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# ABSTRACT

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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 theoretical models 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.

JEL Classification: 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. After presenting theoretical models 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 context, 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.

We show that in the presence of money growth and time-contingent nominal contracts, this argument does not necessarily hold. Under plausible circumstances specified below, 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).

Another problem with the NAIRU theory is that, when combined with the rational expectations hypothesis, it implies that an inverse relation between inflation and unemployment manifests itself primarily in response to unanticipated demand shocks. However, over the 1980s and 1990s many OECD countries had reasonably stable demand conditions (with a few notable exceptions), and nevertheless they frequently experienced large fluctuations in unemployment along-side relatively small changes in inflation for periods as long as five or ten years, or even longer. This evidence is difficult to reconcile with a stable NAIRU.[1] Large and prolonged demand-side shocks were, in many countries, followed by prolonged changes in unemployment accompanied by only very slow declines in inflation. Even longer-term inflation-unemployment tradeoffs were found by Phillips (1958),

[1]One may, of course, drop the assumption of a stable NAIRU and use the data to infer NAIRU movements, in accordance with the NAIRU theory. In that case, however, the NAIRU theory loses much of its predictive power.

Lipsey (1960) and others over the century preceding the late 1960s. Macroeconomic policy authorities often make monetary and fiscal policy decisions with prolonged inflation-unemployment tradeoffs in mind.

This paper presents a model of the Phillips curve that avoids the counterfactual prediction that inflation falls (rises) without limit when unemployment is low (high), and it allows for the possibility of a long-run tradeoff between inflation and unemployment.

Our analysis 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 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. A well-known result in the literature on the microfoundations of wage-price staggering[3] is that when the rate of time discount is positive, the past is weighted more heavily than the future. It is in this sense that current prices and wages may be taken to be characterized by nominal inertia. 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.

In Section 2, we present three "toy models" of the macroeconomy, designed to highlight simply how frictional growth can lead to a long-run inflation unemployment tradeoff. The equations of these models are ad hoc, short-hand summaries of plausible macro relations. In Section 3, we present a Phillips curve model with proper microfoundations. Section 4 contains an empirical model of the Spanish inflation-unemployment tradeoff; we find that this tradeoff is far from vertical in the long run. Section 5 evaluates how this tradeoff has been affected by major shifts in economic policy. Finally, Section 6 concludes. Our analysis suggests that a significant portion of the surge in the Spanish unemployment rate in the 1990s is due to contractionary monetary policy.

[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, Gali and Gertler (1999), Goodfriend and King (1997), Mankiw (2001), and others.

[3]For example, Ascari (2000), Ascari and Rankin (2002), Graham and Snower (2002), and Helpman and Leiderman (1990).

## 2. Toy Models

This section presents transparently simple macro models to describe two channels whereby permanent changes in money growth may have permanent effects on both inflation and unemployment. We call these "toy models" since they are easy to play around with, being merely heuristic devices for introducing our ideas. They are specified in an *ad hoc* way, as stripped-down pictures of how a long-run inflation-unemployment tradeoff may arise.

The first model describes the "real money balance channel," i.e. an increase in money growth affects long-run real money balances and thereby the long-run unemployment rate. The second model considers the "real wage channel," whereby an increase in money growth affects long-run unemployment via the real wage and employment. And the third model considers both channels operating in tandem.

### 2.1. Model 1: The Real Money Balance Channel

In this model and the ones that follow, all variables - except the unemployment rate - are in logs. All uninteresting constants are ignored. 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:

$$\Delta M_t \equiv \mu_t = \mu_{t-1} + \varepsilon_t, \tag{2.1}$$

where $M_t$ is the (log of the) money supply and $\varepsilon_t$ is a white-noise error term.

The current price level depends on the past price level and the money supply:

$$P_t = aP_{t-1} + (1 - a)\, M_t, \tag{2.2}$$

where the "price sluggishness parameter" $a$ is a constant, $0 < a < 1$. This is the only substantive *ad hoc* simplification that this model makes in describing frictional growth. As noted, the microfoundations literature on price staggering indicates that the current price level is a weighted average of past and expected future price levels, with the past weighted more heavily than the future, under time discounting. Equation (2.2) provides a simplified picture of this source of price inertia and it thereby clarifies the mechanism whereby frictional growth generates a downward-sloping long-run Phillips curve. (We will consider a microfounded model in Section 3.)

Aggregate product demand depends on real money balances:

$$Q_t^D = (M_t - P_t). \tag{2.3}$$

The aggregate production function is

$$Q_t^S = \sigma N_t, \tag{2.4}$$

where $\sigma$ is a positive constant[4]. The labor supply is constant:

$$L_t = L, \tag{2.5}$$

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

$$u_t = L - N_t. \tag{2.6}$$

Observe that money illusion is absent in system (2.1)-(2.6): 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.

Defining the inflation rate as $\pi_t \equiv P_t - P_{t-1}$ and taking the first difference of the price equation (2.2), we obtain

$$\pi_t = a\pi_{t-1} + (1 - a)\,\mu_t. \tag{2.7}$$

It is straightforward to show that, in this context, the long-run inflation rate is equal to the long-run money growth rate: $\pi_t^{LR} = \mu_t^{LR}$ (which bears the time subscript since money growth is a random walk).[5] Furthermore, long-run real money balances depend on long-run money growth rate:[6]

$$(M_t - P_t)^{LR} = \frac{a}{1 - a}\mu_t^{LR}. \tag{2.8}$$

[4] $\sigma = 1$ under constant returns to labor, and $\sigma$ is less (greater) than unity under diminishing (increasing) returns.

