between optimum *policy efficiency* (i.e., maximum aggregated achievement of the different macroeconomic objectives) and optimum *policy equity* (i.e., 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 Compromise Programming 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 Section 2 we outline the representation of policy making as a multi-criteria decision problem. In Section 3 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. In Section 4, a very general CP model is applied to the Spanish macroeconomic scenario studied in Section 3. 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.

## 2. BASIC SETTING: MACROECONOMIC POLICY MAKING AS A MULTICRITERIA PROBLEM

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

$$\text{maximise } f_h(z_h, z_{-h}, x) \tag{1}$$

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

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  $h$ , i.e., the value of his decision variables maximising  $f_h$  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  $z^*(x) \equiv (z_1^*(x), \dots, z_m^*(x))$  in such a way that  $z_h^*(x) \in \mathbf{z}_h(z_{-h}^*, x)$  for all  $h=1, \dots, m$ .

After aggregation of  $z^*$ , 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  $Z_1, \dots, Z_K$ , which can be obtained from  $z^*$  according to some aggregation rules:

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

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 Section 4 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, we use a CGE model calibrated for the Spanish economy that is summarized in the next section.

### **3. AN APPLICATION FOR THE SPANISH ECONOMY**

#### **3.1 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 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 (2003) or André et al. (2005).

The CGE model used in the exercise comprises 9 productive sectors (in order to match the aggregated version of 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.

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

$$PD = R - TPS \text{ cpi} - \sum_{j=1}^9 GD_j p_j \quad (3)$$

$\text{cpi}$  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:

$$YD = wL + rK + \text{cpi} TPS + TROW - DT(rK + \text{cpi} TPS + TROW) - DT(wL - WCwL) - WCwL \quad (4)$$

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  $CD_j$  ( $j = 1, \dots, 9$ ) and savings  $SD$ , -according to a Cobb-Douglas utility function, which leads to the following optimisation problem:

$$\begin{aligned} & \text{maximize} && U(CD_1, \dots, CD_9, SD) = \left( \prod_{j=1}^9 CD_j^{\alpha_j} \right) SD^{\beta} \\ & \text{subject to} && \sum_{j=1}^9 p_j CD_j + p_{inv} SD = YD \end{aligned} \quad (5)$$

$p_{inv}$  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  $j$ :

$$\sum_{j=1}^9 INV_j p_{inv} = SD p_{inv} + PD + ROWD \quad (6)$$

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)):

$$\frac{w}{cpi} = \left( \frac{1-u}{1-\bar{u}} \right)^{\frac{1}{\beta}} \quad (7)$$

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  $\beta$  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.

### 3.2 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 2005 for the

technical details about the construction of this matrix), which is the more recent available one. The SAM comprises 21 accounts, including 9 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, 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 wage is taken as numeraire ( $w = 1$ ) and the rest of prices are allowed to vary as required to meet equilibrium conditions.

### **3.3 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 ( $X$ ) 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 three percent with respect to their values in the benchmark situation (denoted as  $x_0$ ), that is the following constraints are imposed to the model:

$$0.97 x_0 \leq x \leq 1.03 x_0$$

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*:

$$\gamma = \frac{GDP_{1995} - GDP_{1994}}{GDP_{1994}} \cdot 100 \qquad \pi = \frac{cpi_{1995} - cpi_{1994}}{cpi_{1994}} \cdot 100 \qquad (8)$$

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 optimisation exercise.

## 4. RESULTS

### 4.1 Pay-off matrix and Pareto-efficient frontier

The equilibrium of the model gives, as a result, the economic growth  $\gamma$  and the inflation rate  $\pi$  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 of an optimum policy (i.e., optimum mix real growth-inflation rate) for the Spanish economy, let us introduce the ideal values  $\gamma^*$  and  $\pi^*$  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  $\gamma_*$  and  $\pi_*$  are introduced. These values represent the achievement of each macroeconomic objective, when the other one has been optimised. 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 maximisation exercise and the second row the values of the same variables obtained when minimising 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  $(\gamma, \pi)$  is efficient if there is not any feasible policy  $x'$  providing  $(\gamma', \pi')$  such that  $\gamma' \geq \gamma$  and  $\pi' < \pi$  or  $\gamma' > \gamma$

and  $\pi' \leq \pi$ . Within the context of our exercise, the set of Pareto-efficient points can be interpreted as a kind of “short-run Philips curve”, that trade-offs employment (linked to economic growth) against 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 optimise on of the objectives, while the other (or in general the others) is placed as a parametric constraint. Through the parameterisation 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).

