Techset Composition Ltd, Salisbury CESR691088.TeX Page#: 20 Printed: 15/5/2012

Economic Systems Research, 2012, Vol. 00(0), Month, pp. 1–20

USING A CGE MODEL TO IDENTIFY THE POLICY TRADE-OFF BETWEEN UNEMPLOYMENT AND INFLATION. THE EFFICIENT PHILLIPS CURVE

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(*Received 6 July 2011; In final form 2 May 2012*)

This paper provides a new reading of a classical economic relation: the short-run Phillips curve. Our point is that, when dealing with inflation and unemployment, policy-making can be understood as a multicriteria decision-making problem. Hence, we use so-called multiobjective programming in connection with a computable general equilibrium (CGE) model to determine the combinations of policy instruments that provide *efficient* combinations of inflation and unemployment. This approach results in an alternative version of the Phillips curve labelled as *efficient Phillips curve*. Our aim is to present an application of CGE models to a new area of research that can be especially useful when addressing policy exercises with real data. We apply our methodological proposal within a particular regional economy, Andalusia, in the south of Spain. This tool can give some keys for policy advice and policy implementation in the fight against unemployment and inflation.

Keywords: Short-run Phillips curve; Multicriteria decision-making; Computable general equilibrium model; Efficient policies; Multiobjective programming

CE: SV QA: Coll:

1. INTRODUCTION

The Phillips curve (Phillips, 1958) is a well-known hypothesis reporting a historical inverse relationship between the rate of unemployment and the rate of inflation. In simple terms, the lower the unemployment in an economy, the higher the rate of inflation. Through the decades, the Phillips curve has been the origin of many developments and controversies on the basis of the theory, its differential short- and long-run behaviours and its utility for political economy purposes.

In the 1960s, the Phillips curve was someway interpreted as a "policy menu" in the sense that, by applying Keynesian (expansive or contractive) policies, the governments might choose among different combinations of inflation and unemployment (Samuelson and Solow, 1960). In this paper, we provide an approach to the Phillips curve fully oriented to policy-making, by empirically identifying an efficient short-run trade-off between inflation and unemployment and studying how macroeconomic policy can be tailored to deal with inflation and unemployment.

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ISSN 0953-5314 print; ISSN 1469-5758 online
http://dx.doi.org/10.1080/09535314.2012.691088

This work is inspired in a methodological approach in which policy-making is seen as a multicriteria decision-making (MCMD) problem (André et al., 2010; Sancho, 2011).[1] The general idea is that macroeconomic policy-making tends to pursue macroeconomic objectives that conflict with each other. This point is rather consistent with the original idea of the Phillips curve: in the short-run, a very active anti-unemployment policy will typically foster inflation and the other way around. In order to deal with this policy conflict, our proposal is to build a set of policy options that consist in different policy mixes giving rise to different unemployment–inflation combinations, what can be seen as something similar to a policy menu. Thus, we envision the (short-run) unemployment–inflation trade-off noted by Phillips as a bicriteria policy problem in which the government acts as a decision-maker, the decision variables are the policy instruments that the government has at hand and the objectives are unemployment and inflation. The policy-maker can design its policy to decide between a lower rate of inflation (typically at the cost of a high rate of unemployment), a lower rate of unemployment (possibly with a high rate of inflation) or an intermediate situation.

To put this idea into practice, we need a structural model of the economy that endogenously gives different combinations of inflation and unemployment as the result of different combinations of policy instruments. For this purpose, we use a computable general equilibrium (CGE) model. Moreover, since there is a virtually infinite number of policy mixes, we need a sensible criterion to determine which of them should be taken into account. Following André and Cardenete (2009a; 2009b), we focus on so-called *efficient policies*, i.e. those policy mixes that are not Pareto-dominated from the point of view of the relevant policy objectives. To illustrate the potential of our approach, we develop an exercise with real data from Andalusia, a region in the south of Spain characterized by a high rate of unemployment and important labour market rigidities that have traditionally compromised its economic growth.

The main novelties of our approach in comparison with the traditional Phillips curve are the following: first, when compared to some theoretical macroeconomic models which include the Phillips curve as an assumption in the form of an additional equation of the model (see, for example, Boscá et al., 2010), in our case, the Phillips curve is not imposed as an assumption, but endogenously obtained from the model as an empirical equilibrium result. Moreover, the relationship derived here is an "ex-post" relation in the sense that it takes into account general equilibrium effects and, therefore, all direct and indirect macroeconomic effects on unemployment and inflation that result from the adjustment of the economy towards a new equilibrium after any new policy has been implemented. Second, in contrast to the classical approach in the empirical literature, we do not mix data from different years, but we restrict ourselves to a given economy in the same period of time. Therefore, along the curve that we obtain, the underlying fundamentals of the economy can be considered as constant and the only thing that changes from one point of the curve to another is the implemented combination of policy instruments. The interesting implication of this feature is that this curve can be more properly interpreted as a real policy trade-off. Third, and perhaps more notably, the unemployment–inflation curve that we obtain can be seen as an efficient (short-run) Phillips-like curve in the sense that all the points in this curve have

[1] See Ballestero and Romero (1998) for an introduction to multicriteria techniques and their applications to economic problems or Figueira et al. (2004) for a state-of-the-art review.

the property that they are not Pareto-dominated. So, our Phillips-like curve is a kind of policy menu built under the assumption that the government aims at combining its policy instruments in an efficient way. Finally, from a purely methodological point of view, there is a contribution with respect to the previous literature in the fact of combining a structural descriptive (CGE) model of the economy with a programming tool for policy simulation.