[5] To see this, rewrite equation (2.7) as $\pi_t = \mu_t - \frac{a}{1-a}\Delta\pi_t$. Thus, given structural stability, the long-run relationship between the inflation rate and the growth rate of money supply is

$$\pi_t^{LR} = \mu_t^{LR} - \frac{a}{1 - a}(\Delta\pi_t)^{LR}. \tag{F1}$$

Now take the first difference of (2.7), $\Delta\pi_t = a\Delta\pi_{t-1} + (1 - a)\,\Delta\mu_t$, and note that the long-run solution this equation is given by its unconditional expectation: $(\Delta\pi_t)^{LR} \equiv E(\Delta\pi_t)$. Taking expectations on both sides of the previous equation, we obtain

$$E(\Delta\pi_t) = 0, \text{ or } (\Delta\pi_t)^{LR} = 0, \tag{F2}$$

since $E(\Delta\pi_t) = E(\Delta\pi_{t-1})$, due to stationarity, and $E(\Delta\mu_t) = 0$, by equation (2.1), where $E$ is the unconditional expectations operator.

Substitution of (F2) into (F1) yields $\pi_t^{LR} = \mu_t^{LR}$.

[6] To see this, note that equation (2.2) may be rewritten as $(1 - a)\,M_t = (1 - a)\,P_t + a\pi_t$, and recall that $\pi_t^{LR} = \mu_t^{LR}$.

Consequently, by (2.3)-(2.6) and (2.8), we obtain a long-run (steady-state) relation between unemployment and inflation:

$$\pi_t^{LR} = \sigma \left( \frac{1 - a}{a} \right) \left( L - u_t^{LR} \right) \tag{2.9}$$

The long-run Phillips curve is flatter,

- the greater is the price sluggishness parameter $a$ and
- the greater is the curvature of the production function (i.e. the smaller $\sigma$).

It is straightforward to see the intuition underlying the downward slope of the Phillips curve. When the money supply grows, the price level chases after a moving target. But since the money supply keeps on increasing, the price adjustments never work themselves out entirely. By the time the current price level has begun to respond to the current increase in the money supply, the money supply increases again, prompting a new round of price adjustments. The greater is money growth, the greater will be the difference between the target and actual price levels (*ceteris paribus*). Thus a permanent increase in money growth not only increases long-run inflation, but also raises real money balances and thereby reduces unemployment in the long run. On this account, there is a long-run tradeoff between inflation and unemployment.

### 2.2. Model 2: The Real Wage Channel

Our second macro model deals with the real wage channel. To illustrate this channel as simply as possible, suppose that the price level adjusts instantaneously to the money supply:

$$P_t = M_t; \tag{2.10}$$

whereas the nominal wage is sluggish, depending on its past value and the current money supply:

$$W_t = bW_{t-1} + (1 - b) M_t; \tag{2.11}$$

where $b$, the "wage sluggishness parameter," is a constant, $0 < b < 1$.

As in the previous section, the growth rate of money supply has a unit root, as given by equation (2.1). In this context, an unexpected change in money growth leads to a change in the real wage. Employment, in turn, depends on the real wage:

$$N_t = c_0 - c_1 (W_t - P_t), \tag{2.12}$$

where $W_t - P_t$ is the log of the real wage, and the labor demand curve is derived from the production function (2.4), so that $c_0 = \frac{\log \sigma}{1-\sigma}$ and $c_1 = \frac{\sigma}{\sigma - 1}$. As in the previous section, the labor supply is constant (equation (2.5)), and the unemployment rate is given by equation (2.6).

Defining the rate of wage inflation as $\nu_t = W_t - W_{t-1}$, and taking the first difference of the wage equation (2.11), we obtain

$$\nu_t = b\nu_{t-1} + (1-b)\,\mu_t, \tag{2.13}$$

Thus the long-run rate of wage inflation is $\nu_t^{LR} = \pi_t^{LR}$. The long-run real wage depends on the long-run money growth rate:[7]

$$(W_t - P_t)^{LR} = \frac{-b}{1-b}\mu_t^{LR}. \tag{2.14}$$

The greater the long-run growth rate of the money supply, the lower is the corresponding long-run real wage. Thus greater is employment and the lower is unemployment in the long run.

To derive the associated long-run Phillips curve, observe that $\mu_t = \pi_t$ (by equation (2.10), recall that $\nu_t^{LR} = \pi_t^{LR}$, and use equations (2.12), (2.6) and (2.14) to obtain:

$$\pi_t^{LR} = \frac{1-b}{c_1 b}\left(L - u_t^{LR}\right) \tag{2.15}$$

This long-run Phillips curve is flatter,

- the greater is the wage sluggishness parameter $b$ and
- the greater is the slope of the labor demand curve $c_1$.

Once again, the intuition is clear. When the nominal wage is subject to more inertia than the price level then, in the presence of money growth, the wage chases after its moving wage target more slowly than the price chases after its moving price target. The faster the money supply grows, the more the price level rises relative to the nominal wage. Thus the real wage falls, labor demand rises, and unemployment falls.

[7] To see this, rewrite the wage equation as $(1-b)P_t = (1-b)W_t + b\nu_t$.

An obvious deficiency of the real wage channel 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. When it is combined with the real money balance channel, for instance, the resulting real wages are no longer necessarily counter-cyclical, as shown below.[8] 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.