#### 4.2 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 optimisation problem:

$$\text{Min } L_p = \left[ \left( \frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} \right)^p + \left( \frac{\pi(x) - \pi^*}{\pi_* - \pi^*} \right)^p \right]^{1/p} \quad (9)$$

*Subject to the constraint set*

where we have implicitly assumed that the government is equally concerned about a 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 minimising the distance function  $L_p$ , different best compromise policies can be obtained. Figure 1 displays the best-compromise policies for metrics 1, 2 and  $\infty$ . Table 3 shows the numerical values of these three macroeconomic policies.

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

$$L_1 \Rightarrow 0.28 \text{ (disagreement for growth)} + 0.46 \text{ (disagreement for inflation)} = 0.74$$

(total disagreement)

$$L_\infty \Rightarrow 0.38 \text{ (disagreement for growth)} + 0.38 \text{ (disagreement for inflation)} = 0.76$$

(total disagreement).

Thus, the  $L_1$  compromise policy is better from an aggregated point of view, whereas the  $L_\infty$  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:

$$MRS(\gamma, \pi) = u_1/u_2 = 1 \text{ on the } L_\infty \text{ path } \frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} = \frac{\pi(x) - \pi^*}{\pi_* - \pi^*} \quad (10)$$

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  $L_\infty$  of the compromise set as policies of maximum efficiency 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:

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

for  $\lambda = 1$ , we have the  $L_1$  solution and for  $\lambda = 0$  the  $L_\infty$  solution. For intermediate values of the control parameter  $\lambda$  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, chaps. 14 and 15)

$$\text{Min } (1-\lambda) D + \lambda \left[ \frac{\gamma^* - \gamma(x)}{\gamma^* - \gamma_*} + \frac{\pi(x) - \pi^*}{\pi_* - \pi^*} \right] \quad (11)$$



subject to

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

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

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 on table 4. For  $\lambda = 1$  the solution of maximum aggregated achievement (maximum efficiency) is obtained. According to reductions in the value of control parameter  $\lambda$ , the equity of the macroeconomic policy is improved in detriment of its efficiency. “The most balanced” policy is obtained when the value of control parameter  $\lambda$  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.

#### 4.4 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 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  $\gamma \geq 2.71$ , 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.

#### **4.5 Evaluating the observed policy**

Each point of the Pareto frontier (i.e., every growth-inflation combination), that we have discussed so far are 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 nineties, as it is illustrated in Figure 4. In the years following the one under study (1995), there was a more active anti-inflationist policy, mainly due to the political pressure to meet the Maastricht requirements.

