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Abstract

This paper takes a new look at the long-run dynamics of inflation and unemployment in response to permanent changes in the growth rate of the money supply. We examine the Phillips curve from the perspective of what we call "frictional growth," i.e. the interaction between money growth and nominal frictions. After presenting a theoretical model of this phenomenon, we construct an empirical model of the Spanish economy and, in this context, we evaluate the long-run inflation-unemployment tradeoff for Spain and examine how recent policy changes have affected it.

Keywords: Inflation-unemployment tradeoff, Phillips curve, staggered wage contracts, nominal inertia, forward-looking expectations, monetary policy.

JEL Classifications: E2, E3, E4, E5, J3.

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1 Introduction

This paper takes a new look at the long-run dynamics of inflation and unemployment in response to permanent changes in the growth rate of the money supply. We examine the Phillips curve from the perspective of what we call "frictional growth," i.e. the interaction between money growth and nominal frictions. In this context, we show a long-run tradeoff between inflation and unemployment can arise, even when agents have rational expectations and no money illusion and there are no permanent nominal rigidities. After presenting a theoretical model of this phenomenon, we construct an empirical model of the Spanish economy that aims to capture the essential features of the interplay between money growth and prolonged nominal adjustment processes. In this framework, we evaluate the long-run inflation-unemployment tradeoff for Spain and examine how recent policy changes have affected it.

The mainstream analysis of inflation and unemployment rests on the standard assumption that economic agents make their demand and supply decisions on the basis of real variables alone and thus, in the long-run labor market equilibrium, a change in the money supply has no real effects; it simply changes all nominal variables in proportion. It was on the basis of such money neutrality that Friedman (1968) and Phelps (1968) formulated the natural rate (or NAIRU) hypothesis, in which there is no permanent tradeoff between inflation and unemployment.[1]

We show that in the presence of money growth and time-contingent nominal contracts, this argument does not necessarily hold. Under plausible circumstances, namely a nonzero discount rate, changes in money growth may affect the unemployment rate and other real variables in the long-run. This result enables our analysis to avoid a well documented - but frequently ignored - counterfactual prediction of the NAIRU theory: Supposing that the NAIRU is reasonably stable through time - a commonly made assumption - inflation falls (rises) without limit when unemployment is high (low).

Our model of the Phillips curve rests on three empirical regularities: (i) the growth rate of the money supply is nonzero, (ii) there is some nominal inertia, so that a current nominal variable is slow to adjust to money growth shocks, and (iii) unemployment is influenced by the ratio of the nominal money supply to that nominal variable (such as the ratio of the money supply to the price level).

The first regularity provides a reasonable time-series description of the money supply in most OECD countries. The second stylized fact is well established empirically and has

[1] Recent microfoundations of the New Phillips Curve often generate a relation of the form $\pi_t = \beta E_t \pi_{t+1} - a\left(u_t - u^n\right) + \varepsilon_t$, where π is the inflation rate, u is the unemployment rate, u^n is the natural rate of unemployment or NAIRU, β is the discount factor, and ε_t is white noise. This Phillips curve is generally taken to be virtually vertical, on the reasoning that the discount factor β is close to unity. Accordingly, in policy analysis this factor is usually set equal to unity and the focus of interest is predominantly the persistence of inflation, rather than permanent real effects of monetary policy.

been rationalized theoretically.[2] In the presence of staggered time-contingent nominal contracts, current wages are a weighted average of their past and expected future values. It can be shown that when there is positive time discounting the past is weighted more heavily than the future. It is this "intertemporal weighting asymmetry" that allows the phenomenon of frictional growth to manifest itself and produce a long-run inflation-unemployment tradeoff. The third regularity can take a variety of conventional forms, e.g. a change in the ratio of the money supply to the price level may affect aggregate demand and thereby the unemployment rate.

Our analysis is akin to several recent breakthroughs concerning the relation between real and monetary activities. Akerlof, Dickens and Perry (1996, 2000) show that in the presence of permanent downward wage rigidities arising from non rational expectations, there is a downward-sloping tradeoff between inflation and unemployment at low inflation rates. In our analysis, by contrast, agents have rational expectations. Holden (2004) argues that, a downward-sloping tradeoff at low inflation rates is due to the strategic consideration that, in wage negotiations in many European countries, nominal wages can be changed only by mutual consent. Hughes-Hallett (2000) shows how a non vertical inflation-unemployment tradeoff can arise due to aggregation over sectoral/regional Phillips curves with heterogenous short-run slopes. In contrast to these contributions, our derivation of a long-run Phillips curve does not rely on non rational expectations, nominal rigidities in bargaining, or aggregation.

We provide an empirical evaluation of this framework for the Spanish economy, based on the estimation of a multi-equation model. We derive the Phillips curve and find it to be far from vertical in the long-run, i.e., we find that disinflation is costly. Our analysis, therefore, suggests that tight monetary policy played a significant role in the increase of Spanish unemployment both in the aftermath of the oil price shocks and in the early 1990s. Had policy makers followed a less contractionary monetary policy, unemployment rate would have been substantially lower. This finding is at stark contrast with the conventional view that institutions like taxes, benefits, employment protection legislation (EPL), and union power are the main driving force of the upward trend in the unemployment rate.

In Section 2, we present a theoretical model of the Phillips curve and show how frictional growth can lead to a long-run inflation-unemployment tradeoff. In Section 3, we discuss the empirical implications of our theoretical analysis and the various unresolved issues in the recent literature on the estimation of the Phillips curve. In Section 4 we estimate a multi-equation model of the Spanish economy. In turn, in

[2] See, for example, Taylor (1979) on wage staggering, Calvo (1983), or Lindbeck and Snower (1999) on price precommitment with production lags. The literature on the effectiveness monetary policy under wage-price staggering has been surveyed by Clarida, Galí and Gertler (1999), Goodfriend and King (1997), Mankiw (2001), and others.

Section 5, we use this empirical model to derive the long-run inflation-unemployment tradeoff and evaluate how this tradeoff has been affected by major shifts in economic policy. In the light of this evidence, Section 6 provides a reappraisal of the Spanish experience. Finally, Section 7 concludes.

2 A Theoretical Model

We present a transparently simple macro model, belonging to a wider, well known family that has been given microfoundations in Graham and Snower (2002) and related work by Ascari (1998, 2000) and Karanassou, Sala, and Snower (2005). In what follows, all uninteresting constants are ignored.

We consider a labor market containing a fixed number of identical firms with monopoly power in the product market. The i'th firm has a production function of the form

$$q_{i,t}^S = An_{i,t}^{\sigma}, \tag{1}$$

where $q_{i,t}^S$ is output supplied, $n_{i,t}$ is employment, A and σ are positive constants, and $0 < \sigma < 1$. Each firm faces a product demand function of the form

$$q_{i,t}^D = \left(\frac{p_{i,t}}{p_t}\right)^{-\eta} \frac{q_t^D}{f}, \tag{2}$$

where q_t^D stands for aggregate product demand (to be specified below), f is the number of firms, $p_{i,t}$ is the price charged by firm i, p_t is the aggregate price level, and η is the price elasticity of product demand (a positive constant).

The firm's profit maximizing employment decision sets its marginal revenue ($MR_{i,t} = p_{i,t}\left(1 - \frac{1}{\eta}\right)$) equal to its marginal cost ($MC_{i,t} = \omega_{i,t}\left(\frac{\partial n_{i,t}}{\partial q_{i,t}}\right) = \frac{\omega_{i,t}}{\sigma A} n_{i,t}^{1-\sigma}$ where $\omega_{i,t}$ is the wage paid by the firm). Thus the firm's labor demand is given by $\frac{\omega_{i,t}}{\sigma A} n_{i,t}^{1-\sigma} = p_{i,t}\left(1 - \frac{1}{\eta}\right)$. In the labor market equilibrium, $p_{i,t} = p_t$ and $\omega_{i,t} = \omega_t$, due to symmetry. Aggregating all the individual firms' labor demand functions and taking logarithms, so that $N_t = \log(fn_{i,t})$, we obtain the following aggregate employment equation:

$$N_t = a - a_w (W_t - P_t), \tag{3}$$

where $W_t = \log(\omega_t)$, $P_t = \log(p_t)$, $a = \frac{\log\left(1-\frac{1}{\eta}\right) + \log(\sigma A) + (1-\sigma)\log f}{1-\sigma}$, and $a_w = \frac{1}{1-\sigma}$.

