Revisiting the Phillips curve:

A CGE-MCDM approach[*]

Francisco J. André

Universidad Complutense, Madrid, Spain

M. Alejandro Cardenete   M. Carmen Lima

Universidad Pablo de Olavide, Sevilla, Spain

ABSTRACT

In this paper we provide 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 (MCDM) 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 that we label as *efficient Phillips curve.* We apply our methodological proposal within a particular regional economy, Andalusia, in the south of Spain. We test if the observed policy is efficient and, if not, we analyze to what extent it could be Pareto improved. The aim of this paper is not a doctrinal positioning on economic thought about the existence or not of the Phillips curve, but a methodological framework to revisit the Phillips curve as well as an applied exercise with real data. In fact, this tool could be used to give some keys for policy advise and policy implementation with the intention of fighting against the Andalusian high rate of unemployment.

***JEL Classification*: C61, C68, D78, R13**

***Keywords*: Multicriteria Decision Making, Computable General Equilibrium Model, Efficient Frontier, Multi-objective.**

Corresponding author: M. Carmen Lima

Department of Economics; Universidad Pablo de Olavide; Carretera de Utrera, km. 1; 41013 Seville (SPAIN). e-mail: mlimdia@upo.es.

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 an economy. In simple terms, the lower the unemployment in an economy, the higher the rate of inflation. In this paper we provide a new and alternative approach to this hypothesis which is fully oriented to policy making by empirically identifying an efficient short run trade-off between inflation and unemployment.

The Phillips curve has been the origin of many developments and controversies on the basis of the theory, its differential short and long run behaviour and its utility for political economy purposes. Phelps (1967) and Friedman (1968), under different but convergent approaches, were two of the first authors that revisited the initial concept. They claimed that 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 (rate consistent with equilibrium in a Walrasian system). The inclusion of this “natural rate” as well as a very simple pattern of adaptative expectations (Cagan, 1956 and Nerlove, 1958) in the inflation-unemployment relationship, was known as the “expectations enhanced Phillips curve”. Under this framework, Friedman made a clear distinction between short run and long run Phillips curve. In the short run the curve plots a decreasing slope but, following his assumption based on the idea that unemployment is determined by changes in the behaviour of inflation (no monetary illusion), a completely inelastic curve would remain in the long run.

The stagflation registered during the second half of the sixties and the seventies 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. Although nowadays there is not a unanimous position among the 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 and, therefore, give rise to a positive, rather than negatively relation between inflation and unemployment. Nevertheless, in the short run, inflation and unemployment still can be negatively connected. More importantly, the relation between both of these variables might 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.[1]

In the 60s, the Phillips curve was interpreted as a "policy menu" in the sense that the government, by applying expansive or contractive policies, could choose among different combinations of inflation and unemployment (Samuelson and Solow 1960). As noted by Laidler (2001), Phillips himself never presented the curve as a policy menu, but he was clearly aware that it could be interpreted that 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 criticized in the literature based on the grounds that the natural rate of unemployment might be very difficult to determine and the curve is not likely to remain in one position (see, for example, Laidler 1997 for a discussion).

The aim of this paper is not a doctrinal positioning on economic thought about the Phillips curve, but a new reading on the basic concept of the Phillips-Lypsey curve which endeavours to be better suited for the sake of short-run economic policy making than traditional works on the Phillips curve. Our proposal is to build a set of policy options by using a calibrated structural model of the economic, such as a CGE (Computable General Equilibrium) model to simulate the inflation-unemployment combinations resulting from different policy mixes. Following this approach, we aim at getting something similar to a policy menu.

This work is inspired in a methodological approach introduced by the authors in which policy making is seen as a multicriteria decision making problem (see André, Cardenete and Romero 2010)[2]. The key idea of this approach is that, in standard contexts, it is virtually not possible to combine the preferences of all the members of the society in a single social preference relationship, with reasonable properties. On the other hand, direct observation of the usual practice in policy making does not seem consistent with the optimisation of a single specific function. Rather, policy makers appear to have several macroeconomic objectives that objectives usually conflict with each other. There is a very direct implication of this general principle in terms of inflation and unemployment: a very active anti-unemployment policy will typically foster inflation and the other way around.