### Efficient Policies and Compromise Programming

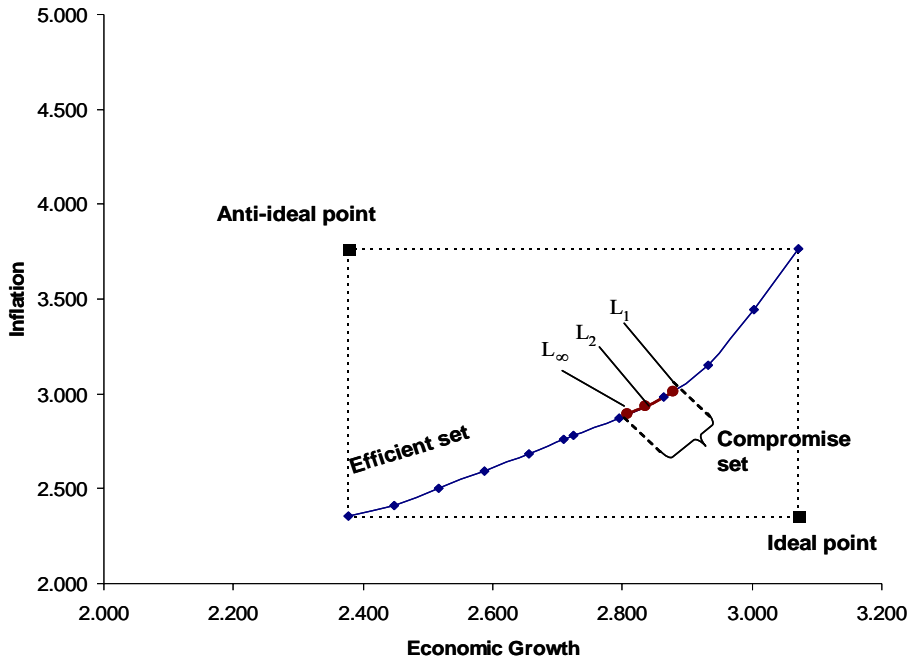


Figure 1

### Compromise set and displaced compromise set

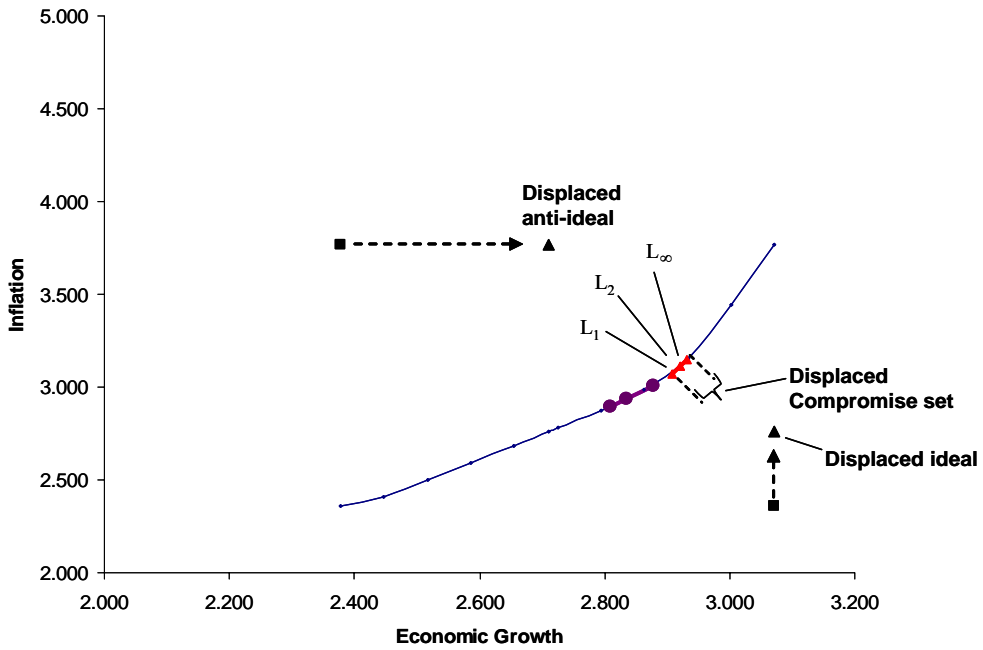


Figure 2

### Evaluating the observed situation

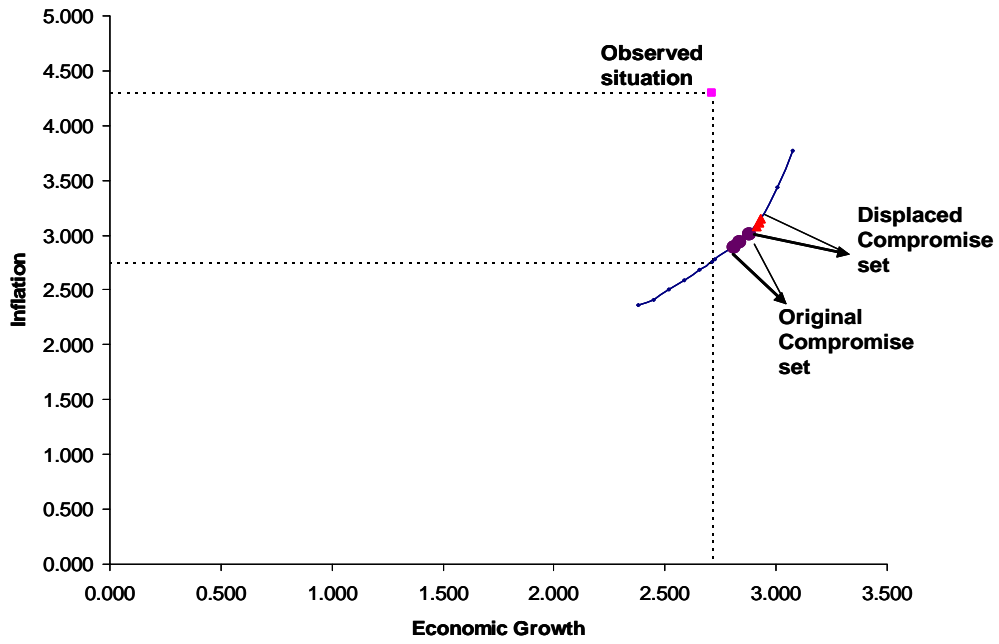


Figure 3

### Inflation Rate in Spain

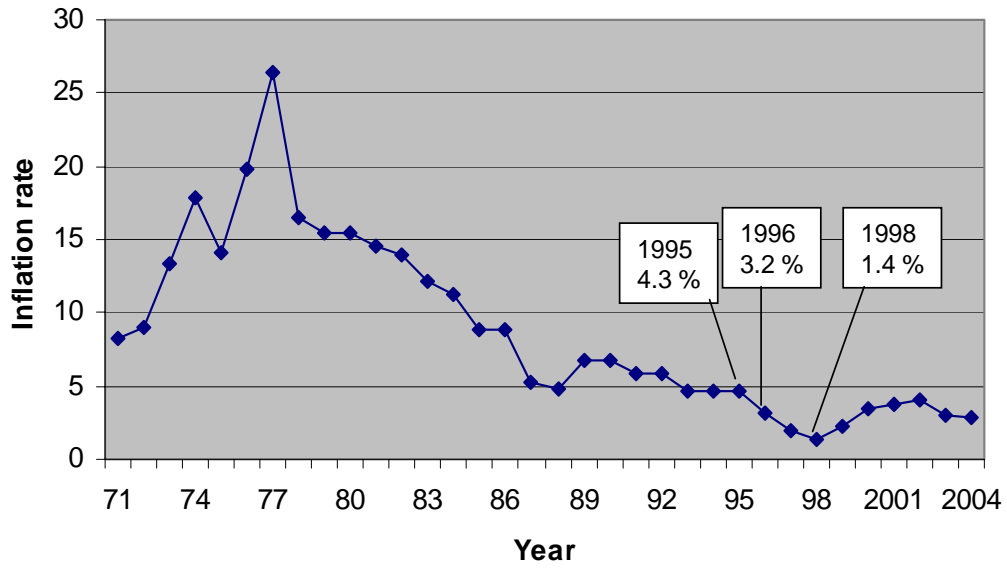


Figure 4

Table 1.: Productive sectors in SAM

N°	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)

**Table 2.** Pay-off matrix for the two criteria considered (bold figures denote ideal values and underlying figures anti-ideal values)

	Growth (%) $\gamma$	Inflation (%) $\pi$
Growth(%) $\gamma$	<b>3.07</b>	<u>3.77</u>
Inflation (%) $\pi$	<u>2.38</u>	<b>2.36</b>

**Table 3.** Best-compromise solutions, for metrics 1,2 and  $\infty$

	growth (%) $\gamma$	inflation (%) $\pi$
$L_1$	2.88	3.01
$L_2$	2.84	2.94
$L_\infty$	2.81	2.89

**Table 4.** Compromise policies for different values of control parameter  $\lambda$

	growth (%) $\gamma$	inflation (%) $\pi$
$\lambda \in [0 \ 0.73) (L_\infty)$	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

**Table 5.** Pay-off matrix of restricted problem (bold figures denote ideal values and underlying figures anti-ideal values)

	<i>Growth (%)</i> $\gamma$	<i>Inflation (%)</i> $\pi$
<i>Growth (%)</i> $\gamma$	<b>3.07</b>	<u>3.77</u>
<i>Inflation (%)</i> $\pi$	<u>2.71</u>	<b>2.76</b>

**Table 6.** Best-compromises policies when the ideal is displaced

	<i>Growth (%)</i>	<i>Inflation (%)</i>
	$\gamma$	$\pi$
L <sub>1</sub>	2.91	3.07
L <sub>2</sub>	2.92	3.11
L <sub>∞</sub>	2.93	3.15



## 5. CONCLUSIONS AND FURTHER RESEARCH

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. Consequently, we propose to use multi-criteria techniques in connection with some structural modelling strategy for the economy in order to get a realistic picture of this decision process and sensible recommendations to improve the efficient use of policy instruments in practice.

This paper has clearly shown how the joint use of Compromise Programming, utility optimisation and Computable General Equilibrium 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.

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 chap. 4). Thus, the boundness 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.