The labor supply is constant

$$L_t = L, \tag{4}$$

so that the unemployment rate (not in logs) can be approximated as

$$u_t = L - N_t. \tag{5}$$

Our aggregate price equation is equivalent to the aggregate employment equation under product market clearing. The product market clearing condition is $fAn_{i,t}^{\sigma} = q_t^D$. Taking logs, defining $h = \log\left(Af^{1-\sigma}\right)$ and $Q_t^D = \log\left(q_t^D\right)$, and rearranging gives: $N_t = \frac{1}{\sigma}Q_t^D - \frac{h}{\sigma}$. Substituting this equation into the aggregate employment equation (3), we obtain the following price equation:[3]

$$P_t = W_t + \rho Q_t^D - \delta, \tag{6}$$

where $\rho = \frac{1}{\sigma a_w} = \frac{1-\sigma}{\sigma}$, and $\delta = \frac{a}{a_w} + \frac{h}{\sigma a_w}$.

Our nominal frictions are the staggered wage contracts of Taylor (1979, 1980a). Along the standard lines, we suppose that there are two wage contracts, evenly staggered, each lasting for two periods. Let Ω_t be the (log of the) contract wage negotiated at the beginning of period t for periods t and $t+1$. Taylor's staggered contract equation is

$$\Omega_t = \alpha\Omega_{t-1} + (1-\alpha)\, E_t\Omega_{t+1} + \gamma\left(c + \alpha\Gamma_t + (1-\alpha)\, E_t\Gamma_{t+1}\right) + \zeta_t, \tag{7}$$

where ζ_t is a white noise process, α, γ, and c are positive constants, and E_t is the expectations operator, denoting the expectation conditional on information available at time t. We assume that agents do not have information about ζ when they set their wage contracts at time t, so $E_t\zeta_t = 0$.

The "demand sensitivity parameter" γ describes how strongly wages are influenced by demand, and the "cost-push parameter" c describes the upward pressure on wages in the absence of excess demand. The variable Γ_t is what Taylor calls "excess demand," specified as actual output (Q_t^s) less full-employment output (in logs). By the production function (1), full-employment output is $Q_t^s = \sigma L + h$, or $Q_t = \sigma L + h$ since we assume that the product market clears. Thus excess demand (in logs) is

$$\Gamma_t = Q_t - \sigma L - h. \tag{8}$$

The fundamental principle of finance that "a dollar today worths more than a dollar tomorrow," implies that the coefficient α is a discounting parameter equal to $\frac{1+r}{2+r}$, where r is the discount rate. This can be seen as follows. The one-period ahead wage (Ω_{t+1}) needs to be discounted by the factor $\beta = \frac{1}{1+r}$ so that it is used in the wage-staggering equation (7) alongside with the wage set in the previous period (Ω_{t-1}) that still applies in period t. Given that wage-staggering requires that the wage set at period t is a weighted average of past and future wages and their respective weights add up to $1+\beta$,

[3] To see this, rewrite the employment equation as $P_t = -\frac{a}{a_w} + W_t + \frac{1}{a_w}N_t$.

we need to rescale them by the parameter $\alpha = \frac{1}{1+\beta}$ so that they add up to unity. It then follows that time discounting and a nonzero interest rate (so that $\beta < 1$ and $\alpha > 1/2$) give rise to an asymmetry in wage determination: the current wage Ω_t is affected more strongly by the past wage Ω_{t-1} than the future expected wage $E_t\Omega_{t+1}$. This result is also obtained by the microfoundations of the contract equation under time discounting[4] - which, for brevity, we need not summarize here.[5]

The average wage is

$$W_t = \frac{1}{2}\left(\Omega_t + \Omega_{t-1}\right). \tag{9}$$

Aggregate demand $\left(Q_t^D\right)$ depends on real money balances

$$Q_t^D = M_t - P_t, \tag{10}$$

where M_t is the log of the money supply. (For brevity, again, we omit the standard microfoundations.)

Since we wish to focus on the long-run inflation-unemployment tradeoff and since movements along this tradeoff arise from permanent changes in money growth, let money growth have a unit root:

$$\Delta M_t \equiv \mu_t = \mu_{t-1} + \varepsilon_t, \tag{11}$$

where ε_t is a white-noise error term. However, it is easy to show that our qualitative conclusions do not depend on the random walk assumption. Any stochastic process that allows for a permanent change in money growth is sufficient for our purposes.[6]

This implies that the contract wage may be expressed in terms of its own lagged value and the money supply:[7]

$$\begin{aligned}\Omega_t = {} & (1-\lambda_1)(1+\rho)(c - \sigma L - h) + (1-\lambda_1)\delta + \lambda_1\Omega_{t-1} \\ & + (1-\lambda_1)M_t + \kappa(1-\lambda_1)\mu_t + \zeta_t,\end{aligned} \tag{12}$$

where $\lambda_{1,2} = \frac{\phi_2 \mp \sqrt{\phi_2^2 - 4\phi_1\phi_3}}{2\phi_3}$, and $\kappa = \frac{\lambda_2}{\lambda_2 - 1} - \alpha$. It can be shown that $0 < \lambda_1 < 1$ and

[4] Ascari (2000), Ascari and Rankin (2002), Graham and Snower (2002), Helpman and Leiderman (1990), and others. See also Huang and Liu (2002).

[5] Since this result is derived by linearizing a wage equation around a steady state of zero money growth, the theoretical analysis of this section applies only to money growth rates that are sufficiently low.

[6] The Appendix of the Discussion Paper version of Karanassou, Sala and Snower (2005) - http://ftp.iza.org/dp636.pdf- shows that our central results can be derived from other money growth processes as well.

[7] To see this, substitute the price equation (6) and the wage equation (9) into the aggregate demand equation (10):

$$Q_t = \left(\frac{1}{1+\rho}\right)M_t - \frac{1}{2(1+\rho)}\left(\Omega_t + \Omega_{t-1}\right) + \frac{\delta}{1+\rho}.$$

$\lambda_2 > 1$ when $0 < \gamma < 2(1+\rho)$.

Substituting (12) into (9), we obtain the aggregate nominal wage dynamics equation:

$$W_t = (1-\lambda_1)(1+\rho)(c-\sigma L-h) + (1-\lambda_1)\delta + \lambda_1 W_{t-1} + (1-\lambda_1) M_t + \left(\kappa - \frac{1}{2}\right)(1-\lambda_1)\mu_t - \frac{1}{2}\kappa(1-\lambda_1)\varepsilon_t + \frac{1}{2}\left(\zeta_t + \zeta_{t-1}\right). \tag{13}$$

Note that in the long-run, wage inflation is equal to the money growth rate: $\Delta W_t^{LR} = \mu_t^{LR}$.[8]

To derive the dynamics of the real wage, we first express price in terms of wages and money (i.e., insert (10) into (6)):

$$P_t = (1-\theta) W_t + \theta M_t - (1-\theta)\delta, \tag{14}$$

where $\theta = \frac{1}{1+\rho}$. Observe that equations (13) and (14) imply that in the long-run, inflation is equal to the money growth: $\pi_t^{LR} = \mu_t^{LR}$. In other words, money illusion is absent in the above system of equations: if all nominal variables are changed in equal proportion, then the associated real variables remain unchanged. Nevertheless, it can be shown that there is a long-run inflation-unemployment tradeoff and that changes in money growth can move the economy along this tradeoff.