### 2.3. Model 3: Both Channels

Our final macro model is concerned with the interplay between the two channels above, which turns out to have interesting implications for the long-run inflation-unemployment tradeoff. For this purpose, we consider a model in which there is lagged adjustment in both wages and prices. Specifically, let the money growth rate be given by equation (2.1), the price equation by (2.2), the wage equation by (2.11), labor supply by (2.5), and unemployment by (2.6):

$$\begin{aligned} \Delta M_t \equiv \pi_t &= \pi_{t-1} + \varepsilon_t; \\ W_t &= bW_{t-1} + (1-b)\,M_t; \\ P_t &= aP_{t-1} + (1-a)\,M_t; \\ L_t &= L; \\ u_t &= L - N_t; \end{aligned}$$

where the price- and wage-sluggishness parameters satisfy $0 < a, b < 1$.

Furthermore, to enable both channels to operate, we extend the labor demand equation to allow employment to depend on both the real wage ($w_t \equiv W_t - P_t$) and real money balances ($M_t - P_t$)[9]:

$$N_t = c_0 - c_1 w_t + \frac{1}{\sigma}\left(M_t - P_t\right); \tag{2.16}$$

where the parameters $c_0, c_1$ and $\sigma$ are positive.

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[8] The reason is that the impulse-response function of the real wage to money growth shocks need not be monotonic.

[9] The underlying assumption now is that changes in product demand (initiated by changes in real money balances) can influence the position of the labor demand function. Lindbeck and Snower (1994), for example, describe various microfounded channels whereby product demand changes can affect the labor demand function in the long run.

To derive the inflation-unemployment tradeoff in this setting, we first obtain the stochastic process for the real wage by subtracting the price equation (2.2) from the wage equation (2.11):

$$w_t = (a+b)\,w_{t-1} - ab w_{t-2} - (b-a)\,\mu_t; \tag{2.17}$$

Next, note that the price equation (2.2) can be rewritten in terms of the real money balances:[10]

$$(M_t - P_t) = a\,(M_{t-1} - P_{t-1}) + a\mu_t. \tag{2.18}$$

Substitute equation (2.17) and (2.18) into the labor demand equation (2.16) to find how employment depends on its past values and money growth:

$$N_t = (a+b)\,N_{t-1} - abN_{t-2} + \left[c_1\,(b-a) + \frac{a}{\sigma}\,(1-b)\right]\mu_t + \frac{ab}{\sigma}\varepsilon_t. \tag{2.19}$$

Finally, by manipulation of equations (2.6) and (2.19) gives the following stochastic process for the unemployment rate:

$$u_t = (a+b)\,u_{t-1} - abu_{t-2} + (1-a)\,(1-b)\,L - \left[c_1\,(b-a) + \frac{a}{\sigma}\,(1-b)\right]\mu_t - \frac{ab}{\sigma}\varepsilon_t; \tag{2.20}$$

Thus the long-run unemployment rate is

$$u_t^{LR} = L - \left[\frac{\sigma c_1\,(b-a) + a\,(1-b)}{\sigma\,(1-a)\,(1-b)}\right]\mu_t^{LR}; \tag{2.21}$$

and the associated long-run Phillips curve is[11]

$$\pi_t^{LR} = \frac{\sigma\,(1-a)\,(1-b)}{\sigma c_1\,(b-a) + a\,(1-b)}\left(L - u_t^{LR}\right). \tag{2.22}$$

It can be shown that

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[10] By equation (2.2),

$$P_t = aP_{t-1} + (1-a)\,M_t \;\Rightarrow\; (M_t - P_t) = aM_t - aP_{t-1}$$
$$(M_t - P_t) = aM_t - aP_{t-1} + aM_{t-1} - aM_{t-1} = a\,(M_{t-1} - P_{t-1}) + a\mu_t.$$

[11] Note that, in the context of this model, $b > a$ (more wage sluggishness than price sluggishness) is a sufficient condition for the Phillips curve to be downward-sloping. In this case, the money balance and real wage channels reinforce one another: an increase in money growth not only raises real money balances, but it also reduces the real wage (since the nominal wage responds less than the price level). But if $b < a$, the Phillips curve is still downward-sloping provided that $\sigma c_1 < \frac{a(1-b)}{(a-b)}$.

- **The greater the wage sluggishness parameter $b$, the flatter is the long-run Phillips curve.**[12] The more sluggish is the nominal wage, the more will a given change in money growth reduce the real wage and thereby raise employment (*ceteris paribus*). Thus the greater will be the reduction in unemployment relative to the rise in inflation.

- **The greater is the price sluggishness parameter $a$, the flatter is the long-run Phillips curve, provided that the real money balance channel dominates the real wage channel,** i.e. when $1/\sigma > c_1$ in the employment equation (2.16).[13] The more sluggish is the price level, the more will a given change in money growth raise real money balances as well as the real wage (*ceteris paribus*). Then, if the money balance channel dominates the real wage channel, the greater will be the rise in employment, and therefore the greater the fall in unemployment relative to the increase in inflation[14].

- **If the money balance channel dominates the real wage channel, then the wage sluggishness and price sluggishness are complementary in their influence in making the long-run Phillips curve flatter.** In particular,[15]

$$\frac{\partial^2 \xi}{\partial b \partial a} = \frac{2\sigma^2 c_1 (1 - a)(1 - b)(1 - \sigma c_1)}{[\sigma c_1 (b - a) + a(1 - b)]^3} > 0 \text{ if } \sigma c_1 < 1.$$

## 3. A Microfounded Model

Whereas the macro models above convey our intuitions as simply as possible, this section develops a model of the real wage channel that can be given firm microfoundations.[16] 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

$$q_{i,t}^S = A n_{i,t}^{\sigma}, \tag{3.1}$$

[12] To see this, let the slope (in absolute value) of the long-run Phillips curve be denoted by $\xi = \frac{\partial \pi_t^{LR}}{\partial u_t^{LR}} = \frac{\sigma(1-a)(1-b)}{\sigma c_1(b-a)+a(1-b)}$. Then observe that $\frac{\partial \xi}{\partial b} = -\frac{\sigma^2 c_1 (1-a)^2}{(\sigma c_1(b-a)+a(1-b))^2} < 0$.