## REFERENCES

- André, F.J., Cardenete, M.A., 2005, Multicriteria Policy Making. Defining Efficient Policies in a General Equilibrium Model. Working Paper Centro de Estudios Andaluces, E2005/04.
- André, F.J., Cardenete, M.A., Velázquez, E., 2005. Performing an Environmental Tax Reform in a Regional Economy. A Computable General Equilibrium Approach, *Annals of Regional Science*, forthcoming.
- Andrés, J., Dolado, J.J., Molinas, C., Sebastián, M., Zabalza, A., 1990. The Influence of Demand and Capital Constraints on Spanish Unemployment. In: Drèze, J., Bean, C. (Eds.), *Europe's Unemployment Problem*, MIT Press, Cambridge, USA.
- Armington, P. S., 1969. A Theory of Demand for Products Distinguished by Place of Production, *International Monetary Fund, Staff Papers* 16: 159-178.
- Ballard, C. L., Fullerton, D., Shoven, J. Whalley, J. (1985). *A General Equilibrium Model for Policy Evaluation*. University of Chicago Press, Chicago.
- Ballesteros E., Anton J. M., Bielza C. (2003). Compromise-based approach to road project selection in Madrid metropolitan area. *Journal of the Operations Research Society of Japan*, Vol 46: 99-122.
- Ballesteros, E., Romero, C., 1991. A Theorem Connecting Utility Function Optimization and Compromise Programming. *Operations Research Letters* 10: 421-427.
- Ballesteros, E., Romero, C., 1994. Utility Optimization when the Utility Function is Virtually Unknown. *Theory and Decision* 37: 233-243.
- Ballesteros, E., Romero, C., 1998. *Multiple Criteria Decision Making and its Applications to Economic Problems*, Kluwer Academic Publishers, Boston.
- Cardenete, M.A., Sancho, F., 2003. An Applied General Equilibrium Model to Assess the Impact of National Tax Changes on a Regional Economy. *Review of Urban and Regional Development Studies* 15 : 55-65.

- Cardenete, M.A., Sancho, F., 2005. Elaboración de una Matriz de Contabilidad Social a través del método de entropía cruzada: España 1995. *Estadística Española*, in press.
- Kehoe T.J., Polo C., Sancho F. (1995) An evaluation of the performance of an applied general equilibrium model of the Spanish economy. *Economic Theory* 6:115-141.
- Mansur, A., Whalley, J., 1984. Numerical Specification of Applied General Equilibrium Models: Estimation, Calibration, and Data, en *Applied General Equilibrium Analysis*, H. Scarf y J. B. Shoven (eds.): 69-117.
- Morón, M. A., Romero, C., Ruiz del Portal, F. R. (1996). Generating Well-Behaved Utility Functions for Compromise Programming. *Journal of Optimization Theory and Applications* 91: 643-649.
- Pérez-Gladish B., Jones D.F., Tamiz M., Bilbao-Terol A. (2006). An interactive three-stage model for mutual funds portfolio selection. *Omega*, Vol.34: (in press).
- Ramsey, R.P., 1927. A Contribution to the Theory of Taxation. *The Economic Journal* 37: 47-61.
- Romero, C., 2001. A Note on Distributive Equity and Social Efficiency. *Journal of Agricultural Economics* 52: 108-110.
- Scarf, H., Shoven, J.B., (Eds.), 1984. *Applied General Equilibrium Analysis*. Cambridge University Press, Cambridge.
- Shoven, J.B., Whalley, J., 1992. *Applying General Equilibrium*. Cambridge University Press, New York.
- Steuer, R. E. (1989). *Multiple Criteria Optimization: Theory, Computation and Application*. Drieger, Malabar, FL.

- Yu, P. L. (1973). A Class of Solutions for Group Decision Problems. *Management Science* 19: 936-946.
- Yu, P. L. (1985). *Multiple-Criteria Decision Making. Concepts, Techniques, and Extensions*. Plenum press, New York.
- Zeleny, M., 1973. Compromise Programming in *Multiple Criteria Decision Making* (Cochrane J.L., Zeleny, M. editors). University of South Carolina Press, Columbia, 262-301.
- Zeleny, M., 1974. A Concept of Compromise Solutions and the Method of the Displaced Ideal. *Computers and Operations Research* 1: 479-496.
- Zeleny, M., 1976. The Theory of the Displaced Ideal in *Multiple Criteria Decision Making: Kyoto 1975* (Zeleny, M. editor). Springer Verlag, 154-206.
- Zeleny, M., Cochrane, J.L., 1973. A Priori and a Posteriori Goals in Macroeconomic Policy Making in *Multiple Criteria Decision Making* (Cochrane J.L., Zeleny, M. editors). University of South Carolina Press, Columbia, 373-391.