Next, substitute this equation and (8) into the contract equation (7):

$$\Omega_t = \alpha\Omega_{t-1} + (1-\alpha) E_t\Omega_{t+1} + \gamma(c-\sigma L-h) + \frac{\delta}{1+\rho} + \zeta_t + \gamma\alpha\left[\left(\frac{1}{1+\rho}\right) M_t - \frac{1}{2(1+\rho)}\left(\Omega_t + \Omega_{t-1}\right)\right] + \gamma(1-\alpha)\left[\left(\frac{1}{1+\rho}\right) E_t M_{t+1} - \frac{1}{2(1+\rho)}\left(E_t\Omega_{t+1} + \Omega_t\right)\right].$$

Apply the expectations operator E_t on the above equation, recall that $E_t\zeta_t = 0$, collect terms together, so that

$$\phi_1 E_t\Omega_{t-1} + \phi_2 E_t\Omega_t + \phi_3 E_t\Omega_{t+1} = -\gamma(1+\rho)(c-\sigma L-h) - \gamma\delta - \gamma\left[\alpha E_t M_t + (1-\alpha) E_t M_{t+1}\right],$$

where $\phi_1 = \alpha\left(1+\rho-\frac{\gamma}{2}\right)$, $\phi_2 = \left(1+\rho+\frac{\gamma}{2}\right)$, $\phi_3 = (1-\alpha)\left(1+\rho-\frac{\gamma}{2}\right)$.

Assuming that the contract wage Ω_t is dynamically stable, the rational expectations solution of the previous equation is given by (12).

[8]The wage inflation equation is given by the first difference of (13):

$$(1-\lambda_1 B)\Delta W_t = (1-\lambda_1)\mu_t + \left(\kappa - \frac{1}{2}\right)(1-\lambda_1)\varepsilon_t - \frac{1}{2}\kappa(1-\lambda_1)\Delta\varepsilon_t + \frac{1}{2}\left(\Delta\zeta_t + \Delta\zeta_{t-1}\right),$$

where B, Δ are the backshift and first difference operators, respectively. The long-run solution of the above equation is obtained by setting the error terms (ζ_t, ε_t) equal to zero and the backshift operator B equal to unity.

Substituting (13) into (14), we find the real wage dynamics equation:[9]

$$W_t - P_t = (1-\lambda_1)(c - \sigma L - h + \delta) + \lambda_1 (W_{t-1} - P_{t-1}) - (1-\lambda_1)\left(\frac{2\alpha - 1}{\gamma}\right)\mu_t - \frac{\theta}{2}\kappa(1-\lambda_1)\varepsilon_t + \frac{\theta}{2}\left(\zeta_t + \zeta_{t-1}\right). \quad (15)$$

An obvious deficiency of the above real wage equation is that, on its own, it implies that real wages always move counter-cyclically, and this prediction is counterfactual. The evidence suggests that although real wages are counter-cyclical in some countries during some time periods, there are plenty of occasions in which they are pro-cyclical and acyclical. In practice, however, the real wage channel is unlikely to operate in isolation. Furthermore, it is well to keep in mind that, in practice, the real wage moves in response to many determinants, of which the money supply is only one. Thus an inverse relation between the real wage and money growth may coexist with pro-cyclical real wage behavior.

Inserting the real wage (15) into the employment equation (3) and the unemployment rate (5), we derive the unemployment dynamics equation:

$$u_t = (1-\lambda_1)(1 - a_w\sigma)L + (1-\lambda_1)[a_w(c + \delta - h) - a] + \lambda_1 u_{t-1} - a_w(1-\lambda_1)\left(\frac{2\alpha-1}{\gamma}\right)\mu_t - a_w\frac{\theta}{2}\kappa(1-\lambda_1)\varepsilon_t + a_w\frac{\theta}{2}\left(\zeta_t + \zeta_{t-1}\right). \quad (16)$$

Thus the long-run unemployment rate is

$$u_t^{LR} = (1 - a_w\sigma)L + a_w(c + \delta - h) - a - a_w\left(\frac{2\alpha - 1}{\gamma}\right)\mu_t^{LR}. \quad (17)$$

Given that $\pi_t^{LR} = \mu_t^{LR}$, the long-run Phillips curve is[10]

$$\pi_t^{LR} = -\frac{\gamma(1-\sigma)}{(2\alpha-1)}u_t^{LR} + \left(\frac{\gamma}{2\alpha-1}\right)\left[c + (1-2\sigma)\left(L + \frac{h}{\sigma}\right)\right]. \quad (18)$$

[9] Equations (13) and (14) imply

$$W_t - P_t = (1-\lambda_1)(c - \sigma L - h + \delta) + \lambda_1(W_{t-1} - P_{t-1}) - \theta\left[\frac{1}{2}(1+\lambda_1) - \kappa(1-\lambda_1)\right]\mu_t - \frac{\theta}{2}\kappa(1-\lambda_1)\varepsilon_t + \frac{\theta}{2}\left(\zeta_t + \zeta_{t-1}\right).$$

It can be shown that $\theta\left[\frac{1}{2}(1+\lambda_1) - \kappa(1-\lambda_1)\right] = (1-\lambda_1)\left(\frac{2\alpha-1}{\gamma}\right)$, and thus we obtain (15).

[10] Specifically, the long-run Phillips curve is

$$\pi_t^{LR} = -\frac{\gamma}{a_w(2\alpha-1)}u_t^{LR} + \frac{\gamma[(1-a_w\sigma)L + a_w(c+\delta-h) - a]}{a_w(2\alpha-1)}.$$

Recalling that $a_w = \frac{1}{1-\sigma}$ and $\delta = \frac{a}{a_w} + \frac{h}{\sigma a_w}$, substituting these expressions into the above equation, and through some algebraic manipulation, we obtain the long-run Phillips curve (18).

Note that, since $\frac{1}{2} < \alpha < 1$, there is a tradeoff between inflation and unemployment both in the short-run and the long-run.[11]

As we can see, the long-run Phillips curve is flatter,

- the greater is the interest rate, and thus the more backward-looking is the contract wage (i.e. the greater is α),
- the less sensitive is the contract wage to aggregate demand (i.e. the lower is γ), and
- the closer to unity is σ, i.e., the less diminishing are the returns to labor.

Intuitively, when α rises or γ falls, the average nominal wage - and therefore the price level - responds more slowly to an increase in money growth. Thus a given increase in money growth leads to a larger increase in the real wage, a larger rise in labor demand, and thus a larger decline in unemployment.

It is easy to see that, for parameter values common in the literature, the long-run Phillips curve is far from vertical. We can express the slope of this Phillips curve as $-\frac{\gamma(2+r)(1-\sigma)}{r}$, where r is the discount rate ($\beta = \frac{1}{1+r}$). When $\sigma = 0.75$ and γ is 0.1,[12] the slope is -2.53 for a discount rate of 2 percent, and it is -1.03 for a discount rate of 5 percent.

Two upshots from this analysis are important to be emphasized. First, the real wage channel is unlikely to be operative in isolation. Indeed, the theoretical model above is far too narrowly focused to generate reliable measures of the inflation-unemployment tradeoff. We can gain a broader perspective through an estimated macro model, to which we turn in the following sections.

Second, if the long-run Phillips curve is not vertical, permanent changes in money growth are associated with changes in real activity. This implies that the NAIRU does not exist and, instead, different long-run unemployment rates are associated with different long-run money growth and inflation rates. Our approach, therefore, suggests a reevaluation of how monetary policy affects macroeconomic activity and sheds new light on our understanding of macroeconomic events.

3 Empirical Considerations

Modeling the inflation-unemployment tradeoff involves some hard choices. Our theoretical model in the previous section provides the following insights for our empirical

[11] Of course, this occurs under diminishing returns to labor ($0 < \sigma < 1$). Increasing returns to labor will produce an upward-sloping Phillips curve.

[12] There is broad disagreement about the appropriate value of γ. Empirical estimates range from around 0.5 to 0.1 (see, for example, Taylor (1980b) and Sachs (1980)), whereas calibration of micro-founded models often assigns values between 0.2 and 1 (see, for example, Huang and Liu (2002)).

concerns:

1. The phenomenon of frictional growth cannot be captured by estimating a single-equation Phillips curve. The reason is that a single-equation Phillips curve does not contain money growth as an argument. After all, the Phillips curve is simply an equation that translates the impulse-response function of inflation to a monetary shock into the impulse-response function of unemployment to that shock; thus the monetary shock is substituted out in deriving the relation between inflation and unemployment. Consequently, the single-equation Phillips curve cannot portray the interplay between money growth and nominal frictions, which is the focus of our analysis.