The remainder of the paper has the following structure: in Section 2, we present a brief overview of the related literature. In Section 3, we outline the main features of our approach, including the CGE model used all over the paper, the database used to calibrate the model and the basic elements of our policy design exercise. In Section 4, we display the main results of our calculations in which we obtain an efficient Phillips curve for the Andalusian conomy. In Section 5, we suggest that our policy-oriented interpretation of the Phillips curve can be seen as a particular case of a broader approach in which policy design is a decision problem with multiple conflicting objectives. We show that the observed policy could have been improved in several directions with respect to the observed situation (by improving one or more objectives without worsening any of the other). Section 6 summarizes the main findings of the paper.

2. RELATED LITERATURE

Phelps (1967) and Friedman (1968), under convergent approaches, were two of the first authors that revisited the initial concept of the Phillips curve introduced by Phillips (1958). Friedman argued that the Phillips relation only holds in the short-run and both authors claimed that in the long-run, employers and workers would pay attention only to real wages and the unemployment rate would then stand at a constant level called the "natural rate" of unemployment or non-accelerating inflation rate of unemployment (NAIRU). In the long-run, only the NAIRU would be consistent with a stable inflation rate. The inclusion of this "natural rate" as well as a simple pattern of adaptative expectations (Cagan, 1956; Nerlove, 1958) in the inflation–unemployment relationship, was known as the "expectations augmented Phillips curve". Under this framework, Friedman made a clear distinction between short-run and long-run Phillips curve. In the short-run, the curve slopes down but a completely inelastic curve would remain in the long-run. The stagflation registered during the second half of the 1960s and the 1970s raised new insights in economic thought and the discussion was taken up again: the rational expectations hypothesis from the new classical economists planted the seed of doubts of the curve even in the short-run, but again the new Keynesians went back to the idea of a short-run Phillips curve, marked by rigidities in nominal and real prices and wages.

Recently, a new generation of monetary general equilibrium models, called the (new Keynesian) dynamic stochastic general equilibrium (DSGE) models has made some contributions to the explanation of the links between money, output and inflation over the business cycle.[2] In traditional DSGE models, unemployment is ruled out by assumption (all variation in labour input occurs along the intensive hours margin), and inflation is mainly driven by the workers' marginal rate of substitution between leisure and consumption. But in contrast to this theoretical viewpoint, the empirical evidence suggests that in periods of low output,

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[2] More information about new Keynesian DSGE models can be found in Galí (2008).

employed workers work less hours, but also fewer workers are employed; and the other way round. This is the reason why several authors have incorporated a theory of unemployment into the new Keynesian theory, giving rise to the so-called new Keynesian Phillips curve. That is the case of Blanchard and Galí (2008), Clarida et al. (1999) or Trigari (2009) among others. In a similar fashion, Walsh (2003; 2005) outlines "the importance of combining a labour market structure based on a Mortensen–Pissarides (1994) aggregate matching function with an optimising model of price rigidity", arguing that the real side of the economy must be taken into account.

Many authors have attempted to incorporate the extensive margin and unemployment into new Keynesian models (see, for example, Krause and Lubik, 2007; Ravenna and Walsh, 2008). Most of these authors study how the elasticity of inflation with respect to unemployment depends on structural characteristics of the labour market and they directly focus on the implications of the labour market specification for the Phillips curve. According to Ravenna and Walsh (2008), "the search-friction Phillips curve can potentially reconcile the new Keynesian model of inflation with the data" (p. 1495). In a recent paper, Galí et al. (2011) propose a reformulation of the Smets and Wouters (2007) framework in which the unemployment rate is modelled as an additional observable variable. This way, they develop an approach that tries to overcome the labour market limitations of the new Keynesian papers to measure the output gap. Some other relevant contributions in the field are due to Shimer in the last decade. In Shimer (2005), for example, this author remarks that when an economy experiences a shock, the search and matching model cannot produce the observed business-cycle-frequency fluctuations in variables such as unemployment and job vacancies.

Summing up, although nowadays there is not a unanimous position among economists, there seems to be a certain degree of consensus on the idea that, in the long-run, price stability is more likely to support higher investment and employment, giving rise to an inexistent or even positive, rather than negative relation between inflation and unemployment. Nevertheless, in the short-run, many arguments have been offered to support the idea that inflation and unemployment can be inversely related. Actually, the relationship between both of these variables will depend on the specific structure of the economy and, therefore, the analysis of the Phillips curve (either if it exists or not and its specific shape) is essentially an empirical issue and remains influential nowadays.[3]

Phillips himself never presented the curve as a policy menu, but he was clearly aware that it could be interpreted in this way, and might be treated as such by governments. That is why, when considering the implications of his work for the international monetary system towards the end of his inaugural lecture in 1962, he suggested that a "limited degree of exchange rate flexibility would allow each country time to find by trial and error that compromise between its internal objectives which was consistent with its exchange rate policy" (cited in Laidler, 2001). This interpretation of the curve as a policy menu has been extensively discused in the literature based on the grounds that the "natural rate" of unemployment might be very difficult to determine and that the curve is not likely to remain in one position (see Laidler, 1997 for a discussion).

[3] For further discussion and new insights about the Phillips curve, see Usabiaga and Gómez (1996), Galí and Gertler (1999), Gordon (2009) and Karanassou et al. (2010).

3. METHODOLOGY AND DATA

Our approach consists in determining the trade-off between inflation and unemployment by constructing and calibrating a structural model of the economy and using that model to check the pairs of inflation and unemployment resulting from different policy mixes. We develop a CGE model and we calibrate it with data from the Spanish region of Andalusia. Then, we simulate different policy combinations and evaluate the resulting values of unemployment and inflation.