Our new proposal here is to envision the (short-run) unemployment-inflation trade-off noted by Phillips as a bicriteria policy problem in which the government is the decision maker. The decision variables are the policy instruments that the government has at hand and the objective variables are unemployment and inflation. Therefore, the policy maker has to design its policy to decide between a lower rate of inflation (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 apply this approach we need a structural model of the economy under study and such model should endogenously give different combinations of inflation and unemployment as the result of different combinations of policy instruments. Specifically, we use a Computable General Equilibrium (CGE) model which turns out to be of considerable help to get operative policy recommendations and, therefore, to decide how to use policy instruments in practice. 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 to the Phillips curve are the following: first, as 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. Second, as compared 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. Finally, 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 the property that they are not Pareto dominated.

As regards the structure of this paper, in Section 2, we present the main characteristics of our methodological approach, the computable general equilibrium model used all over the paper, the database used to calibrate the model and the main elements of our policy design exercise. In Section 3 we display the results of our calculations in which we obtain an *efficient Phillips curve* for the Andalusian Economy. In Section 4 we suggest the policy-oriented interpretation of the Phillips curve as a particular case of a broader approach in which policy design is a decision problem with multiple conflicting objectives. Using these objectives, we show that the observed policy can be improved in several directions with respect to the observed situation (by improving one or more objectives without worsening any of them). Section 5 summarizes the main findings of the paper.

2. METHODOLOGY AND DATA

Our approach consists in determining the Phillips-like 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 combinations. Specifically, we use 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 the unemployment rate and the average price, which is used to compute the inflation rate.

The economic model

The CGE model used in our application follows the basic principles of the walrasian equilibrium -as in Scarf and Shoven (1984) or Shoven and Whalley (1992)-. This kind of models 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, Srinivasan and Whalley (2005) for the state of the art. Following the CGE tradition, this model performs a structural disaggregate representation of the activity sectors in the economy as well as the equilibrium of markets, according to basic microeconomic principles.

Taxes and the activity of the public sector are taken as exogenous by consumers and firms, while they are considered as decision variables by the government. Assuming that consumers maximize their utility and firms maximize their profits (net of taxes), 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, supply equals demand in all the markets ("markets clearance") and public income equals the total payments from all economic agents. To save some space, we only present some basic features of the model. A more detailed description of the model can be found in Cardenete and Sancho (2003b) or André, Cardenete and Velázquez (2005).

The model comprises 25 productive sectors[3] (we provide a list of the sectors disaggregation in Table 1). We deal with one representative firm in each sector, a single representative consumer, one public sector and one foreign sector (which, in our application, represents the commercial relationships between Andalusia and the rest of the world, including the rest of Spain and any other countries).

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.

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

Source: Cardenete and Sancho (2003a).

There are 25 different goods –corresponding to the number of productive sectors- and 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*, as well as it provides transfers to the private sector, *TPS*, and demands goods and services GD_j from each sector $j=1,\ldots,25$. *PD* denotes the final balance (surplus or deficit) of the public budget (in nominal terms):

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

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 Consumer Price

Index 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.

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

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

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

$$\text{(3)} \quad \begin{aligned} & \textit{maximise} && U\,(CD_1,\ldots,CD_{25}, SD) = \left(\prod_{j=1}^{25} CD_j^{\alpha_j} \right) SD^{\beta} \\ & \textit{subject to} && \sum_{j=1}^{25} p_j CD_j + p_{inv}\, SD = YD \end{aligned}$$

p_{inv} being an investment price index. Saving, SD, can be defined as the amount of income which 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, savings are 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:

$$\text{(4)} \quad \sum_{j=1}^{25} INV_j \cdot p_{inv} = SD \cdot p_{inv} + PD + ROWD$$

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 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:

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

where u and $\bar{u}$ are respectively, the unemployment rates in the simulation and in the benchmark equilibrium, *w*/*cpi* is the real wage and β is a flexibility parameter. This formulation is consistent with an institutional setting where the employers decide the amount of labour demanded and workers decide real wage taking into account the unemployment rate (see Kehoe, Polo and Sancho 1995): if labour demand increases (decreases), the unemployment rate u decreases (increases) and workers demand higher (lower) real wages. If, after the simulation, employment remains unchanged, the real wage is the same as in the benchmark equilibrium. For the empirical exercises, we take an estimated value for Spain from the econometric literature: β=1.25 (Andrés *et al.* 1990).

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

Databases and calibration

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

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

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 one during all the analysis) because this kind of models is formulated in terms of relative prices rather than absolute prices. The rest of prices in the model are allowed to vary as required to meet equilibrium conditions and the variations of the other prices 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 what matter are just relative prices 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.

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 (see equation 5) whereas the inflation rate (π) is calculated as the annual rate of change of the consumer price index (cpi):

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

where the subscript denotes the year. The value of cpi for 1994 is exogenously given[4] and the value for 1995 is endogenously determined, as an equilibrium result.