2. This phenomenon of frictional growth can be assessed by estimating a multi-equation system, containing wage-price equations as well as real equations. The nominal wage-price equations are to describe how the nominal variables depend on the money supply and, via the nominal frictions, on the past and future nominal variables. Then, in the presence of frictional growth, money growth shocks lead to changes in the relative magnitudes of nominal variables, such as changes in real money balances or changes in the real wage. On this basis, the real equations are to describe how real variables, such as unemployment, respond to these changes in the relations among nominal variables.

3. The relation of wages and prices to their past and expected future values may be expressed in terms of nominal equations that are backward-looking. The reason, as explained above, is that when the general equilibrium model is solved, the expected future values of nominal variables can be expressed in terms of current and past endogenous variables.

The mainstream empirical literature on the Phillips curve, however, has pursued a different track, focusing on single-equation estimation. Overall, there is no agreement about the appropriate method of estimating the New Phillips curve (NPC) and how to test it against the traditional Phillips curve. The core of the forward-looking NPC is an equation of the form

$$\pi_t = \beta E_t \pi_{t+1} + \gamma x_t, \tag{19}$$

where the forcing variable x_t is a measure of excess demand (unemployment rate, output gap) or a measure of real marginal costs (such as the labor share in GNP). The hybrid

Phillips curve is commonly expressed as[13]

$$\pi_t = \beta^f E_t \pi_{t+1} + \beta^b \pi_{t-1} + \gamma x_t. \tag{20}$$

It is customary to use the lead of inflation as a proxy for expected future inflation and rewrite the forward-looking NPC (19) as

$$\pi_t = \beta \pi_{t+1} + \gamma x_t + \epsilon_{t+1} \tag{21}$$

where the expectational error ϵ_{t+1} is proportional to $(E_t \pi_{t+1} - \pi_{t+1})$. Under rational expectations this error is unforecastable at time t, i.e. it is uncorrelated with information dated t and earlier. Thus the NPC can be consistently estimated by using a set of variables z_t (dated t and earlier) to instrument actual future inflation π_{t+1}. The orthogonality condition $E_t \left[(\pi_t - \beta \pi_{t+1} - \gamma x_t) z_t \right] = 0$ can be used to estimate the model (21) via the generalized method of moments (GMM). Alternatively, two stage least squares can be used since the model is linear in the parameters. Bårdsen, Jansen and Nymoen (2004) show that the empirical results of the above model are sensitive to the choice and exact implementation of the estimation method.

The choice of the forcing variable is crucial when estimating the inflation dynamics associated with the Phillips curve. Galí and Gertler (1999), Galí, Gertler and López-Salido (2001) estimate (21) with GMM and find evidence in support of the NPC only when they use labor income share (rather than the output gap or unemployment) as the forcing variable.[14] As Galí and Gertler indicate, the resulting equation should be called an inflation dynamics equation, rather than a Phillips curve, since the latter is meant to describe the relation between inflation and some measure of the magnitude of macroeconomic activity.

Rudd and Whelan (2005) observe that rational expectations should also be model consistent and thus use repeated substitution to express equation (19) in terms of a present value term of the forcing variable: $\pi_t = \beta^{k+1} E_t \pi_{t+k+1} + \gamma \sum_{j=0}^{k} \beta^j E_t x_{t+j}$. When they include lagged inflation terms in the above equation and estimate it with GMM, they report results that are consistent with a backward-looking (traditional) Phillips curve. However, Galí, Gertler and López-Salido (2005) argue that the Rudd-Whelan framework cannot provide consistent estimates of the structural parameters of the hybrid model (20).

[13] In the context of the hybrid specification of the Phillips curve (20), much of the current literature is concerned with the question of whether the observed inflation autocorrelation results from backward looking behavior $\left(\beta^f = 0\right)$ or forward looking behavior $\left(\beta^b = 0\right)$ that is proxied by inflation lags.

[14] Also, Galí and López-Salido (2001) show that the NPC fits the Spanish data well over the disinflationary period 1980-1998.

Lindé (2005) rearranges (21) by having future inflation on the left hand side and estimates the resulting equation by nonlinear least squares. He finds that the NPC does not perform well when either real marginal costs or output are used as forcing variables. Galí, Gertler and López-Salido (2005) argue that nonlinear least squares is inappropriate since the explanatory variables may be correlated with the error term.

GMM estimation of the NPC is also sensitive to the choice of instruments. One would expect that the test for overidentifying restrictions can detect invalid instruments, but it is widely accepted that this test has low power. In addition, Bårdsen, Jansen and Nymoen (2004), and Rudd and Whelan (2005) argue that the results can be significantly biased by using variables as instruments that actually belong in a well-specified inflation regression. Furthermore, estimation is sensitive to the time span of the chosen instruments, i.e. whether the instrument list should be dated t and earlier or $t-1$ and earlier.[15]

Finally, the exogeneity/endogeneity of the driving variable x_t is of major importance. Bårdsen, Jansen and Nymoen (2004) argue that the derivation of the dynamic properties of inflation require an analysis of a system that includes the forcing variable as well as the rate of inflation and conclude that "..as statistical models, both the pure and hybrid NPC are inadequate."

In view of these unresolved empirical issues and the desirability of estimating the Phillips curve through an equation system in which both inflation π_t and the macroeconomic activity variable x_t are endogenous, it appears appropriate to align our empirical analysis closely to the empirical implications of our theory, noted at the beginning of this section. Accordingly, we proceed to construct an empirical model in which the Phillips curve is derived from an estimated system of real and nominal equations. These equations describe how monetary shocks affect the relative magnitudes of nominal variables and thereby affect the real variables.

4 Empirical Implementation

This section applies our analysis of the inflation-unemployment tradeoff to an empirical investigation of the Spanish economy. Spain is a particularly interesting country for

[15] For example, Galí and Gertler (1999) and Rudd and Whelan (2005) use instruments dated t and earlier, whereas Galí, Gertler and López-Salido (2001) and Bårdsen, Jansen and Nymoen (2004) use instruments dated $t-1$ and earlier. The latter papers justify the use of lagged instruments on the basis of considerable error in the measure of the driving variable x_t. The use of lagged instruments can also be motivated by an expectational error that arises when the NPC (19) is the outcome of wage staggering à la Taylor: $\pi_t = \beta E_t \pi_{t+1} + \gamma x_t + \beta \left(E_{t-1} P_t - P_t \right)$. (See, for example, Roberts (1995)). Thus the inflation equation to be estimated is $\pi_t = \beta \pi_{t+1} + \gamma x_t + \epsilon_{t+1} + v_t$, where $v_t = \beta \left(E_{t-1} P_t - P_t \right)$. Note that v_t is a (rational) expectational error unforecastable at period $t-1$ and thus uncorrelated with information dated $t-1$ and earlier. In this case, for consistent estimation, the instrument list should contain lagged values of the variables involved.

such an analysis, since it has witnessed major institutional and policy changes over the past three decades - the transition to democracy, the advent of unionized collective wage bargaining, several waves of labor market reforms, entry into the EEC, and central bank independence, to name a few. We attempt to capture shifts of policy regimes through the use of dummy variables in our empirical model. This is a transparently rough procedure, but difficult to refine in macroestimation.

We first present estimates of a structural model of the Spanish economy, in which context the long-run inflation-unemployment tradeoff can be derived. We then investigate how various important institutional and policy changes in Spain over the past few decades may have affected this tradeoff. Due to data limitations, however, our results should be seen as merely a tentative, first step towards a full-blown empirical reappraisal of the Phillips curve on the basis of frictional growth.

Finally, we endeavor to take seriously the common finding that productivity growth and capital accumulation play an important role in determining employment and unemployment. Thus productivity and the capital stock are not exogenous variables in our analysis;[16] rather, our empirical model includes an aggregate production function, relating output to employment and capital, and a capital stock equation, containing further lagged endogenous variables.

This leaves us with a sizable econometric model, comprising seven equations: employment, labor force,[17] wage, price, and capital stock equations, as well as a production function and the definition of the unemployment rate. This leaves us with fewer degrees of freedom than we might ideally wish for, but more than enough to identify well-specified structural equations. There is a well-known tradeoff between structural detail and the power of econometric tests and our empirical model favors the structural detail.