3.1. The Economic Model

We use a CGE model in the walrasian tradition as in Scarf and Shoven (1984) or Shoven and Whalley (1992). This kind of model has been widely used for policy analysis. See, for example, Hagger and Madden (2003), Naastepad (2003), Savard (2005) or Yao and Liu (2000) for some recent applications and Kehoe et al. (2005) for the state of the art. Following the CGE tradition, this model performs a structural disaggregate representation of the economic activity as well as the equilibrium of markets, according to basic microeconomic principles.

In our model, 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), the 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, all markets clear and public income equals 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 André et al. (2005).

The model comprises 25 productive sectors (Table 1) with one representative firm in each sector, a single representative consumer, one public sector and one foreign sector (representing the commercial relationships between Andalusia and the rest of the world, including the rest of Spain and any other countries).[4]

The production technology is described by a nested production function: the domestic output of sector j, denoted by Xd_j, is obtained by combining, through a Leontief technology, outputs from the rest of sectors and 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 $X\mathrm{row}_j$, according to the Armington (1969) hypothesis, in which domestic and imported products are taken as imperfect substitutes.

There are 25 different goods – corresponding to the number of productive sectors. The representative consumer demands present consumption goods and saves the remainder of his disposable income after paying taxes. The government raises taxes to obtain public revenue, R – direct, indirect and payroll taxes – as well as it provides transfers to the private

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[4] Since we focus on aggregate results, the exact number of sectors considered is not crucial. The level of disaggregation is an arbitrary decision of the researcher or the policy-maker: the more disaggregate is the model, the more information one can manage in the analysis, but the computational burden is higher as well.

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 textile 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 and 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 (2003).

sector, TPS, and demands goods and services, GD_j, from each sector $j = 1, \ldots, 25$.[5] PD denotes the final balance (surplus or deficit) of the public budget (in nominal terms):

$$\mathrm{PD} = R - \mathrm{TPS} \cdot \mathrm{cpi} - \sum_{j=1}^{25} \mathrm{GD}_j \cdot p_j, \tag{1}$$

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 cpi is calculated as a weighted average of the prices of all sectors, according to the share of each one in the overall consumption of the economy. Both TPS and GD_j ($j = 1, \ldots, 25$) are real variables and they are multiplied by the relevant price variable to get the nominal version. Hence, TPS is measured in constant monetary units, whereas $\mathrm{TPS} \cdot \mathrm{cpi}$ is measured in current monetary units. GD_j is measured in goods, whereas $\mathrm{GD}_j \cdot p_j$ is measured in (current) monetary units. Similar transformations are done for other variables of the model.

Consumer disposable income (YD henceforth) is expressed in nominal terms and equals labour and capital income, plus transfers, minus direct taxes:

$$\begin{aligned} \mathrm{YD} = {} & w \cdot L + r \cdot K + \mathrm{cpi} \cdot \mathrm{TPS} + \mathrm{TROW} - \mathrm{DT}(r \cdot K + \mathrm{cpi} \cdot \mathrm{TPS} + \mathrm{TROW}) \\ & - \mathrm{DT}(w \cdot L - \mathrm{WC} \cdot w \cdot L) - \mathrm{WC} \cdot w \cdot L, \end{aligned} \tag{2}$$

where w and r denote input (labour and capital) prices, L and K denote input quantities sold by the consumer, TROW represents transfers 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

[5] In our model, the payroll tax (Social Security paid by employers) works similar to other indirect taxes. Specifically, it operates by taxing wages paid by employers to workers. The total revenue from this tax (denoted as R_{FSS}) is calculated as $R_{\mathrm{FSS}} = \sum_{j=1}^{25} \mathrm{FC}_j \cdot w \cdot L_j$, where FC_j is the payroll tax rate paid by employers in sector i, w is the wage and L_j is the sectoral labour factor endowment. On the other hand, the direct labour tax (Social Security paid by employees) is calculated according to $R_{\mathrm{WSS}} = \mathrm{WC} \cdot w \cdot L$, where R_{WSS} is the revenue from this tax, WC is the payroll tax rate paid by employees and L is the total labour factor endowment.

his utility (welfare), subject to his budget constraint. Welfare is obtained from consumption goods CD_j ($j = 1, \ldots, 25$) and savings SD – according to a Cobb–Douglas utility function – that leads to the following optimization problem:[6]

$$\begin{aligned} &\text{maximize} \quad U(\mathrm{CD}_1, \ldots, \mathrm{CD}_{25},\ \mathrm{SD}) = \left(\prod_{j=1}^{25} CD_j^{\alpha_j} \right) \mathrm{SD}^{\beta} \\ &\text{subject to} \quad \sum_{j=1}^{25} p_j \mathrm{CD}_j + p_{\mathrm{inv}}\ \mathrm{SD} = \mathrm{YD}, \end{aligned} \tag{3}$$

p_{inv} being an investment price index. Saving, SD, is defined as the amount of disposable income that is not consumed.