# FUNDACIÓN DE LAS CAJAS DE AHORROS

---

## DOCUMENTOS DE TRABAJO

### Últimos números publicados

- 159/2000 Participación privada en la construcción y explotación de carreteras de peaje  
Ginés de Rus, Manuel Romero y Lourdes Trujillo
- 160/2000 Errores y posibles soluciones en la aplicación del *Value at Risk*  
Mariano González Sánchez
- 161/2000 Tax neutrality on saving assets. The spanish case before and after the tax reform  
Cristina Ruza y de Paz-Curbera
- 162/2000 Private rates of return to human capital in Spain: new evidence  
F. Barceinas, J. Oliver-Alonso, J.L. Raymond y J.L. Roig-Sabaté
- 163/2000 El control interno del riesgo. Una propuesta de sistema de límites  
riesgo neutral  
Mariano González Sánchez
- 164/2001 La evolución de las políticas de gasto de las Administraciones Públicas en los años 90  
Alfonso Utrilla de la Hoz y Carmen Pérez Esparrells
- 165/2001 Bank cost efficiency and output specification  
Emili Tortosa-Ausina
- 166/2001 Recent trends in Spanish income distribution: A robust picture of falling income inequality  
Josep Oliver-Alonso, Xavier Ramos y José Luis Raymond-Bara
- 167/2001 Efectos redistributivos y sobre el bienestar social del tratamiento de las cargas familiares en  
el nuevo IRPF  
Nuria Badenes Plá, Julio López Laborda, Jorge Onrubia Fernández
- 168/2001 The Effects of Bank Debt on Financial Structure of Small and Medium Firms in some Euro-  
pean Countries  
Mónica Melle-Hernández
- 169/2001 La política de cohesión de la UE ampliada: la perspectiva de España  
Ismael Sanz Labrador
- 170/2002 Riesgo de liquidez de Mercado  
Mariano González Sánchez
- 171/2002 Los costes de administración para el afiliado en los sistemas de pensiones basados en cuentas  
de capitalización individual: medida y comparación internacional.  
José Enrique Devesa Carpio, Rosa Rodríguez Barrera, Carlos Vidal Meliá
- 172/2002 La encuesta continua de presupuestos familiares (1985-1996): descripción, representatividad  
y propuestas de metodología para la explotación de la información de los ingresos y el gasto.  
Llorenç Pou, Joaquín Alegre
- 173/2002 Modelos paramétricos y no paramétricos en problemas de concesión de tarjetas de credito.  
Rosa Puertas, María Bonilla, Ignacio Olmeda

- 174/2002 Mercado único, comercio intra-industrial y costes de ajuste en las manufacturas españolas.  
José Vicente Blanes Cristóbal
- 175/2003 La Administración tributaria en España. Un análisis de la gestión a través de los ingresos y de los gastos.  
Juan de Dios Jiménez Aguilera, Pedro Enrique Barrilao González
- 176/2003 The Falling Share of Cash Payments in Spain.  
Santiago Carbó Valverde, Rafael López del Paso, David B. Humphrey  
Publicado en "Moneda y Crédito" nº 217, pags. 167-189.
- 177/2003 Effects of ATMs and Electronic Payments on Banking Costs: The Spanish Case.  
Santiago Carbó Valverde, Rafael López del Paso, David B. Humphrey
- 178/2003 Factors explaining the interest margin in the banking sectors of the European Union.  
Joaquín Maudos y Juan Fernández Guevara
- 179/2003 Los planes de stock options para directivos y consejeros y su valoración por el mercado de valores en España.  
Mónica Melle Hernández
- 180/2003 Ownership and Performance in Europe and US Banking – A comparison of Commercial, Co-operative & Savings Banks.  
Yener Altunbas, Santiago Carbó y Phil Molyneux
- 181/2003 The Euro effect on the integration of the European stock markets.  
Mónica Melle Hernández
- 182/2004 In search of complementarity in the innovation strategy: international R&D and external knowledge acquisition.  
Bruno Cassiman, Reinhilde Veugelers
- 183/2004 Fijación de precios en el sector público: una aplicación para el servicio municipal de suministro de agua.  
M<sup>a</sup> Ángeles García Valiñas
- 184/2004 Estimación de la economía sumergida en España: un modelo estructural de variables latentes.  
Ángel Alañón Pardo, Miguel Gómez de Antonio
- 185/2004 Causas políticas y consecuencias sociales de la corrupción.  
Joan Oriol Prats Cabrera
- 186/2004 Loan bankers' decisions and sensitivity to the audit report using the belief revision model.  
Andrés Guiral Contreras and José A. Gonzalo Angulo
- 187/2004 El modelo de Black, Derman y Toy en la práctica. Aplicación al mercado español.  
Marta Tolentino García-Abadillo y Antonio Díaz Pérez
- 188/2004 Does market competition make banks perform well?.  
Mónica Melle
- 189/2004 Efficiency differences among banks: external, technical, internal, and managerial  
Santiago Carbó Valverde, David B. Humphrey y Rafael López del Paso