Our theoretical analysis and attention to policy changes have led us to chose structural modeling rather than the VAR approach.[18] The structural models are able to give more attention to policy variables and other exogenous variables outside the labor market, which tend not to be included in the VAR models.

[16] Just as the costs of buying and selling (or depreciating) capital make investment decisions intertemporal, so the costs of hiring, training and firing labor make employment decisions intertemporal as well. Thus, we view firms as making their employment, investment, and production decisions together, with reference to broadly similar time horizons. On this account it appears inadvisable to treat the capital stock and productivity as exogenous when estimating an employment equation.

[17] Empirical macroeconomic models of the Spanish labor market have tended to focus on employment rather than the labor force. A significant exception is De Lamo and Dolado (1993).

[18] Both approaches have received ample attention in empirical labor market studies. Following Blanchard and Quah (1989), a number of the recent studies devoted to the Spanish labor market analysis opt for the structural VAR approach. For instance, Dolado and Jimeno (1997), Andrés *et al.* (1998) or Dolado *et al.* (2000) estimate VAR models. On the other hand, the structural modeling approach, in a partial equilibrium setting, has been followed by others, e.g. Andrés *et al.* (1990) or Blanchard *et al.* (1995).

Our estimation uses OECD annual data over a sample from 1966 to 1998.[19] The definitions of variables are given in Table 1.

Table 1: Definitions of variables

M_t	money supply (M3)	N_t	employment
P_t	price level (GDP deflator)	L_t	labor supply
W_t	nominal wages	u_t	unemployment rate
w_t	real wage $(W_t - P_t)$	Z_t	working age population
m_t	real money balances $(M_t - P_t)$	τ_t	indirect taxes as a % of GDP
θ_t	real labor productivity	b_t	real social security benefits
y_t	real GDP	P_t^I	import price level
k_t	real capital stock	c_t	competitiveness $(\frac{\text{import price}}{\text{GDP deflator}})$
t	linear time trend		
d_t^j	$= \left\{ \begin{array}{l} 1, \text{ for } t = j, ..., 1998, \ j > 1971 \\ 0, \text{ otherwise} \end{array} \right\}$	d_t^{71}	$= \left\{ \begin{array}{l} 1, \text{ for } t = 1971 \\ 0, \text{ otherwise} \end{array} \right\}$

All variables are in logs except for the unemployment rate u_t and the tax rate τ_t.
For any variable x_t in our data set, slope dummies are given by $x_t^j = d_t^j x_t$.

We first estimated each of the equations in our model using the autoregressive distributed lag (ARDL) approach to cointegration analysis,[20] and used the Akaike and Schwarz information criteria to determine the optimal lag-length. The selected specifications are dynamically stable (i.e., the roots of their autoregressive polynomials lie outside the unit circle), and pass the standard diagnostic tests (for no serial correlation, linearity, normality, homoskedasticity, and constancy of the parameters of interest) at conventional significance levels. An important implication of the above methodology is that the long-run solution of the ARDL can be interpreted as the cointegrating vector of the variables involved (since an ARDL equation can be reparameterized as an error correction one).

Next, the following plausible restrictions were imposed on the model and accepted by the data: (i) constant returns to scale in production,[21] (ii) the long-run elasticity of the labor force with respect to the working age population is unity, and (iii) absence of money illusion.[22] Finally, we estimated the equations of our macro model as a system, using three stages least squares (3SLS), to take into account potential endogeneity of

[19] 1998 is the last year that data is available on the individual money supply series of the EMU countries.

[20] Pesaran (1997), Pesaran and Shin (1999) and Pesaran *et al.* (2001), show that the traditional ARDL estimation procedure can be applied even when the variables follow I(1) processes. (See also Henry, Karanassou, and Snower (2000) for an application of this approach and a discussion of its merits.)

[21] The sum of the labor and capital coefficients in our Cobb-Douglas production function is unity.

[22] That is, the equations in our model are homogeneous of degree zero in all nominal variables. This restriction was imposed and accepted in the wage and price equations, and it automatically holds in all other equations since the real endogenous variables only depend on real variables.

the regressors and cross equation correlation.[23]

Tables 2a and 2b present the restricted 3SLS estimates of each equation. In the nominal wage equation, the explanatory variables have coefficients of plausible magnitudes and signs, e.g. wages are inversely related to the unemployment rate and positively related to productivity. The price equation has a similar structure to the wage equation. Higher wages contribute to rise prices, but with some delay, and with a substantially smaller effect than prices on wages. Money supply exerts a greater influence on prices than on wages in the short-run.

Table 2a: Spanish model, 3SLS, 1966-1998.

Dependent variable: W_t			Dependent variable: P_t			Dependent variable: L_t		
	coef.	t-stat.		coef.	t-stat.		coef.	t-stat.
Cnt	5.36	(6.79)	Cnt	−7.02	(−10.8)	Cnt	0.02	(0.64)
W_{t-1}	0.66	(7.69)	P_{t-1}	0.57	(4.65)	L_{t-1}	0.85	(19.3)
W_{t-1}^{74}	−0.002	(−2.69)	P_{t-1}^{79}	−0.017	(−7.18)	ΔL_{t-2}	−0.29	(−1.97)
W_{t-1}^{84}	−0.003	(−4.95)	P_{t-1}^{87}	−0.005	(−2.16)	w_t	−0.01	(−1.85)
W_{t-1}^{87}	−0.005	(−7.77)	P_{t-2}	−0.27	(−4.11)	Δu_t	−0.18	(−3.69)
W_{t-1}^{97}	−0.001	(−2.52)	W_{t-1}	0.43	(5.95)	Z_t	0.15	(+)
W_{t-2}	−0.44	(−6.35)	M_t	0.28	(∗)			
P_t	0.68	(8.22)	M_t^{88}	0.002	(2.98)			
P_t^{89}	−0.008	(−4.96)	M_t^{94}	0.0002	(0.83)			
M_t	0.12	(∗)	θ_t	−1.04	(−10.6)			
u_{t-1}	−0.40	(−3.84)	P_t^I	0.04	(3.34)			
θ_t	0.55	(4.51)	$P_t^{I,77}$	0.013	(5.51)			
P_t^I	0.08	(5.16)	$P_t^{I,86}$	0.007	(4.21)			

(∗) restricted coefficient for no money illusion in the long-run; Δ denotes the difference operator; (+) coefficient is restricted so that the long-run elasticity with respect to Z_t is unity.

In the labor force equation, the size of the labor force depends on its own past values (due to, say, monetary and psychic costs of entry and exit from labor force participation). It also depends negatively on the real wage, implying that the income effect dominates the substitution effect.[24] This negative sign appears plausible for Spain, where income sharing among adult members of families is common, so that a rise in the wage of the main bread winner reduces the need for the spouse and children to seek work.[25] Finally, the labor force depends inversely on the change in the unemployment

[23]The specific results on the underlying full econometric analysis (OLS estimates, misspecification tests, tests on restricted coefficients, etc.) are available upon request.

[24]This reduces the influence of the real wage channel, contained in the employment equation.

[25]This argument is supported by the fact that the unemployment rate of the main bread winners is half that of the second earner one and one third that of the corresponding child earners. These

rate. This may be interpreted as a type of discouraged worker effect: the greater the increase in the unemployment rate, the greater the level of long-term unemployment, *ceteris paribus*, and the greater the likelihood of exit from the labor force.[26]

Table 2b: Spanish model, 3SLS, 1966-1998.