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

$$\sum_{j=1}^{25} \mathrm{INV}_j \cdot p_{\mathrm{inv}} = \mathrm{SD} \cdot p_{\mathrm{inv}} + \mathrm{PD} + \mathrm{ROWD}. \tag{4}$$

Labour and capital demands are computed under the assumption that firms minimize the cost of producing value added. Since we make a short-term analysis, in the capital market, we consider that total supply is perfectly inelastic. For labour supply, we reconcile the existence of unemployment with the equilibrium assumption by following the approach used in Kehoe et al. (1995). Specifically, we assume that unions fix the real salary taking into account the current rate of unemployment according to the following equation:[7]

$$\frac{w}{\mathrm{cpi}} = \left(\frac{1-u}{1-\bar{u}} \right)^{1/\beta}, \tag{5}$$

where u is the current unemployment rate (i.e. that rate resulting from the simulated policies) and $\bar{u}$ is the benchmark unemployment rate (in our case, that rate observed in reality in the economy under study, i.e. Andalusia 1995) and w/cpi is the real wage. Following Oswald (1982), this equation is based on the assumption that firms determine labour demand (and hence, total employment) and unions determine the real wage. Moreover, we assume that labour is inelastically supplied, which, together with the endogenous labour demand function allows us to determine equilibrium unemployment. As a result of this setting, if

[6] Alternative (dynamic) modelling approaches represent saving as a mechanism to allocate income intertemporally. Problem (3) can be seen as a simplified (static) specification in which saving is justified because it provides some utility to the consumer. This utility can be rationalized as summarizing the flow of utility that the consumer would obtain from future consumption, thanks to saving.

[7] One may think that Equation 5 can be seen as a wage Phillips curve. Nevertheless, note that Equation 5 shows a connection between two real variables: real wages and unemployment, whereas in the Phillips curve, we look for a connection between a real variable (unemployment) and a nominal variable (nominal wages in the case of the wage Phillips curve or price inflation in our case). Since both w and p are free variables, Equation 5 does not imply any specific relationship between unemployment and wage inflation or between unemployment and price inflation.

labour demand increases (decreases), the unemployment rate u decreases (increases) and workers demand higher (lower) real wages. The rationale for this mechanism is that a lower (higher) rate of unemployment endows unions with more (less) bargaining power. If, after the simulation, employment remains unchanged, the real wage will be the same as in the benchmark equilibrium.

On the other hand, β is a flexibility parameter measuring the sensitivity of wages with respect to unemployment. If β approaches zero, unemployment approaches its benchmark value, meaning that wages adjust perfectly to keep unemployment unchanged. As β approaches infinity, the real wage tends to 1, its benchmark value, meaning that (real) wages are perfectly rigid and do not respond to changes in unemployment. 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 are those contained in the social accounting matrix (SAM hereafter) for Andalusia 1995 (see Cardenete and Sancho, 2003, for technical details). The SAM comprises 40 accounts, including 25 productive sectors (Table 1), 2 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.

Regarding the sectoral composition of the Andalusian economy, from our database, we conclude that the four most important sectors in terms of their share in total output are Commerce (21), that represents a 15.8% of total output, Other services (23) with 13.3%, Food (16) with 9.8% and Construction (20) with 9.4%. These sectors, altogether, represent a 48.3% of total regional output. An additional insight from the sectoral point of view is the large importance of services in Andalusia (including Commerce (21) and Other services (23) again, as well as Transport and Communications (22), Sales services (24) and Non-sales services (25)) that represent a 44.3% share of total production.

The numerical values for the parameters in the model are obtained by the usual procedure of calibration (see, for example, Mansur and Whalley, 1984). 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 to reproduce the 1995 SAM as an initial equilibrium that is used as a benchmark for all the simulations. In such a benchmark, all the prices and the activity levels are set equal to 1, so that, after any of the simulation exercises, it is immediate to observe the change rate of relative prices and activity levels in the resulting equilibrium.

As it is common in GGE models, we need to choose a price as the numeraire (which will be held as constant and equal to 1 during all the analysis) because these models are formulated in terms of relative rather than absolute prices. The rest of prices in the model are allowed to vary as required to meet equilibrium conditions and those variations should be interpreted in terms of the numeraire. In other words, if the model gives as a result that a price increases by, say, y percent, we should interpret that this price increases y percent more than the numeraire. In most CGE applications, only relative prices matter and then the selection of the numeraire is rather arbitrary. But in our application, since we are interested in having a credible measure of inflation, it is particularly relevant to choose an adequate numeraire.

The idea is to choose one price that, as far as possible, can be argued to be realistically robust to internal policy changes in practice. We have decided that the best candidate was the price of capital, r. The reason is that this price is mainly determined by the interest rate, and being Spain a small open economy, the interest rate in practice is, to a large extent, exogenously determined by the international financial markets. Nowadays, since Spain is a member of the European Monetary Union, its interest rate is essentially determined by the European monetary policy. The idea is to have a numeraire that is expected not to change under different policy changes so that we can meaningfully interpret the variations of the prices obtained from the model (which are, by construction, relative variations) as a reasonable approximation to the absolute variations of those prices in practice.

3.3. Policy Setting

Once the model is built and calibrated, our aim is to simulate the effects of different policy combinations and compute the resulting values of inflation and unemployment. Our methodological approach could, in principle, be applied to any kind of policy mix, but we decided to focus just on fiscal policy because this is the type of policy that our CGE is more adequate to deal with. We envision policy design as a bi-criteria decision problem where the decision-maker is the government, the objective variables are inflation and unemployment and the decision variables are public expenditure and taxes.

Concerning the policy objectives, the rate of unemployment (u) is obtained as the result of the job market equations (Equation 5), whereas the inflation rate (π) is calculated as the annual rate of change of the cpi:

$$\pi = \frac{\mathrm{cpi}_{1995} - \mathrm{cpi}_{1994}}{\mathrm{cpi}_{1994}} \times 100, \tag{6}$$

where the subscript refers to years. The value of cpi for 1994 is exogenously given and the value for 1995 is endogenously determined, as an equilibrium result.[8]

Denote as $\mathbf{x}$ the vector of policy instruments, including public expenditure in goods and services of each activity sector ($\mathrm{GD}_j, i = 1, \ldots, 25$) and the average tax rates applied to every economic sector, including indirect taxes – Social Security contributions paid by employers (EC_j) and VAT_j – as well as direct taxes: Social Security contributions paid by employees (W_j) and IT (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 5% with respect to their values in the benchmark situation (denoted as $\mathbf{x}_0$), i.e.

$$0.95\ \mathbf{x}_0 \leq \mathbf{x} \leq 1.05\ \mathbf{x}_0. \tag{7}$$

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[8] Source: IEA, Andalusian Statistical Institute.