[13] Observe that $\frac{\partial \xi}{\partial a} = \frac{-\sigma(1-\sigma c_1)(1-b)^2}{[c_1(b-a)+ae(1-b)]^2} < 0$ if $\sigma c_1 < 1$.

[14] Conversely, if $\sigma c_1 > 1$, increased price sluggishness makes the Phillips curve steeper: $\frac{\partial \xi}{\partial a} > 0$.

[15] On the other hand, if the real wage channel dominates, then wage sluggishness and price sluggishness are substitutes ($\frac{\partial^2 \xi}{\partial b \partial a} < 0$, $\sigma c_1 > 1$).

[16] For microfoundations of the real money balance channel, see Karanassou, Sala, and Snower (2002).

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

$$q_{i,t}^{D} = \left(\frac{p_{i,t}}{p_t}\right)^{-\eta} \frac{q_t^{D}}{f}, \tag{3.2}$$

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 $\eta$ 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 $N_t = \log(f n_{i,t})$, we obtain the following aggregate employment equation:

$$N_t = a - a_w (W_t - P_t), \tag{3.3}$$

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 $a_w = \frac{1}{1-\sigma}$.

As above, the labor supply is constant (equation (2.5). Our aggregate price equation is equivalent to the aggregate employment equation under product market clearing. The product market clearing condition is $f A n_{i,t}^{\sigma} = q_t^{D}$. Taking logs, defining $h = \log(A f^{1-\sigma})$ 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 (3.3), we obtain the following price equation:[17]

$$P_t = W_t + \rho Q_t^{D} - \beta, \tag{3.4}$$

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

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 $\Omega_t$ 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

$$\Omega_t = \alpha\Omega_{t-1} + (1-\alpha)E_t\Omega_{t+1} + \gamma\left(c + \alpha\Gamma_t + (1-\alpha)E_t\Gamma_{t+1}\right) + \varepsilon_t, \tag{3.5}$$

where $\varepsilon_t$ is a white noise process, $\alpha$, $\gamma$, and $c$ are positive constants, and $E_t$ is the expectations operator, denoting the expectation conditional on information

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

available at time $t$. We assume that agents do not have information about $\zeta$ when they set their wage contracts at time $t$, so $E_t\zeta_t = 0$. The variable $\Gamma_t$ is what Taylor calls "excess demand," specified as actual output ($Q_t^s$) less full-employment output (in logs). By the production function (3.1), 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

$$\Gamma_t = Q_t - \sigma L - h. \tag{3.6}$$

The microfoundations of the contract equation under time discounting[18] - which, for brevity, we need not summarize here - indicate that the coefficient $\alpha$ is a discounting parameter equal to $\frac{1}{1+\delta}$, where $\delta$ is the discount factor.[19] $\gamma$ is a "demand sensitivity parameter" (describing how strongly wages are influenced by demand), and $c$ as a "cost-push parameter" (describing the upward pressure on wages in the absence of excess demand). Since $\delta < 1$, we infer that $\alpha > 1/2$, i.e. discounting gives rise to an asymmetry in wage determination: the current wage $\Omega_t$ is affected more strongly by the past wage $\Omega_{t-1}$ than the future expected wage $E_t\Omega_{t+1}$.

The average wage is

$$W_t = \frac{1}{2}\left(\Omega_t + \Omega_{t-1}\right). \tag{3.7}$$

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

$$Q_t^D = M_t - P_t, \tag{3.8}$$

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

Finally, money growth follows a random walk (equation (2.1)). This implies that the contract wage may be expressed in terms of its own lagged value and the money supply:[20]

$$\begin{aligned}\Omega_t = {} & (1-\lambda_1)(1+\rho)(c-\sigma L-h) + (1-\lambda_1)\beta + \lambda_1\Omega_{t-1} \\ & + (1-\lambda_1)M_t + \kappa(1-\lambda_1)\mu_t + \zeta_t,\end{aligned} \tag{3.9}$$

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

[19] 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.

[20] To see this, substitute the price equation (3.4) and the wage equation (3.7) into the aggregate demand equation (3.8):

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

where $\lambda_{1,2} = \frac{\phi_2 \pm \sqrt{\phi_2^2 - 4\phi_1\phi_3}}{2\phi_3}$; and $\kappa = \frac{\lambda_2}{\lambda_2 - 1} - \alpha$. It can be shown that $0 < \lambda_1 < 1$ and $\lambda_2 > 1$ when $0 < \gamma < 2(1+\rho)$.