Dependent variable: N_t			Dependent variable: k_t			Dependent variable: y_t		
	coef.	t-stat.		coef.	t-stat.		coef.	t-stat.
Cnt	−0.17	(−0.61)	Cnt	−0.10	(−0.63)	Cnt	0.17	(5.67)
N_{t-1}	0.86	(14.6)	k_{t-1}	1.39	(14.0)	y_{t-1}	0.50	(3.07)
N^{74}_{t-1}	−0.001	(−2.98)	k_{t-2}	−0.66	(−5.93)	y_{t-2}	−0.31	(−2.50)
N^{84}_{t-1}	−0.001	(−1.81)	k_{t-3}	0.18	(3.47)	k_t	0.38	(5.11)
N^{93}_{t-1}	−0.002	(−9.95)	N_t	0.22	(6.34)	k^{75}_t	−0.001	(−2.21)
k_t	0.64	(4.70)	N_{t-1}	−0.12	(−2.11)	N_t	0.43	(∗)
k_{t-1}	−1.34	(−6.21)	N_{t-2}	−0.01	(∗)	N^{84}_t	0.002	(3.90)
k_{t-2}	0.84	(∗)	θ_t	0.19	(3.90)	t	0.005	(3.28)
w_t	−0.16	(−6.53)	θ_{t-1}	−0.09	(−1.82)	t^{78}	−0.002	(−3.82)
θ_{t-1}	0.30	(3.04)	m_t	0.04	(3.08)			
θ^{79}_{t-1}	0.02	(2.82)	w_{t-1}	−0.03	(−2.06)			
ΔL_t	0.75	(5.10)	c_{t-1}	−0.01	(−3.72)			
b_t	−0.21	(−13.9)	τ_{t-1}	−0.41	(−4.75)			
τ_t	−0.24	(−1.44)	d^{71}	−0.014	(−6.11)			
d^{71}	0.01	(2.67)						

(∗) restricted coefficient for constant returns to scale.

In the employment equation, labor demand depends, among other things, on the real wage, the capital stock and productivity.[27] Restricting the long-run coefficient of the capital stock to unity is accepted by the data, implying constant returns to scale, which are also features in the production function. Employment also depends negatively on the real wage (representing the real wage channel, analyzed above), social security benefits per employee (reducing work effort by improving workers' outside options) and the indirect tax rate. The capital stock equation is analogous to the employment equation. Constant returns to scale is accepted: the long-run elasticity of capital stock

differences are largest in regions with the highest unemployment rates. Furthermore, data from the 1990 Household Budget Survey (Encuesta de Presupuestos Familiares) show that the net wage of the main bread winner was 1.390.091 pts. in that year, more than 40% higher than the one of the second earner (813.038 pts.) and twice the one of the child earners (684.700 pts.).

[26]For example, from 1986 to 1990, the 1.7 million newly employed reduced unemployment only by 0.5 milion.

[27]Note that employment also depends on the change in the labor force. A rationale is developed in Coles and Smith (1996), which argues that job matches depend more on new entrants to the labor force than on the level of the labor force, since firms' search primarily for new job applicants, rather than review the old ones. Thus the greater the increase in the labor force, the greater the number of new job applicants, and the greater the consequent number of matches.

with respect to labor can be restricted to one. Productivity has a positive influence on capital stock. Real wages, competitiveness, and the indirect tax rate have negative effects. Real money balances have a positive effect (working, say, via credit constraints and the real interest rate); they represent the real money balance channel analyzed above. Finally, the production function is standard, displaying constant returns to scale.

As noted, we endeavor to capture institutional and policy changes - henceforth called IPCs - through multiplicative dummy variables. These are given in Table 3. The introduction of unionized wage bargaining, beginning in 1973 (unions were not formally legalized till 1977), reduced wage persistence (as many of the Franco-era employment regulations were scrapped) and employment persistence. As is well known, after the first oil price shock Spanish production became less capital intensive. The Moncloa Pacts[28] reduced domestic price persistence (by making prices more flexible) and increased the influence of productivity swings on employment (by reducing firms' incentives to hoard labor). The first wave of labor market reforms reduced wage and employment persistence. Spain's entry into the EEC in 1986 reduced wage and price persistence, and augmented the influence of money on prices (via increased credibility of monetary policy).[29] Spain's entry into the EMS in 1989 reduced the effect of domestic prices on wages. The second wave of labor market reforms, announced in 1993, further reduced employment persistence. And finally, the third wave of reforms reduced wage persistence.

Table 3: Institutional and Policy Changes (IPCs)
1. Introduction of unionized wage bargaining: W_{t-1}^{74} and N_{t-1}^{74}
2. Oil price shock: k_t^{75}
3. The Moncloa Pacts: P_{t-1}^{79} and θ_{t-1}^{79}
4. First wave of labor market reforms: W_{t-1}^{84}, N_{t-1}^{84}, and N_t^{84}
5. Entry into the EEC: W_{t-1}^{87}, P_{t-1}^{87}, M_t^{88}
6. Entry into the EMS: P_t^{89}
7. Second wave of labor market reforms: N_{t-1}^{93}
8. Third wave of labor market reforms: W_{t-1}^{97}

In this way our structural model of the Spanish economy endeavors to capture the interplay between macro shocks and lagged adjustment processes that are central to our analysis of the inflation-unemployment tradeoff, as well as the influence of institutional and policy changes on this tradeoff.

[28] These pacts consisted of a set of policy agreements between the government, firms and unions in response to the crisis in the aftermath of the first oil price shock. One of their central features was the immediate implementation of a very restrictive monetary policy to reduce inflation.

[29] M_t^{94} aims to serve a similar purpose with regard to central bank independence.

5 The Spanish Phillips Curve

In the context of the empirical model above, given by the restricted 3SLS estimates, we now assess the slope of the long-run Phillips curve for Spain. We then examine how this tradeoff was affected by institutional and policy changes.

5.1 The Long-Run Inflation-Unemployment Tradeoff

To derive the slope of the long-run Phillips curve, we begin with a change in the growth rate of the money supply and simulate the associated changes in the long-run inflation and unemployment rates. The change in money growth may be interpreted as a realization of the stochastic process generating the money growth rates, and thus our analysis is not subject to the Lucas critique. In particular, the money supply may be treated as an I(2) variable,[30] so that changes in the money growth rate are permanent. Since our empirical model is linear and thus the implied Phillips curve is linear as well, the size of the money growth change clearly makes no difference to our estimated slope of the long-run Phillips curve.[31] We choose a 10% fall in money growth and let all the endogenous variables in our system converge to their long-run values.[32] We then derive the slope of the long-run Phillips curve as the ratio of the changes in the long-run inflation and unemployment rates associated with tight monetary policy.

The simulation exercise indicates that a 10% reduction in money growth leads to a permanent increase of 3.70% in the unemployment rate, along with a permanent decrease of 10% in the inflation rate. Thus our model implies that the slope of the Spanish long-run Phillips curve is $d\pi/du = -2.70$ (to the nearest two significant digits) once all institutional and policy changes have taken place. The influence of each IPC on the long-run slope of the Phillips curve is examined below.

This estimate lies between the range of values obtained by Dolado *et al.* (2000) for Spain using a structural VAR model with quarterly data from 1964 to 1995. They find that the long-run slope of the Phillips curve is -3.33 under a "Monetarist" identifying scheme, and -1.67 under a "Keynesian" identifying scenario.

Finally, our estimate of the long-run inflation-unemployment tradeoff implies a flatter long-run Phillips curve than the European Union and the US ones, which are placed

[30] The Dickey-Fuller (DF) and Phillips Peron (PP) tests indicate that we cannot reject the I(2) hypothesis for the money supply. In particular, for ΔM_t we have DF$= -0.26$ and PP$= -.41$; the 5% critical value is -2.95. (For $\Delta^2 M_t$ the DF and PP tests are -4.91 and -7.96, respectively.) However, as mentioned earlier, our analysis does not hinge on the random walk property of the money growth rate.

[31] Since the model is linear, the evolution of the other exogenous variables has no influence on the slope of the long-run Phillips curve. Thus these exogenous variables can be set to zero in the simulation exercise.

[32] The reason for choosing a 10% change in money growth is given in Section 6.

at -3.18 and -3.66 in Karanassou, Sala and Snower (2003, 2005). These estimates, obtained using the same structural modeling methodology, point to the presence of a smaller degree of nominal and real sluggishness in the US economy, in contrast with Spain, which in the 80s and most of the 90s was characterized by its persistent unemployment rate. In fact, most of the institutional and policy changes undertaken in the last decades in Spain aimed at enhancing flexibility. The influence of these changes on the long-run Phillips curve tradeoff are the focus of the analysis we undertake next.