(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.[9]

4. RESULTS: AN EFFICIENT (SHORT-RUN) PHILLIPS CURVE

The equilibrium of our CGE model gives, as a result, the unemployment and inflation rates as (implicit) functions of the policy variables, that is, $u = u(\mathbf{x})$ and $\pi = \pi(\mathbf{x})$ and, with this information, the policy-making problem is fully described. In this section, we make the assumption that the policy-maker is concerned about inflation and unemployment as the only policy objectives. Moreover, we assume that the policy-maker acts rationally by choosing the values of its policy instruments (in our case, the fiscal policy variables: taxes and public expenditure) to optimize in some sense its policy objectives (in this case, unemployment and inflation).

The first question we want to answer is to what extent both policy objectives are compatible or not. In other words, is it possible for the policy-makers to get simultaneously a good result in unemployment and inflation? In practice, asking this question is almost the same as determining if there exists a downward sloping Phillips curve or not. With our model, we can asses the degree of conflict between both objectives by computing the so-called pay-off matrix. This is done by solving two mono-criteria problems that consist of optimizing each objective separately disregarding the other one. First, we find the minimum feasible value of unemployment. This is done by solving a well-defined optimization problem where the objective function is unemployment, the decision variables are taxes and public expenditues and the feasible set is determined by two types of constraints: on the one hand, all the equations of the CGE model (including accounting identities, behavioural equations and equilibrium conditions) and, on the other hand, the upper and lower bounds on the decision variables introduced in Section 2.3.[10] This exercise renders the minimum attainable value of unemployment, which is refereed to as *ideal* value of unemployment and denoted as u^*. As a by-product of this exercise, we get an associated value of inflation (which is interpreted as that value of inflation that one needs to accept in order to minimize unemployment). Both of these values for unemployment and inflation comprise the first row of the pay-off matrix (Table 2). In the same way, we obtain the ideal (i.e. minimum attainable) value of inflation, π^* and an associated value of unemployment. The worst (maximum) value of each column is called the anti-ideal (or nadir) value for the associated objective: u_* and π_*, which corresponds to the achievement of each objective, when the other one is optimized.

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 $\pi_* = 3.6\%$. Similarly, (as the result of an opposite policy) the second row shows another feasible combination with essentially a zero inflation rate (actually, a slight deflation, $\pi^* = -0.1\%$) compatible

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

[10] In practical terms, this problem is solved using GAMS software and, more specifically, MINOS solver. For more details about the algorithm, see GAMS documentation at http://www.gams.com/docs/minoslog.

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.

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 column (in this case, the maximum unemployment rate and the maximum inflation rate) gives the *anti-ideal* or *nadir point*.

Regarding the behaviour of the most relevant sectors (that were identified in Section 3.2), Construction (20) and Other services (23) grow under both policies although this growth is bigger when minimizing unemployment (8.3% and 7%, respectively) than when minimizing inflation (4.7% and 4.5%). The minimum-unemployment solution involves a positive growth of all sectors except for Non-sales services (which decreases by 14.5%). The most significant growth rates correspond to the already mentioned sectors (20) and (23) although Manufacturing of construction (10), Manufacturing of metals (12) and Machinery (13) also register a remarkable growth around 6% in all three cases. On the other hand, minimizing inflation entails a reduction in the activity of 18 out of 25 sectors and an increment in just 6 of them, while Transports (15) remain broadly unchanged. As in the minimum-unemployment policy, the largest growth corresponds to sectors 20 (4.7%), 23 (4.5%), 10 (3%), 12 (2.9%) and 13 (2.7%). Minery also experiences a more modest growth of around 1.4%.

One first conclusion we can draw from Table 2 is that there is a conflict between both policy objectives, in the sense that it is not possible to get at the same time, the minimum feasible unemployment and the minimum inflation rate. The reason is that minimizing unemployment implies accepting a higher degree of inflation and the other way around. 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 fiscal 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, 2003) and it amounts to the notably high values of unemployment displayed in the table. Recall that unemployment has traditionally been a very hard problem in Spain (see, for example, Blanchard et al., 1995) and especially in Andalusia. Table 3 presents some macroeonomic indicators regarding the Spanish and Andalusian economy in 1995.

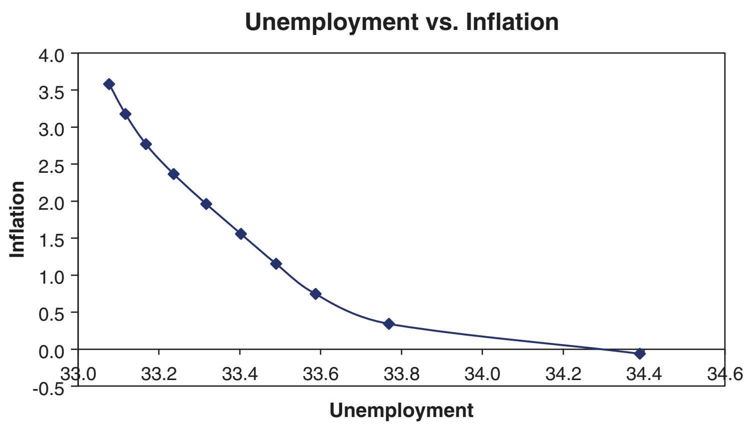
TABLE 3. Some macroeconomic indicators of Andalusia and Spain, 1995.