Substituting (3.9) into (3.7), we obtain the aggregate nominal wage dynamics equation:

$$\begin{aligned} W_t = {} & (1-\lambda_1)(1+\rho)(c - \sigma L - h) + (1-\lambda_1)\beta + \lambda_1 W_{t-1} + (1-\lambda_1) M_t \\ & + \left(\kappa - \frac{1}{2}\right)(1-\lambda_1)\mu_t - \frac{1}{2}\kappa(1-\lambda_1)\varepsilon_t + \frac{1}{2}\left(\zeta_t + \zeta_{t-1}\right). \end{aligned} \tag{3.10}$$

Note that in the long-run, wage inflation is equal to the money growth rate: $\Delta W_t^{LR} = \mu_t^{LR}$.[21]

To derive the dynamics of the real wage, we first express price in terms of wages and money (i.e., insert (3.8) into (3.4)):

$$P_t = (1-\theta) W_t + \theta M_t - (1-\theta)\beta, \tag{3.11}$$

where $\theta = \frac{1}{1+\rho}$. Observe that equation (3.10) and (3.11) imply that in the long-run, inflation is equal to the money growth: $\pi_t^{LR} = \mu_t^{LR}$. Substituting (3.10) into

Next, substitute this equation and (3.6) into the contract equation (3.5):

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

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

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

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 $\Omega_t$ is dynamically stable, the rational expectations solution of the previous equation is given by (3.9).

[21] The wage inflation equation is given by the first difference of (3.10):

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

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

(3.11), we find the real wage dynamics equation:[22]

$$W_t - P_t = (1-\lambda_1)(c - \sigma L - h + \beta) + \lambda_1 (W_{t-1} - P_{t-1}) - (1-\lambda_1)\left(\frac{2\alpha - 1}{\gamma}\right)\mu_t$$
$$- \frac{\kappa}{2}(1-\lambda_1)\varepsilon_t + \frac{\kappa}{2}\left(\zeta_t + \zeta_{t-1}\right). \quad (3.12)$$

Inserting this real wage into the employment equation (3.3) and the unemployment rate (2.6), we derive the unemployment dynamics equation:

$$u_t = (1-\lambda_1)(1-a_w\sigma)L + (1-\lambda_1)[a_w(c+\beta-h) - a] + \lambda_1 u_{t-1}$$
$$- a_w(1-\lambda_1)\left(\frac{2\alpha-1}{\gamma}\right)\mu_t - a_w\frac{\kappa}{2}(1-\lambda_1)\varepsilon_t + a_w\frac{\kappa}{2}\left(\zeta_t + \zeta_{t-1}\right); \quad (3.13)$$

Thus the long-run unemployment rate is

$$u_t^{LR} = (1-a_w\sigma)L + a_w(c+\beta-h) - a - a_w\left(\frac{2\alpha-1}{\gamma}\right)\mu_t^{LR}. \quad (3.14)$$

Given that $\pi_t^{LR} = \mu_t^{LR}$, the long-run Phillips curve is[23]

$$\pi_t^{LR} = -\frac{\gamma(1-\sigma)}{(2\alpha-1)}u_t^{LR} + \left(\frac{\gamma}{2\alpha-1}\right)\left[c + (1-2\sigma)\left(L + \frac{h}{\sigma}\right)\right]. \quad (3.15)$$

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.[24]

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

[22] Equations (3.10) and (3.11) imply

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

It can be shown that $\left[\frac{1}{2}(1+\lambda_1) - \kappa(1-\lambda_1)\right] = (1-\lambda_1)\left(\frac{2\alpha-1}{\gamma}\right)$, and thus we obtain (3.12).

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

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

Recalling that $a_w = \frac{1}{1-\sigma}$ and $\beta = \frac{a}{a_w} + \frac{h}{\sigma a_w}$, substituting these expressions into the above equation, and through some algebraic manipulation, we obtain the long-run Phillips curve (3.15).

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

- the greater is the real interest rate, and thus the more backward-looking is the wage contract (i.e. the greater is $\alpha$), and
- the less sensitive is the contract wage to aggregate demand (i.e. the lower is $\gamma$)
- the greater is $\sigma$, i.e., the less diminishing are the returns to labor.

Intuitively, when $\alpha$ or $\gamma$ 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 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 real discount rate ($\delta = \frac{1}{1+r}$). When $\sigma = 0.75$ and $\gamma$ is 0.1,[25] the slope is -2.53 for a real discount rate of 2 percent, and it is -1.03 for a real discount rate of 5 percent.

It is important to emphasize, however, that 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 now turn.

# 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 such an analysis, since it has witnessed major institutional and policy changes over the sample period - 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. In our empirical analysis below, we attempt a rough assessment of how such changes influenced the Phillips curve.[26] 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.

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

[26] Appendix A presents a short account of these major events.

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.

## 4.1. The Empirical Model

Modeling the inflation-unemployment tradeoff involves some hard choices. Since our theory rests on lagged labor market responses to money growth, we can gain a broad macro perspective on the underlying propagation mechanisms by considering a wide set of lagged responses in employment, wage setting, and labor force participation activities. Moreover, since our theory is concerned with the way in which wage and price adjustments influence real economic activities, our empirical model contains a nominal wage equation and a price equation, as well as careful structural specifications of employment and labor force participation equations.[27] Thus we assess the long-run inflation-unemployment tradeoff by estimating a multi-equation system, rather than the more common single-equation, reduced-form Phillips curve. Our analysis indicates that the interactions among our various adjustment processes play a significant role in determining the long-run inflation-unemployment tradeoff.

Since Spain has witnessed several profound policy changes over the past three decades (see Appendix A for a discussion) 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.

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;[28] 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, wage, price, and capital stock equations, as well as a production function and the definition of the unemployment rate. This leaves us with

[27] 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).

[28] 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 hold the capital stock and productivity constant when estimating an employment equation.

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.[29] 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.