5.2 The Influence of Institutional and Policy Changes on the Long-Run Phillips Curve

In our model, as we have seen, some of the institutional and policy changes (captured by the dummy variables above) affect the labor market adjustment processes, and these processes - interacting with money growth - affect the slope of the long-run Phillips curve. We now assess the magnitude and significance of this influence.

In the absence of all IPCs, i.e. prior to 1974, we find that the slope of the long-run Phillips curve is $S_n = -1.89$ (where the subscript n stands for "no IPC"). This is the base-run case.

Next, we add the first IPC to the base run, and we obtain the associated long-run Phillips curve slope.[33]. We call this slope S_1. We derive the contribution of first IPC ($S_{\wedge 1}$) by subtracting S_n from S_1: $S_{\wedge 1} = S_1 - S_n$.

Analogously, we add the second IPC to the previous system, and evaluate the slope of the associated long-run Phillips curve in the presence of the first and second IPCs, to be called S_2. The contribution of IPC 2 is then measured as $S_{\wedge 2} = S_2 - S_1$. Along these lines, we evaluate the individual contribution of each IPC to the long-run Phillips curve slope. The results are given in Table 4. The top section of the table shows the influence of a 10 percentage points decrease in money growth (ΔM) on unemployment (Δu) and the slope of the long-run Phillips curve. The bottom section gives the individual contributions of each IPC to the slope ($S_{\wedge i}$) and the percentage difference (%) in the slope implied by each IPC.[34]

Observe that the IPCs which appear to have had the greatest impact are the introduction of the Moncloa Pacts and entry into the EEC and EMS. Our calculations show that these changes all made the Spanish long-run Phillips curve steeper.

[33]Specifically, this is the slope in the presence of IPC 1 but in the absence of all other IPCs. After including the first IPC, we reimpose on the macro system the restrictions to ensure no money illusion and constant returns to scale.

[34]For example, entry into the EEC shifts the slope from -2.28 to -2.51 (in the top part of the table), which corresponds to a difference of -0.23 percentage points that makes the slope 10.1% steeper (in the bottom part of the table).

Table 4: The long-run Phillips curve slope. Unemployment rate response to a 10 %points decrease in ΔM		
Cumulative impact of IPCs	Δu	*slope*
Trade-off before 1974 (S_n)	5.29	-1.89
IPC 1 (S_1)	5.22	-1.92
IPCs 1+2 (S_2)	5.25	-1.91
IPCs 1+2+3 (S_3)	4.47	-2.24
IPCs 1+2+3+4 (S_4)	4.38	-2.28
IPCs 1+2+3+4+5 (S_5)	3.98	-2.51
IPCs 1+2+3+4+5+6 (S_6)	3.74	-2.67
IPCs 1+2+3+4+5+6+7 (S_7)	3.76	-2.66
All IPCs considered (1+2+3+4+5+6+7+8) (S_8)	3.70	-2.70
Individual contribution of IPCs	$S_{\wedge i}$	(%)
1. Introduction of unionized wage bargaining ($S_{\wedge 1}$)	0.03	-1.6
2. First oil price shock ($S_{\wedge 2}$)	-0.01	0.5
3. Institutional changes associated with the Moncloa Pacts ($S_{\wedge 3}$)	0.33	-17.3
4. First wave of labor market reforms ($S_{\wedge 4}$)	0.04	-1.8
5. Entry into the EEC ($S_{\wedge 5}$)	0.23	-10.1
6. Entry into the EMS ($S_{\wedge 6}$)	0.16	-6.4
7. Second wave of labor market reforms ($S_{\wedge 7}$)	-0.01	0.4
8. Third wave of labor market reforms ($S_{\wedge 8}$)	0.04	-1.5
(%) percentage difference with respect to the case without any of the IPCs considered.		

5.3 Monte Carlo Simulations

We now examine whether our point estimates of the long-run Phillips curve slope are significantly different from infinity. Accordingly, we conduct Monte Carlo experiments, each of which consists of 1000 replications. In each replication (i), a vector of error terms $\varepsilon_t^{(i)} = \left(\varepsilon_{1t}^{(i)}, \varepsilon_{2t}^{(i)}, \varepsilon_{3t}^{(i)}, \varepsilon_{4t}^{(i)}, \varepsilon_{5t}^{(i)}, \varepsilon_{6t}^{(i)}\right)'$(of the labor demand, nominal wage, price, labor force, capital stock, and production equations, respectively) was drawn from the normal distribution,[35] $N(0, \sum)$. The vector $\varepsilon_t^{(i)}$ was then added to the vector of estimated equations to generate a new vector of endogenous variables $y_t^{(i)} = \left(N_t^{(i)}, W_t^{(i)}, p_t^{(i)}, L_t^{(i)}, k_t^{(i)}, y_t^{(i)}, u_t^{(i)} = L_t^{(i)} - N_t^{(i)}\right)$. Next, the equations of the model were estimated using the new vector of endogenous variables $y_t^{(i)}$, and the set of exogenous variables. Finally, the above simulation exercises for the computation of the long-run Phillips curve slope were conducted on the newly estimated system. In this way, each replication (i) yielded a set of measures for the cumulative impact of IPCs on the long-run Phillips curve slope: $x_i = \left\{S_n^{(i)}, S_1^{(i)}, S_2^{(i)}, S_3^{(i)}, S_4^{(i)}, S_5^{(i)}, S_6^{(i)}, S_7^{(i)}, S_8^{(i)}\right\}$. We grouped the values of each generated series x_i into class intervals of 0.5 units. In Table 5 we

[35] We used the normal distribution because the assumption of normality is valid in the estimated system of equations. Thus $\varepsilon_t \sim N(0, \sum)$, where $\sum$ is the variance-covariance matrix of the estimated model.

present the percentage count of slopes within specific class intervals. For example, in the presence of all IPCs, the probability that the long-run Phillips curve slope is below -50 is 1.3%. Using as a cut-off point a 2% count, there is no class interval below [-6,-5.5) or above [-1,-0.5) that contains at least 2% of the values of each x_i. So in Table 5 we also give the probability that the long-run Phillips curve slope is greater than -6.0 and smaller that -0.5.

Table 5: Monte Carlo simulations, 1000 replications
probability (%) that the PC slope is within a specific interval

	S_n	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
$(-\infty, -50)$	0.5	0.9	0.8	1.0	0.9	1.2	1.4	1.2	1.3
$(-\infty, -20)$	2.1	2.6	2.6	2.1	2.6	3.3	3.4	3.6	3.6
$[-6, -0.5)$	77.7	76.8	76.8	72.3	71.1	67.6	65.5	65.9	65.3

Observe that in the absence of all IPCs the probability that the slope of the Phillips curve (S_n) is in the [-6, -0.5) interval is 77.7%. The Phillips curve slope remains more or less unaffected by the introduction of unionized wage bargaining and the occurrence of the oil price shock (see columns S_1 and S_2, respectively, in Table 5). However, when the institutional changes associated with the Moncloa Pacts are introduced, the Phillips curve slope becomes steeper (column S_3 in Table 5). In this case the probability that the slope lies between -6 and -0.5 drops to 72.3%. The Phillips curve slope does not change much when the first wave of labor market reforms takes place (column S_4 in Table 5). But with the entry into the EEC the probability that the slope lies in the [-6, -0.5) interval further decreases to 67.6%, thus the Phillips curve gets steeper (column S_5 in Table 5). Finally, the entry into the EMS,[36] and the second and third waves of labor market reforms do not appear to have a significant impact on the Phillips curve slope (column S_6, S_7, and S_8 in Table 5).