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

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

(7) $$0.95\, \mathbf{x_0} \leq \mathbf{x} \leq 1.05\, \mathbf{x_0}$$

b) Furthermore, to avoid obtaining policies that could affect drastically the public budget, we impose the condition that both the overall tax revenue and the overall public expenditure in goods and services must be equal to their values in the benchmark situation, although the composition by sectors may change[5].

3. 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. The implicit assumption is that the policy maker is concerned about inflation and unemployment as the only policy objectives. In Section 4 we test a way to relax this assumption and get a more realistic setting for policy making.

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? We can asses the degree of conflict between both objectives by computing the so-called payoff matrix. This is done by solving two mono-criteria problems which consists of optimising each objective separately disregarding the other one: firstly, we find the minimum feasible value of unemployment (subject to the specified constraints on the policy variables and all the equations of the model). This minimum value is refereed to as *ideal* value of unemployment and denoted as u^*. By plugging the optimal values of the policy variables $\mathbf{x}_u = arg\ max\ u$ in the relevant equations of the model, we obtain an associated value of inflation. Both of these values constitute the first row of the pay-off matrix (Table 2). In the same way we obtain the ideal (= minimum) value of inflation, π^* and an associated value of unemployment. The worst (= maximum) value of each column is 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.

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.

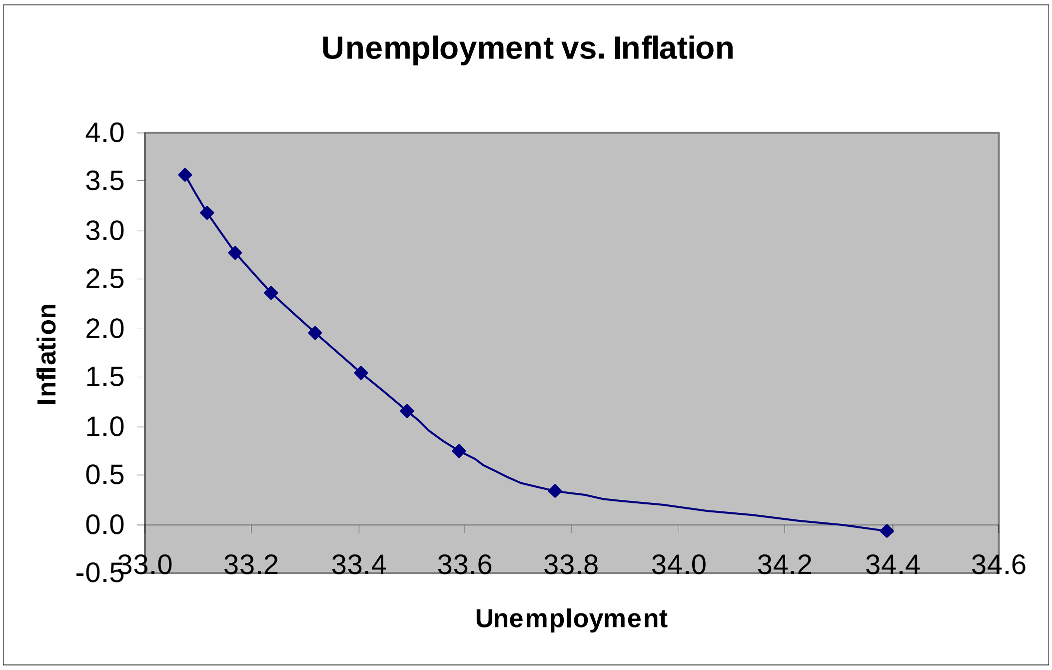
The first row of Table 2 shows that it would be possible to obtain an unemployment rate u^*=33.1%, together with a high inflation rate π_*=3.6%. Similarly, (as the result of an opposite policy) the second row shows another feasible combination with essentially a zero inflation rate (actually, a slight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

From Table 2 we can draw the following conclusions: first, there is a conflict between both objectives, in the sense that it is not possible to get at the same time the minimum feasible unemployment and the minimum inflation rate, since minimizing unemployment implies accepting a higher degree of inflation and the other way round. This conflict is an essential element to have a genuine multicriteria (in this case, bicriteria) problem. The second observation is that, whereas inflation displays a rather wide range of variation, the unemployment in Andalusia, (at least in the period under analysis), seems to show a low degree of sensitivity with respect to 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 2003b) 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[6].