Our estimation uses OECD annual data over a sample from 1966 to 1998.[30] 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 ($M_t - P_t$) | $\tau_t$ | indirect taxes as a % of GDP |
| $\theta_t$ | 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 | | |
| $d_t^j$ | $= \begin{cases} 1; & \text{for } t = j, \ldots, 1998; \; j > 1971 \\ 0; & \text{otherwise} \end{cases}$ | $d_t^{71}$ | $= \begin{cases} 1; & \text{for } t = 1971 \\ 0; & \text{otherwise} \end{cases}$ |

All variables are in logs except for the unemployment rate $u_t$ and the tax rate $\tau_t$.
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,[31] 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 polynomia lie outside the unit circle), and pass the standard diagnostic tests

[29] 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).

[30] 1998 is the last year that data is available on the individual money supply series of the EMU countries.

[31] Pesaran and Shin (1995), Pesaran (1997), and Pesaran et al. (1996), 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.)

(for no serial correlation, linearity, normality, homoskedasticity, and constancy of the parameters of interest) at conventional significance levels.[32] 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[33], (ii) the long-run elasticity of the labor force with respect to the working age population is unity, and (iii) absence of money illusion.[34] 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 the regressors and cross equation correlation.

Tables 2a and 2b present the restricted 3SLS estimates of each equation.[35] 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.

[32] See Tables A1-A6 in Appendix B.

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

[34] 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.

[35] Figures A2 in Appendix B picture the actual and fitted values of the unemployment and inflation rates. The plots indicate that our model tracks the data very well.

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

| Dependent variable: $W_t$ | coef. | t-stat. | Dependent variable: $P_t$ | coef. | t-stat. | Dependent variable: $L_t$ | 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) |
| $W^{74}_{t-1}$ | $-0.002$ | ($-2.69$) | $P^{79}_{t-1}$ | $-0.017$ | ($-7.18$) | $\Delta L_{t-2}$ | $-0.29$ | ($-1.97$) |
| $W^{84}_{t-1}$ | $-0.003$ | ($-4.95$) | $P^{87}_{t-1}$ | $-0.005$ | ($-2.16$) | $w_t$ | $-0.01$ | ($-1.85$) |
| $W^{87}_{t-1}$ | $-0.005$ | ($-7.77$) | $P_{t-2}$ | $-0.27$ | ($-4.11$) | $\Delta u_t$ | $-0.18$ | ($-3.69$) |
| $W^{97}_{t-1}$ | $-0.001$ | ($-2.52$) | $W_{t-1}$ | 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) | $M^{88}_t$ | 0.002 | (2.98) | | | |
| $P^{89}_t$ | $-0.008$ | ($-4.96$) | $M^{94}_t$ | 0.0002 | (0.83) | | | |
| $M_t$ | 0.12 | (*) | $\mu_t$ | $-1.04$ | ($-10.6$) | | | |
| $u_{t-1}$ | $-0.40$ | ($-3.84$) | $P^I_t$ | 0.04 | (3.34) | | | |
| $\mu_t$ | 0.55 | (4.51) | $P^{I,77}_t$ | 0.013 | (5.51) | | | |
| $P^I_t$ | 0.08 | (5.16) | $P^{I,86}_t$ | 0.007 | (4.21) | | | |

(*) restricted coefficient for no money illusion in the long-run; $\Delta$ 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.[36] 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[37]. Finally, the labor force depends inversely on the change in the unemployment 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[38].

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

[37] 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 differences are largest in regions with the highest unemployment rates. Furthermore, data from the 1990 Household Budget Survey (Encuesta de Presupuestos Familiares, EPF) 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.).

[38] From 1986 to 1990, the 1.7 million newly employed reduced unemployment only by 0.5 milion.

| 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 | (¤) | $\mu_t$ | 0:19 | (3:90) | $t$ | 0:005 | (3:28) |
| $w_t$ | ¡ 0:16 | ( ¡ 6:53) | $\mu_{t¡1}$ | ¡ 0:09 | ( ¡ 1:82) | $t^{78}$ | ¡ 0:002 | ( ¡ 3:82) |
| $\mu_{t¡1}$ | 0:30 | (3:04) | $m_t$ | 0:04 | (3:08) | | | |
| $\mu^{79}_{t¡1}$ | 0:02 | (2:82) | $w_{t¡1}$ | ¡ 0:03 | ( ¡ 2:06) | | | |
| $\Delta L_t$ | 0:75 | (5:10) | $c_{t¡1}$ | ¡ 0:01 | ( ¡ 3:72) | | | |
| $b_t$ | ¡ 0:21 | ( ¡ 13:9) | $¿_{t¡1}$ | ¡ 0:41 | ( ¡ 4:75) | | | |
| $¿_t$ | ¡ 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[39]. 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 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.

[39]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.

As noted, we endeavor to capture institutional and policy changes - henceforth called IPCs - through multiplicative dummy variables, as shown 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 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 wage 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).[40] 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 $\mu_{t-1}^{79}$ |
| 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.[41]

## 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.

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

[41] As the figures in Appendix B show, our model fits the data closely.

### 5.1. The Long-Run Inflation-Unemployment Trade-off

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 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,[42] 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. We let our initial money growth rate be 15% and our final one be 5%. These values were derived by estimating the Kernel density function for the growth rate of the money supply (along the same lines as Bianchi and Zoega (1998), for example).[43]

For the initial and final money growth rates above, we let all the endogenous variables in our system converge to their long-run steady state growth rates, given the dummy variables that obtain at the end of our sample period. We thereby find the change in the long-run inflation and unemployment rates associated with the change in the money growth rate, enabling us to derive the slope of the long-run Phillips curve at the end of our sample period.[44]

The simulation exercise indicates that the above 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 $d\pi/du = -2.7$ (to the nearest two significant digits) at the end of our sample period.[45]

Of course this estimate of the slope pertains only to the range of observed variations in the inflation and unemployment rates. It is not permissible to extrapolate outside this observed range. Indeed, there are good theoretical reasons (lying beyond the scope of our theoretical model above) to believe that the long-run Phillips is nonlinear over a wider range and that the slope may turn vertical or even positive when the long-run inflation rate is sufficiently high.