- 190/2004 Una aproximación al análisis de los costes de la esquizofrenia en España: los modelos jerárquicos bayesianos  
F. J. Vázquez-Polo, M. A. Negrín, J. M. Cavasés, E. Sánchez y grupo RIRAG
- 191/2004 Environmental proactivity and business performance: an empirical analysis  
Javier González-Benito y Óscar González-Benito
- 192/2004 Economic risk to beneficiaries in notional defined contribution accounts (NDCs)  
Carlos Vidal-Meliá, Inmaculada Domínguez-Fabian y José Enrique Devesa-Carpio
- 193/2004 Sources of efficiency gains in port reform: non parametric malmquist decomposition tfp index for Mexico  
Antonio Estache, Beatriz Tovar de la Fé y Lourdes Trujillo
- 194/2004 Persistencia de resultados en los fondos de inversión españoles  
Alfredo Ciriaco Fernández y Rafael Santamaría Aquilué
- 195/2005 El modelo de revisión de creencias como aproximación psicológica a la formación del juicio del auditor sobre la gestión continuada  
Andrés Guiral Contreras y Francisco Esteso Sánchez
- 196/2005 La nueva financiación sanitaria en España: descentralización y prospectiva  
David Cantarero Prieto
- 197/2005 A cointegration analysis of the Long-Run supply response of Spanish agriculture to the common agricultural policy  
José A. Mendez, Ricardo Mora y Carlos San Juan
- 198/2005 ¿Refleja la estructura temporal de los tipos de interés del mercado español preferencia por la liquidez?  
Magdalena Massot Perelló y Juan M. Nave
- 199/2005 Análisis de impacto de los Fondos Estructurales Europeos recibidos por una economía regional: Un enfoque a través de Matrices de Contabilidad Social  
M. Carmen Lima y M. Alejandro Cardenete
- 200/2005 Does the development of non-cash payments affect monetary policy transmission?  
Santiago Carbó Valverde y Rafael López del Paso
- 201/2005 Firm and time varying technical and allocative efficiency: an application for port cargo handling firms  
Ana Rodríguez-Álvarez, Beatriz Tovar de la Fe y Lourdes Trujillo
- 202/2005 Contractual complexity in strategic alliances  
Jeffrey J. Reuer y Africa Ariño
- 203/2005 Factores determinantes de la evolución del empleo en las empresas adquiridas por opa  
Nuria Alcalde Fradejas y Inés Pérez-Soba Aguilar
- 204/2005 Nonlinear Forecasting in Economics: a comparison between Comprehension Approach versus Learning Approach. An Application to Spanish Time Series  
Elena Olmedo, Juan M. Valderas, Ricardo Gimeno and Lorenzo Escot