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 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*. We say that a policy combination **x** providing the objective values (u, π) is said to be efficient if there is not another feasible policy **x**' providing (u', π') such that, either $u' \leq u$ and $\pi' < \pi$, or $u' < u$ and $\pi' \leq \pi$. We obtain (an approximation to) the efficient set of policies using the multicriteria technique known as multiobjetive programming implemented by means of the *constraint method*. This procedure consists of optimising one of the objectives, while the other one is placed as a parametric constraint. In our case, we make a grid for the feasible values of π, from $\pi = -0.1$ 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: Trade-off between unemployment and Inflation



Source: Own elaboration.

Figure 1 shows the results of these calculations. It can be seen that, in the set of efficient policies, there is a monotonic relationship between unemployment and inflation but the trade-off between both rates, as measured by the slope of the frontier, is not constant. The resulting curve can be interpreted as an approximation to the traditional short-run Phillips curve. 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 (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) is an empirical finding, not an assumption of the model.

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 may 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 may 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, a subtle remark for his curve should be made when it is to be interpreted as a Phillips curve: since the government can, in principle, implement a wide variety of policy combinations, it is also possible that some of these policies result in unemployment-inflation combinations strictly above (and to the right of) the curve in Figure 2, meaning that the implemented policy is not efficient 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 2 can be labeled as an “efficient Phillips curve” in the sense that all the points in this curve result from efficient 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 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.

4. A BROADER APPROACH: POLICIES WITH MULTIPLE CRITERIA

In this paper we are adopting a very pragmatic approach of the 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 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, first, the maximization of economic growth, γ, calculated as

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

Where GDP_{1994} is the Gross Domestic Product of Andalusia, 1994, which is exogenously given (source: Spanish Statistical Institute, INE) and GDP_{1995} is equilibrium result of the model after any of the simulations. Since GDP_{1994} is given, note that 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 the Public Deficit (*PD*) which is an important political concern in practice in many countries and regions. Finally, since the policy makers are supposed to aim at increasing social welfare, we include as an objective (the maximization of) Compensating Variation (*CV*) which is a conventional welfare measure in monetary terms (see, for example, Mass-Colell, Whinston and Green 1995). We arbitrarily set as zero *CV* in the observed situation, in such a way that $CV > 0$ (<0) means that, after implementing the analyzed policy combination, the consumers are better off (worse off) than before implementing it. Summing up, we have two "more is better" objectives (which must be maximized): growth and compensating variation, and three "less is better" objectives (to be minimized): unemployment, public deficit 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 percentages, whereas *PD* and *CV* are measured in 10^6 euros.

By solving five mono-criteria problems, we get the pay-off matrix for this policy problem, which is shown in Table 3. As in the previous 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) conform the anti-ideal point. A visual inspection of the matrix show that we have the following conflicts among objectives: as discussed above, growth and unemployment have a joint behaviour in the sense that there is no conflict between them, but both of them strongly conflict with inflation and public deficit. Public deficit, in turn, behaves almost exactly the same as inflation. The reason for this is the particular way in which the policy exercises are designed: public deficit is measured in nominal terms (current monetary units) so that its value can vary, on the one hand, because of real shifts in public income or expenditure, and on the other hand, because of changes in prices. As documented in the previous section (see endnote 5), the policy exercises are constrained to give the same (nominal) value for public income, whereas public expenditure is restricted to be constant in real terms. Given these constraints, the only way to reduce (nominal) public deficit is to reduce prices, so that the nominal value of public expenditure will decrease (while the nominal value of public income is fixed). Finally, the compensating variation seems to display a moderate degree of conflict with growth and unemployment and a strong degree of conflict with inflation and public deficit[7].

TABLE 3: Pay-off matrix of the problem with five objectives

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

Source: Own elaboration.

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 illustrate the technique, we force all objectives except the one being optimized to have an equal or better value than that in the observed situation. The observed values (taken from the databases reported in section 3) are the following:

(9) $\gamma = 2.79\%$ $\quad \pi = 4.4\%$ $\quad u = 33.9\%$ $\quad PD = 110800.7$ $\quad CV = 0$

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

(10) $$Max\ \gamma$$

$$\text{subject to} \quad \pi \leq 4.4,\ u \leq 33.9, PD \leq 110800.7, CV \geq 0$$

all the equations of the model

The solution of problem (10) is given by

$\gamma = 3.4$ $\pi = 3.6$ $u = 33.1$ $PD = 108605.4$ $CV = 2243.5$

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

By doing similar calculations for each objective, we obtain five points which are displayed in the rows of Table 4. Note that some rows of this matrix are the same as those in Table 3. Specifically, the solution for growth, unemployment and the compensating variation are the same as in the respective mono-criteria problems. The reason is simply that the constraints imposed are not binding since the unconstrained optima shown in Table 3 dominate the observed situation for all the objectives. Nevertheless, the situation is different for inflation and public deficit, since the unconstrained optimal values (those in Table 3) violate the constraints for growth and unemployment. This makes the constrained optima being different from the unconstrained ones. Nevertheless, observe that, in the optimal solution found, some constraints are 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 can not be sure that the solutions found up to now are efficient, although any of them Pareto-dominates the observed situation.