[42] 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 $\Delta M_t$ 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.)

[43] The results on this estimation are reported in Appendix C.

[44] Since the model is linear, the evolution of the 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.

[45] The influence of previous institutional and policy changes is examined below.

## 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 - at the beginning of our sample period - 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.[46]. 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 ($\Delta M$) on unemployment ($\Delta u$) 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.[47]

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.

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[46] 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.

[47] 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 $\Delta M$ | | |
|---|---|---|
| **Cumulative impact of IPCs** | $\Delta u$ | slope |
| Trade-off before 1973 ($S_n$) | 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** | $\hat{S}_i$ | (%) |
| 1. Introduction of unionized wage bargaining ($\hat{S}_1$) | 0.03 | -1.6 |
| 2. First oil price shock ($\hat{S}_2$) | -0.01 | 0.5 |
| 3. Institutional changes associated with the Moncloa Pacts ($\hat{S}_3$) | 0.33 | -17.3 |
| 4. First wave of labor market reforms ($\hat{S}_4$) | 0.04 | -1.8 |
| 5. Entry into the EEC ($\hat{S}_5$) | 0.23 | -10.1 |
| 6. Entry into the EMS ($\hat{S}_6$) | 0.16 | -6.4 |
| 7. Second wave of labor market reforms ($\hat{S}_7$) | -0.01 | 0.4 |
| 8. Third wave of labor market reforms ($\hat{S}_8$) | 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,[48] $N(0; \Sigma)$. 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

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

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 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.

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,[49] 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).

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 |

## 6. Conclusions

This paper has provided a theoretical rationale for a long-run tradeoff between inflation and unemployment due to the interplay between money growth and

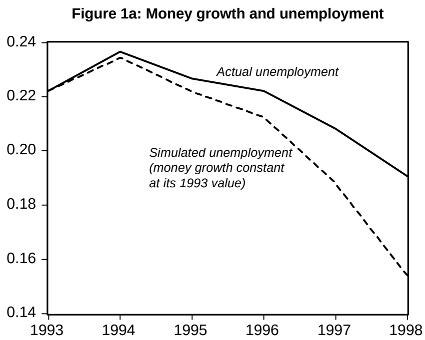
[49] The result concerning EMS contrasts with our finding in Table 4.

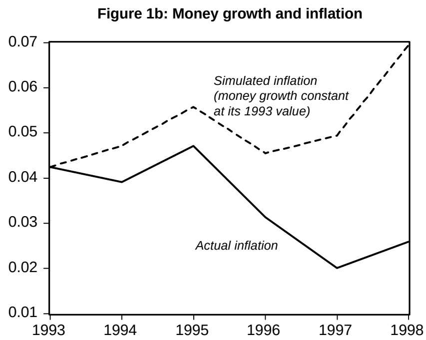
nominal frictions. In this context we have seen that the absence of money illusion and money neutrality does not prevent changes in money growth from having long-run effects on unemployment (as well as inflation, of course). Thereby our analysis avoids the counterfactual prediction of the NAIRU theory that inflation falls without limit when unemployment is high.

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

Our empirical model yields a point estimate of -1.89 for the slope of the Spanish long-run Phillips curve at the beginning of our sample period (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 at the end of our sample period (so that a 10% decrease in money growth leads to a permanent rise in unemployment by 3.7 percentage points). Our Kernel density analysis captures two broad money growth regimes, one at 15% (predominantly at the beginning of the sample period) and one at 5% (predominantly at the end). In short, our analysis suggests that this policy regime change had a pronounced effect on Spain's long-run employment rate.

Not surprisingly, the short- and medium-run effects on unemployment may be even more powerful. For instance, Spain experienced a precipitate fall in money growth over the 1990s, 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 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 rise 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, Figures 1 nevertheless tell an interesting tale.




Figures 1: Unemployment and Inflation Effects Attributable to Monetary Policy

Figure 1a gives the trajectory of the actual unemployment rate vis-a-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 rise in unemployment, through time, that is attributable to the fall in money growth. Along the same lines, Figure 1b depicts the trajectory of actual inflation against the one 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 attributabe to the decline in money growth. In this simple accounting exercise, we see that, by 1998, the contractionary monetary policy 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.

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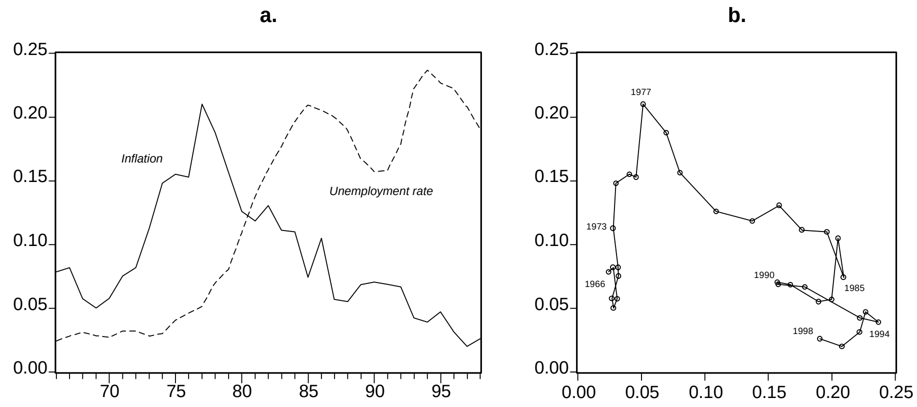
# APPENDICES

## Appendix A: An Overview of In°ation and Unemployment in Spain

The story of the Spanish economy over the past 25 years is one of declining in°ation and persistent unemployment, as shown in Figures A1 and Figure 3a in the text. The rate of in°ation has gradually declined from 24.5% in 1977 to 1.8% in 1998, permitting Spain to join the EMU in 1999. The unemployment rate started low - below 5% until 1976 - but reached more than 21% in 1985. After hovering near this peak for another decade, it has since fallen to less than 15%.