	GDP current 10^6 euros	One-year growth rate (%)	Activity rate (%)	Unemployment rate (%)	PD 10^6 current euros	Inflation rate (%)
Andalusia	58,384.3	2.79	48.91	33.9	11,080.1	4.4
Spain	447,205.0	2.76	51.01	22.8	29,068.5	4.7

Source: Spanish Institute of Statistics and Andalusian Institute of Statistics.

FIGURE 1. Trade-off between unemployment and inflation.Source: Own elaboration.

Colour online, B/W in print



The second step is to evaluate the available options to trade-off inflation for unemployment. The idea is to test different combinations of the policy instruments and compute the resulting values of inflation and unemployment. Nevertheless, since we have intentionally allowed for a very large range of policy combinations, it is not possible (not useful) to test all of them. Following the approach suggested in André and Cardenete (2009a; 2009b), we focus on the set of so-called efficient policies. Following the classical Pareto criterion, we say that a policy combination $\mathbf{x}$ providing the objective values (u, π) is efficient if there is not another feasible policy $\mathbf{x}'$ 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 of policies using the multicriteria technique known as multiobjetive programming, implemented by means of the so-called *constraint method*. This procedure consists of optimizing 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 $\pi = -0.1$ to $\pi = 3.6$. 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 which objective is parameterized and which one is optimized in every point).

Figure 1 shows the results of these calculations. The resulting curve can be interpreted as an approximation to the traditional short-run Phillips curve and its slope can be understood as the policy trade-off between objectives, i.e. the increment in inflation that one must accept in order to decrease unemployment or the other way around. Note that the slope is negative but decreasing. The interpretation of this fact is that, when unemployment is "low", further unemployment reductions require larger increments in inflation. Alternatively, if the inflation rate is low, reaching additional reductions would be more costly in terms of increased unemployment. This seems reasonable from an economic point of view: if the economy is at very good levels on one objective, it would be difficult to realize additional improvements on that same objective.

Three important remarks apply to this particular version of the Phillips curve: 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. In our model, the labour supply Equation 5 states a positive relationship between prices and unemployment for a given value of wages (what, by itself, would result in an increasing rather than decreasing Phillips curve), but the goods-demand side of the model pulls in the opposite direction: more economic activity entails both less unemployment and more demand, which, in turns, pushes prices up (what tends to generate a decreasing relationship between unemployment and inflation). Therefore, the final observed trade-off between both variables is a result of all the economic forces in equilibrium. The existence of a Phillips-like relationship between inflation and unemployment (i.e. a decreasing curve) in Andalusia 1995 is an empirical finding, not an assumption of the model. Moreover, it is an ex-post equilibrium relationship between unemployment and inflation that takes into account all general equilibrium (direct and indirect) effects of policies on unemployment and prices.

Second, 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). Given that the points in such plots correspond to different years, some structural elements of the economy might change across those points. As a consequence, those results might not be strictly interpreted as a policy trade-off, since moving from one point to another across the curve would not be possible just by changing the economic policy. The Phillips-like curve shown in Figure 1 is obtained for a given economy in the same period of time. Therefore, the underlying fundamentals of the economy can be considered as constant and the only thing that changes from one point of the curve to another is the implemented combination of policy instruments. In this sense, this curve can be more properly interpreted as a pure policy trade-off or, to follow the classical jargon, a (short-run) "policy menu".

Third, an important remark should be made regarding the interpretation of this result as a Phillips-like 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 1, meaning that the implemented policy is not efficient since it would be Pareto-dominated by some points in the curve. By construction, no observations could be found below the curve. From this point of view, the curve obtained in Figure 1 can be labelled as an "efficient Phillips curve" in the sense that all the points in this curve result from efficient (i.e. non-dominanted) policies.

The main political implications of these results for the region of Andalusia are, first, that by implementing different combinations of taxes and public expenditure in an efficient manner it is possible, to some extent, to trade-off between inflation and unemployment and, second, as a result of changing these policy combinations, we can expect to get relatively large variations in inflation even in the short-run, whereas the possibilities to reduce the rate of unemployment in the short-run are very limited.

5. A BROADER APPROACH: POLICIES WITH MULTIPLE CRITERIA

In this paper, we are adopting a very pragmatic approach of the short-run Phillips curve in the sense that we are not dealing with doctrinal or philosophical issues but rather with a purely policy-oriented motivation: to what extent the government can adjust its policy options to trade-off between unemployment and inflation.

In this same pragmatic spirit, we can argue that, in practice, the government is normally concerned, not only about inflation and unemployment, but also about other economic indicators such as economic growth, public deficit (PD) and so on. Moreover, it is reasonable to think that all these indicators are related with each other. As an immediate conclusion, we can see the short-run Phillips curve (from the point of view of policy design) as a particular case of a more general setting in which the government cares about many conflicting policy objectives and has to design its policy in order to find a compromise among all of them.