6 A Reappraisal of the Spanish Experience

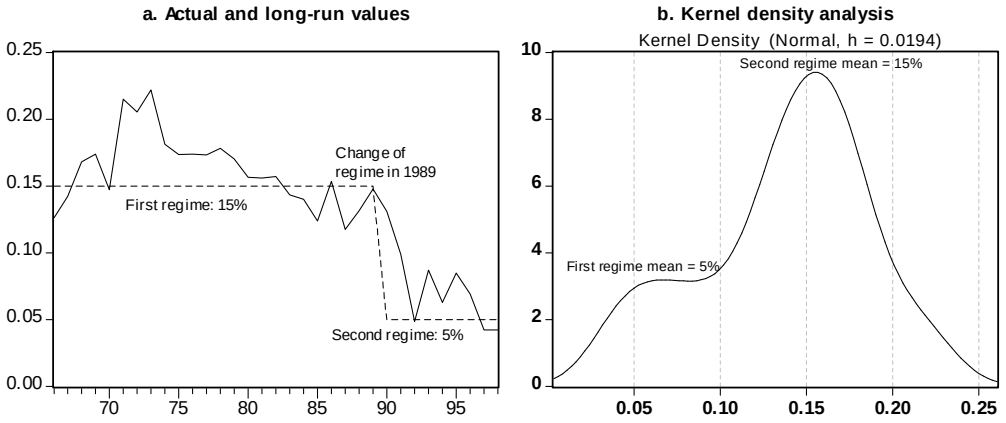
The story of the Spanish economy, from democracy (achieved in 1977) to its entrance in the EMU in 1999, is one of declining inflation and persistent unemployment. In this period the rate of inflation gradually declined from 24.5% in 1977 to its historical minimum below 2% in 1998; unemployment, meanwhile, rose from full-employment levels to more than 20% in most of the 1980s and 1990s, and has since then remained high (in recent years it has reached a plateau of 10%).

According to the mainstream literature, this unemployment trajectory would be a reflection of the path followed by the equilibrium rate of unemployment. Our analysis,

[36] The result concerning EMS contrasts with our finding in Table 4.

however, suggests a significant role for monetary policy in shaping Spanish unemployment in the long-run. This role has been reduced somewhat through successive policy changes, particularly after the Moncloa Pacts, Spain's entry into the EEC and possibly the EMS.

Figure 1. Money supply growth in Spain, 1966-1998.



Following Raurich, Sala and Sorolla (2006) we have conducted a Kernel density analysis on the money supply growth series (Figure 1), capturing two broad money growth regimes, one at 15% (predominantly at the beginning of the sample period) and one at 5% (predominantly at the end). This 10% change in money growth is the size of the permanent shock we introduced in the estimated model yielding a substantial rise in unemployment: according to our analysis in Table 4, the long-run effect of this fall in money growth is an increase in unemployment of approximately 4 percentage points.

The unemployment rate went up from full-employment levels (4.5% in 1976) to 16.5% in 1990, just after the regime change; therefore about a third of this rise can be associated with the restrictive monetary policy that took place from 1977 to 1995 (with the exception of 1986-87). In short, our analysis suggests that the policy regime change pictured in Figure 1a, which is the expression of a strong contractionary monetary policy, had a pronounced effect on Spain's long-run unemployment rate. The role of the "usual suspects" like union power, taxes, unemployment benefits or restrictive employment protection legislation (EPL) is therefore weakened.[37]

Of course, the short- and medium-run effects on unemployment can be even more powerful. We measure these effects by taking a closer look at the post 1992 economic events. Spain experienced a precipitate fall in money growth over the 1990s (see Figure 1a), largely in response to the convergence criteria of the Maastricht Treaty (signed in February 1992), Spain's EMS crisis (from September 1992 to August 1993), and

[37]For a detailed explanation of our conception on the long-run unemployment rate versus the NAIRU see Karanassou, Sala and Snower (2006).

the independence of the Bank of Spain (granted in June 1994). In the context of our empirical model, we can ask how much of the variation in Spanish unemployment since 1993 can be accounted for by the experienced changes in money growth. Although it is important to emphasize that our empirical model is merely illustrative, Figure 2 nevertheless tells an interesting tale.

Figure 2. Unemployment and Inflation Effects Atributable to Monetary Policy

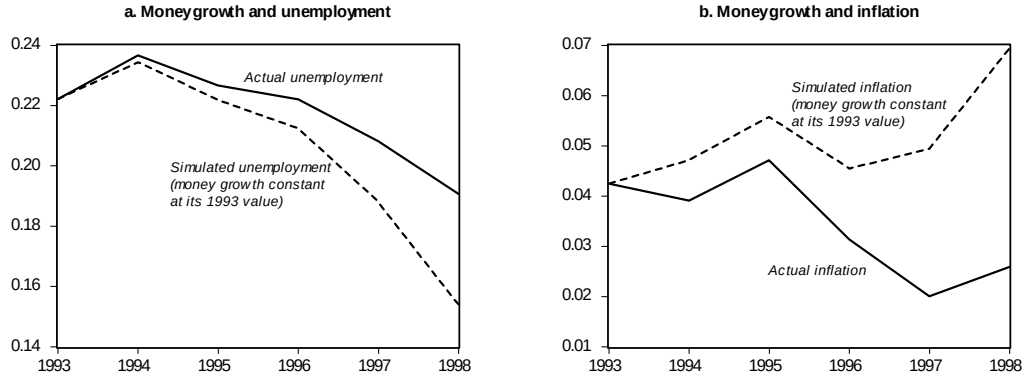


Figure 2a gives the trajectory of the actual unemployment rate *vis-à-vis* the one the unemployment rate would have followed, in our model, if money growth had remained constant at its 1993 rate. The difference between the two trajectories stands for the extra unemployment, through time, that is attributable to the fall in money growth. Along the same lines, Figure 2b depicts the trajectory of actual inflation against the simulated inflation rate under money growth fixed at its 1993 rate, so that the difference stands for the fall in inflation, through time, that is attributable to the decline in money growth. In this simple accounting exercise, we see that, by 1998, the contraction in money growth accounts for a rise in the Spanish unemployment rate of about 4 percentage points and a fall in the inflation rate of also about 4 percentage points. In short, our model suggests that monetary policy has had a very substantial and prolonged effect on unemployment (and of course inflation). Our empirical analysis of Spain's long-run inflation-unemployment tradeoff indicates that some of this unemployment effect is permanent.

From 1999 to 2005 Spain has continued to reduce its unemployment rate from almost 20% to a plateau of 10%. It is commonplace to relate this successful experience to institutional changes such as the 1997 and the 2001 labor market reforms. Nevertheless, our analysis indicates that monetary policy and its prolonged real after-effects, due to lagged adjustment processes, may have played a significant role in the evolution of unemployment.

7 Conclusions

This paper provided a theoretical rationale for a long-run tradeoff between inflation and unemployment due to the interplay between money growth and nominal frictions. In this context we have seen that the absence of money illusion and money neutrality does not prevent changes in money growth from having long-run effects on unemployment (as well as inflation, of course). Thereby our analysis indicates that the NAIRU does not exist and different long-run inflation rates are associated with different unemployment rates. This suggests a reevaluation of how monetary policy affects macroeconomic activity and sheds new light on our understanding of the macroeconomic developments in the Spanish economy.

To capture the phenomenon of frictional growth, we estimated a dynamic system of equations that allows the intertemporal influence of money on wages and prices, as well as the intertemporal influence of the relation between money and prices on unemployment.

Our empirical model yields a point estimate of -1.89 for the slope of the Spanish long-run Phillips curve prior to the introduction of the institutional and policy changes (so that a 10% decrease in money growth leads to a permanent rise in unemployment by 5.3 percentage points) and a point estimate of -2.70 after the IPCs took place (so that a 10% decrease in money growth leads to a permanent rise in unemployment by 3.7 percentage points). This calls for a reappraisal of the Spanish unemployment experience along the following lines. First, a substantial part of the unemployment increase in the post 1973 era can be attributed to the subsequent restrictive monetary policies. In other words, the common explanation that institutions are responsible for the high unemployment rates is not sufficient, on its own, to account for the realized unemployment trajectory. Second, had money growth been higher throughout the nineties, the fall in unemployment witnessed at the end of the decade would have been significantly reinforced.

In short, monetary policy may have more important and long-lasting effects on real macroeconomic activity, and on unemployment in particular, than the conventional wisdom allows for. The phenomenon of frictional growth, therefore, represents a challenge for monetary policy: It is no longer obvious that the objective of monetary authorities should be restricted exclusively to fighting inflation. On the contrary, it may be desirable that monetary policy is formulated to achieve both inflation and unemployment objectives.

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