TABLE 4: Using the constraint method with respect to the observed situation					
	γ (%)	**π (%)**	***u* (%)**	***PD*** ***(10^6 euros)***	***CV*** ***(10^6 euros)***
***Max* γ**	3.4	3.6	33.1	108605.4	2243.5
***Min* π**	3.2	1.7	33.4	105427.3	0.0
Min u	3.4	3.6	33.1	108547.7	2177.4
Min PD	3.2	1.7	33.4	105401.9	0.0
Max CV	3.2	3.9	33.4	110723.8	3049.0
Source: Own elaboration.					

At this point, to find solutions that are efficient for sure, we have two possibilities: the first one is using still the *constraint method* and making the parametric constraints tougher, by increasing the value of the "more is better objectives" (growth and CV) and/or decreasing the value of the "less is better" objectives (inflation, unemployment and public deficit) until we find a solution when all of them are binding at the same time.

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

(11) $$\omega_\gamma \frac{\gamma-\gamma_*}{\gamma^*-\gamma_*}+\omega_\pi \frac{\pi-\pi_*}{\pi^*-\pi_*}+\omega_u \frac{u-u_*}{u^*-u_*}+\omega_{DP} \frac{DP-DP_*}{DP^*-DP_*}+\omega_{CV} \frac{CV-CV_*}{CV^*-CV_*}$$

where each objective is normalized by subtracting the anti-ideal value and dividing by the difference between the ideal and the anti-ideal value (both of them being given in Table 3), so that the resulting quotient is bounded by construction between zero (when the objective is equal to the anti-ideal value) and one (when it is equal to the ideal value)[8]. This normalization eliminates units of measurement and allows the addition having mathematical and economic sense. The coefficients ω_i are preference parameters representing how concerned the policy maker is about each objective *i*. We illustrate the policy combination obtained with $\omega_\gamma = \omega_\pi = \omega_u = \omega_{PD} = \omega_{CV} = 1$, meaning that the policy maker is equally concerned about all the objectives. The maximization of (11) with this set of weights gives the following solution:

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

which Pareto-dominates the observed situation (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 ω_i=1 for a specific objective and ω_j=0 for the rest, meaning that the policy maker is concerned only about objective *i*, we would get the *i*-th row of the pay-off matrix.

5. CONCLUSIONS

In this paper, we combine two methodologies (CGE and MCDM) to get a new, policy-oriented reading of the short-run Phillips curve, initially reported by Phillips (1958), which trade-offs employment against inflation.

We discuss 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. Firstly, from a conceptual perspective, it seems a sensible way to understand and represent the concerns and the procedures actually followed by policy makers.

Secondly, from an empirical perspective, MCDM techniques can be of considerable help to get operative policy advises and, therefore, to decide how to use policy instruments in practice.

A CGE model properly 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 be since as 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.

This paper aims at providing a new an operational approximation to the classical short run Phillips Curve getting some initial insights about what results can be obtained with real data. The analysis can be extended an 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.

Another important conclusion of our approach is that 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 by the analysis of five policy objectives, 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 policymaker to each objective.

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ENDNOTES

[1] For further discussion and new insights about the Phillips curve see Galí and Gertler (1999), Gordon (2009), Karanassou, Sala and Snower (2010) and Usabiaga and Gómez (1996). For applications to the Spanish and the Andalusian economies see Gómez and Usabiaga (2001) and Caraballo and Usabiaga (2009).

[2] See Ballestero and Romero (1998) for an introduction to multicriteria techniques and their applications to economic problems or Figueira, Greco and Ehrgott (2004) for a state of the art review.

[3] 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.

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

[5] 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.

[6] In 1993, the unemployment rate was 23.90% in Spain and 34.18% in Andalusia. In 2002, it was 11.36% in Spain and 19.65% in Andalusia (data from the Andalusian Statistical Institute- IEA). For a better understanding of Andalusian labour market, its

structural problems and rigidities, see Usabiaga (2004) and Lima, Cardenete and Usabiaga (2010).

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

[8] 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.

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