In order to illustrate this broader approach, consider now that the government is concerned about five objectives. Apart from inflation and unemployment, we also include three other additional objectives, the first one of which is the maximization of economic growth, γ, calculated as

$$\gamma = \frac{\mathrm{GDP}_{1995} - \mathrm{GDP}_{1994}}{\mathrm{GDP}_{1994}} \cdot 100, \tag{8}$$

where GDP_{1994} is the GDP of Andalusia, 1994, which is exogenously given (source: Spanish Statistical Institute, INE) and GDP_{1995} is the value of GDP in the equilibrium the model after any of the simulations. Since GDP_{1994} is given, maximizing growth is totally equivalent to maximizing GDP_{1995}, but we incorporated the former as a policy objective since it is a more standard indicator in real policy-making. Second, we introduce as an additional policy objective the minimization of PD which is, in practice, an important political concern in many countries and regions. Third, 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, Mas-Colell et al., 1995). We arbitrarily set $\mathrm{CV} = 0$ in the benchmark situation, in such a way that $\mathrm{CV} > 0$ (<0) means that, after implementing the analysed policy combination, the consumers are better off (worse off) than before implementing it. PD and CV are measured in million euros.

Summing up, we consider two “more is better” objectives (which must be maximized): growth and CV, and three “less is better” objectives (to be minimized): unemployment, PD and inflation. One of the advantages of MCDM is its ability to deal with objectives measured in different units. In this case, γ, π and u are measured in percentage terms, whereas PD and CV are measured in million euros.

By solving five mono-criteria problems, we get the pay-off matrix for this policy problem, which is given in Table 4. As in the previous exercise, the values in the main diagonal, which are displayed in bold characters, constitute the ideal point, whereas the worst value for each column (displayed underlined) comprises the anti-ideal point. A visual inspection of the matrix reveals the following conflicts among objectives: 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 PD. PD, in turn, behaves almost exactly the same as inflation. The reason for this is the particular way in which the policy exercises are designed: PD

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

	γ (%)	π (%)	u (%)	PD (106 euros)	CV (106 euros)
Max γ	**3.4**	3.6	33.1	10,860.5	2,243.5
Min π	2.4	**−0.1**	34.5	10,058.6	−7,642.7
Min u	3.4	3.6	**33.1**	10,854.8	2,177.4
Min PD	2.3	−0.1	34.5	**10,056.5**	−7,903.9
Max CV	3.2	3.9	33.4	11,072.4	**3,049.0**

Source: Own elaboration.

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 endnote 8), 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, reducing (nominal) PD is consistent with reducing prices (while the nominal value of public income is constrained to be fixed). Finally, the CV seems to display a moderate degree of conflict with growth and unemployment and a strong degree of conflict with inflation and PD.[11]

It is important to recall that all these five combinations can be seen as five alternative policy mixes which, in turn, result in different sectoral implications. Nevertheless, when we analyse the most significant changes across simulations, it is interesting to note that there are important similarities among all five. Actually, if we focus on the five sectors that grow more in each case, we see that these five sectors are the same in the five simulations although the order is not always the same. Two of those sectors (20 and 23) have been classified as big sectors in Section 3.2 and the other three belong to manufacturing branches – Machinery (13), Manufacturing of Construction (10) and Manufacturing of Metals (12). When minimizing unemployment or maximizing GDP, we notice that the activity of these five sectors grows well above the average sectoral growth, with positive increments ranging from 6% to 8.60%. In the other three simulations, the increments displayed in the outlined sectors are more moderate, but still clearly over the average. On the contrary, we also find another important common element of all five simulations' behaviour in the fact that Non-sales services (25) always decreases around 14%. This result can be interpreted as a recommendation to reduce the dimension of the public sector in the region and this conclusion seems to be very strongly supported by our results in the sense that it is extremely robust to the policy objective that the policy-maker might choose to focus on.

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 optimize one single objective while keeping the rest as parametric constraints. The way to fix these constraints depends on the specific problem to be solved. 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 (Table 3) are the following:

$$g = 2.79\%, \quad p = 4.4\%, \quad u = 33.9\%, \quad \text{PD} = 11{,}080.1, \quad \text{CV} = 0, \tag{9}$$

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

$$\begin{array}{c} \text{Max}\,\gamma \\ \text{subject to} \quad \pi \leq 4.4, \quad u \leq 33.9, \quad \text{PD} \leq 11{,}080.1, \quad \text{CV} \geq 0. \\ \text{all the equations of the model} \end{array} \tag{10}$$

The solution of problem (10) is given by

$$\gamma = 3.4, \quad \pi = 3.6, \quad u = 33.1, \quad \text{PD} = 10{,}860.5, \quad \text{CV} = 2243.5.$$

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[11] Given the joint behaviour of some objectives, an operational way to deal 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.

TABLE 5. Using the constraint method with respect to the observed situation.

	γ (%)	π (%)	u (%)	PD (106 euros)	CV (106 euros)
Max γ	3.4	3.6	33.1	10,860.5	2,243.5
Min π	3.2	1.7	33.4	10,542.7	0.0
Min u	3.4	3.6	33.1	10,854.8	2,177.4
Min PD	3.2	1.7	33.4	10,540.2	0.0
Max CV	3.2	3.9	33.4	11,072.4	3,049.0

Source: Own elaboration.

Note that this combination Pareto-dominates the observed situation, since not only the growth rate is higher than the observed one, but also the CV is higher and inflation, unemployment and PD 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 changing the policy mix.

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 when optimizing growth, unemployment and the CV 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 given in Table 4 dominate the real observed values for all the objectives. Nevertheless, the situation is different for inflation and PD, 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. Anyway, note that all of the solutions presented in Table 5 dominate the observed situation in Andalusia 1995. One immediate conclusion is that the policy that was implemented in practice could be seen as Pareto inefficient (if we restrict the five policy objectives considered here) or, in other words, that it could have been improved (in Pareto sense) in several directions.

On the other hand, form a technical point of view, it is important to observe that, in the solutions found in Table 5, some constraints are not binding. A sufficient condition for the constraint method to provide efficient solutions is that all the parametric constraints are binding. This means that we cannot be sure that the solutions found up to now are efficient, although any of them Pareto-dominates the observed situation.