- 205/2005 Precio de la tierra con presión urbana: un modelo para España  
Esther Decimavilla, Carlos San Juan y Stefan Sperlich
- 206/2005 Interregional migration in Spain: a semiparametric analysis  
Adolfo Maza y José Villaverde
- 207/2005 Productivity growth in European banking  
Carmen Murillo-Melchor, José Manuel Pastor y Emili Tortosa-Ausina
- 208/2005 Explaining Bank Cost Efficiency in Europe: Environmental and Productivity Influences.  
Santiago Carbó Valverde, David B. Humphrey y Rafael López del Paso
- 209/2005 La elasticidad de sustitución intertemporal con preferencias no separables intratemporalmente: los casos de Alemania, España y Francia.  
Elena Márquez de la Cruz, Ana R. Martínez Cañete y Inés Pérez-Soba Aguilar
- 210/2005 Contribución de los efectos tamaño, book-to-market y momentum a la valoración de activos: el caso español.  
Begoña Font-Belaire y Alfredo Juan Grau-Grau
- 211/2005 Permanent income, convergence and inequality among countries  
José M. Pastor and Lorenzo Serrano
- 212/2005 The Latin Model of Welfare: Do 'Insertion Contracts' Reduce Long-Term Dependence?  
Luis Ayala and Magdalena Rodríguez
- 213/2005 The effect of geographic expansion on the productivity of Spanish savings banks  
Manuel Illueca, José M. Pastor and Emili Tortosa-Ausina
- 214/2005 Dynamic network interconnection under consumer switching costs  
Ángel Luis López Rodríguez
- 215/2005 La influencia del entorno socioeconómico en la realización de estudios universitarios: una aproximación al caso español en la década de los noventa  
Marta Rahona López
- 216/2005 The valuation of spanish ipos: efficiency analysis  
Susana Álvarez Otero
- 217/2005 On the generation of a regular multi-input multi-output technology using parametric output distance functions  
Sergio Perelman and Daniel Santin
- 218/2005 La gobernanza de los procesos parlamentarios: la organización industrial del congreso de los diputados en España  
Gonzalo Caballero Miguez
- 219/2005 Determinants of bank market structure: Efficiency and political economy variables  
Francisco González
- 220/2005 Agresividad de las órdenes introducidas en el mercado español: estrategias, determinantes y medidas de performance  
David Abad Díaz



- 221/2005 Tendencia post-anuncio de resultados contables: evidencia para el mercado español  
Carlos Forner Rodríguez, Joaquín Marhuenda Fructuoso y Sonia Sanabria García
- 222/2005 Human capital accumulation and geography: empirical evidence in the European Union  
Jesús López-Rodríguez, J. Andrés Faña y Jose Lopez Rodríguez
- 223/2005 Auditors' Forecasting in Going Concern Decisions: Framing, Confidence and Information Processing  
Waymond Rodgers and Andrés Guiral
- 224/2005 The effect of Structural Fund spending on the Galician region: an assessment of the 1994-1999 and 2000-2006 Galician CSFs  
José Ramón Cancelo de la Torre, J. Andrés Faña and Jesús López-Rodríguez
- 225/2005 The effects of ownership structure and board composition on the audit committee activity: Spanish evidence  
Carlos Fernández Méndez and Rubén Arrondo García
- 226/2005 Cross-country determinants of bank income smoothing by managing loan loss provisions  
Ana Rosa Fonseca and Francisco González
- 227/2005 Incumplimiento fiscal en el irpf (1993-2000): un análisis de sus factores determinantes  
Alejandro Estellér Moré
- 228/2005 Region versus Industry effects: volatility transmission  
Pilar Soriano Felipe and Francisco J. Climent Diranzo
- 229/2005 Concurrent Engineering: The Moderating Effect Of Uncertainty On New Product Development Success  
Daniel Vázquez-Bustelo and Sandra Valle
- 230/2005 On zero lower bound traps: a framework for the analysis of monetary policy in the 'age' of central banks  
Alfonso Palacio-Vera
- 231/2005 Reconciling Sustainability and Discounting in Cost Benefit Analysis: a methodological proposal  
M. Carmen Almansa Sáez and Javier Calatrava Requena
- 232/2005 Can The Excess Of Liquidity Affect The Effectiveness Of The European Monetary Policy?  
Santiago Carbó Valverde and Rafael López del Paso
- 233/2005 Inheritance Taxes In The Eu Fiscal Systems: The Present Situation And Future Perspectives.  
Miguel Angel Barberán Lahuerta
- 234/2006 Bank Ownership And Informativeness Of Earnings.  
V́ctor M. González
- 235/2006 Developing A Predictive Method: A Comparative Study Of The Partial Least Squares Vs Maximum Likelihood Techniques.  
Waymond Rodgers, Paul Pavlou and Andres Guiral.
- 236/2006 Using Compromise Programming for Macroeconomic Policy Making in a General Equilibrium Framework: Theory and Application to the Spanish Economy.  
Francisco J. André, M. Alejandro Cardenete y Carlos Romero.