At this point, in order to find solutions that are efficient for sure, we have at least two possibilities: the first one is to use 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 PD) until we find a solution when all of them are binding at the same time.

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

$$\omega_\gamma \frac{\gamma - \gamma_*}{\gamma^* - \gamma_*} + \omega_\pi \frac{\pi - \pi_*}{\pi^* - \pi_*} + \omega_u \frac{u - u_*}{u^* - u_*} + \omega_{\mathrm{DP}} \frac{\mathrm{DP} - \mathrm{DP}_*}{\mathrm{DP}^* - \mathrm{DP}_*} + \omega_{\mathrm{CV}} \frac{\mathrm{CV} - \mathrm{CV}_*}{\mathrm{CV}^* - \mathrm{CV}_*}, \quad (11)$$

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 0 (when the objective is equal to the anti-ideal value) and 1 (when it is equal to the ideal value).[12] This normalization eliminates any 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 $\omega_\gamma = \omega_\pi = \omega_u = \omega_{\mathrm{PD}} = \omega_{\mathrm{CV}} = 1$, meaning that the policy-maker is equally concerned about all the objectives. The maximization of (11) with this set of weights gives the following solution:

$$g = 3.4, \quad p = 3.5, \quad u = 33.1, \quad \mathrm{PD} = 10{,}913.1, \quad \mathrm{CV} = 2643.1,$$

which Pareto-dominates the observed situation (10) 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 $\omega_i = 1$ for a specific objective and $\omega_j = 0$ for the rest, meaning that the policy-maker is concerned only about objective i, we would get the ith row of the pay-off matrix.

6. CONCLUSIONS

The aim of this paper is not a doctrinal positioning on economic thought about the Phillips curve, but a pragmatic reading which endeavours to be better suited for the sake of short-run economic policy-making than traditional works on the Phillips curve. We do so by combining two methodologies (CGE modelling and MCDM) to get a new, policy-oriented reading of the short-run Phillips curve.

We conclude that the trade-off between unemployment and inflation (in the same fashion as more general policy settings) can be seen as a multicriteria decision problem in which the government can use its policy instruments to pursue different conflicting policy objectives. Economic policy-making in general (and specifically the unemployment–inflation trade-off) can be suitably represented as a multicriteria problem for a double reason. First, from a conceptual perspective, it seems a sensible way to understand and represent the concerns and the procedures actually followed by policy-makers. Second, from an empirical perspective, MCDM techniques can be of considerable help to get operative policy advises and, therefore, to decide how to use policy instruments in practice.

A CGE model calibrated for the Andalusian economy allows us to obtain a set of efficient policies that can be interpreted as a particular version of the classical (short-run) Phillips curve, which we can label as *optimal Phillips curve* or *efficient Phillips curve*. This curve can provide a new reading of the short-run concept of the Phillips curve because it is built as a real policy-based trade-off between inflation and unemployment at a specific moment in time since the rest of fundamentals of the economy are fixed. Moreover, it is a ex-post curve in the sense that its existence and its shape are not *a priori* imposed as an assumption, but is a result of all the equilibrium effects in the economy.

Regarding sectoral implications, our results help us to identify some sectors of the Andalusian economy, namely Construction, Other Services, Machinery, Manufacturing

[12] 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.

of Construction and Manufacturing of Metals, that seem to be particularly receptive to changes in fiscal policy and, moreover, tend to grow very notably under any policy oriented to maximize a relevant policy objective. On the other hand, our model very consistently recommends to decrease the weight of Non-sales services in Andalusia. This information can be useful for regional policy-makers who, facing the current uncertain economic situation, will have to prioritize their investment decisions for promoting growth under a scenario of severe austerity.

This paper aims at providing a new operational approximation to the classical short-run Phillips curve, getting some initial insights about what results can be obtained with real data and how to use those results for policy-making. The analysis can be extended and improved in a number of ways, such as constructing a dynamic and/or multiregional version of the model and refining the definition and selection of policy goals. This is left for future work, since the fundamental contribution of the paper is not the applications itself, but rather to suggest a methodological line of research combining different analytical instruments to search for Pareto-optimal levels of inflation and unemployment rates in an specific economy.

The Phillips curve (when interpreted from the point of view of policy-making) can be seen as a particular case of a broader approach for policy design. Enlarging the number of objectives makes the problem computationally more demanding but also more interesting and realistic. In the exercise, we have addressed the analysis of five policy objectives and we have shown that the observed policy in Andalusia could have been unambiguously improved (in Pareto sense) in a number of ways depending on the weights given by the policy-maker to each objective. Another obvious line of future research is to perform a more detailed analysis of the importance of each policy objective and the policy mixes that should be implemented to optimize those objectives.

Acknowledgments

The authors thank Carlos Usabiaga for useful discussion. Francisco J. André acknowledges financial support from research Projects SEJ 04992, ECO2009-14586-C02-01, SEJ 04992 and P07-SEJ-02936. M. Alejandro Cardenete thanks Project SEC2003-05112 from Spanish Ministry of Education and Science and Project XT0095-2004 from Generalitat de Catalunya. He also thanks SGR578-2009-2011 (Generalitat de Catalunya) and SEJ 2006-00712 (Ministry of Science and Innovation). M. Alejandro Cardenete and M. Carmen Lima thank Project PAI SEJ-479 (Andalusian Regional Government). M. Carmen Lima thanks ECO 2009-13357 (Ministry of Science and Innovation), Excellence Project SEJ-4546 (Andalusian Regional Government) and Project APP2D09033 (Universidad Pablo de Olavide).

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