**Figure A1. Inflation and unemployment rate. Spain. 1966-1998.**




Within this broad picture, we can distinguish ¯ve di®erent macroeconomic periods relevant to the Spanish Phillips curve.

### The Period 1969-1977

From 1969 to 1974, Spain experienced a very strong expansion, with GDP growing at an annual rate of 6.6%. 1973 was the ¯rst year in the postwar period when in°ation exceeded 10%, primarily on account of intense domestic demand pressure. In the following years, Spain had to deal with two severe macroeconomic shocks. One was the ¯rst oil price shock, which had a pronounced e®ect on in°ation and unemployment since Spanish industry was heavily dependent on oil imports. The other was the advent of unions in collective wage bargaining. Although unions were not legalized until 1977, their de facto in°uence was asserting itself already in 1973. The immediate implication in the period 1973-77 was a wage-price spiral, in which unions pushed up wages su±ciently to permit real wage growth after taking past in°ation into account, while ¯rms raised prices at an accelerating rate in order to recover their margins. This spiral was aggravated through accommodating macroeconomic policies. As a result, in°ation rose above 15% during the period 1974-76 and reached 24.5% in 1977. However, the e®ects of the above shocks on unemployment were delayed; unemployment remained low, as shown in Figure A1 and Figure 3a.

### The Period 1978-1985

This period featured the following further shocks. First, tight monetary policy was implemented in 1978 to control in°ation, in accordance with the Moncloa Pacts[1]. Next, the second oil price shock occurred in 1979. Together, these shocks reduced consumption, investment, and employment. As a consequence of the Moncloa Pacts, an incomes policy was implemented between 1978 and 1986, whereby the government set an in°ation target, the unions agreed to accept moderation in wage increases, and ¯rms agreed to price moderation.

In 1984 the government began a ¯rst wave of labor market reform by introducing ¯xed-term contracts to increase labor market °exibility and stimulate job creation. As a result temporary employment grew to one third of total employment over the second half of the 1980s.

As Figures A1 and 3a indicate, in°ation came down during this period, but the unemployment rate rose dramatically, as a consequence of the lagged e®ects of the 1973-77 shocks as well as the 1978-1985 shocks.

### The Period 1986-1990

Spain joined the EEC in 1986, and the resulting need for international competitiveness in what were previously highly protected product markets put downward pressure on wages and prices. Monetary policy was relaxed in 1986 and 1987, in view of the previous fall in in°ation. These developments, together with the lagged e®ects of the labor market reforms of 1984, led to a sharp increase in employment[2]. GDP grew at a 4.5% annual rate, stoked by strong domestic demand. To prevent a resurgence of high in°ation, monetary policies were tightened in the late 1980s, a move reinforced by Spain's entry into the EMS in 1989.

The upshot of these developments was that the unemployment rate fell from 21.5% in 1985 to 16.3% in 1990, whereas in°ation remained °at (the in°ation rate, measured by the GDP de°ator, was at 7.7% in 1985 and 7.3% in 1990).

### The Period 1991-2000

A rise in household indebtedness, the Iraqi war of 1991, the upward pressure on interest rates due to German uni¯cation, and the EMS crisis of 1992 and 1993 together pushed the Spanish economy into a short-lived but deep recession. The unemployment

[1] These pacts consisted of a set of policy agreements between the government, ¯rms and unions in response to the economic crisis. On the one hand, there was a very restrictive monetary policy; on the other, there were various structural measures, especially tax reform, incomes policy, and measures to promote competition, such as those in the ¯nancial market. The restrictive monetary policy was implemented right away; the structural policies took several years to apply.

[2] Whereas temporary contracts were a rarity before 1984, the ratio of ¯xed-term employment to dependent employment rose to 15.6% in 1987 (¯rst year with o±cial data), and further to 32.2% in 1991.

rate rose from 15.9% in 1990 to 23.7% in 1994. This recession, together with the tight monetary policy implemented in accordance with the Maastricht Treaty signed in 1991, led to a decline in in°ation from 7.3% in 1990 to 4.0% in 1994.

In 1994 the Spanish government implemented a second wave of labor market reform[3], and the Central Bank became independent, with a mandate to focus exclusively on in°ation control. In 1997 there followed a third reform wave, in which ¯ring costs on permanent contracts were reduced, thereby partially reversing the trend towards temporary employment[4].

These two labor market reforms played an important role in containing real wage growth and this in°uence, along with a new cyclical upturn, provided a strong stimulus to employment in the second half of the 1990s. In years 1995-99, the annual growth rate of GDP reached 3.5% with an annual increase of 3.3% in employment and around 1.8 million jobs created.

These developments were reinforced by the monetary policy run-up to Spain's EMU entry in 1999, involving a sharp reduction in interest rates after 1995. In an attempt to keep in°ation under control nevertheless, the government supplemented its labor market reforms by opening its product markets to foreign competition. Whereas this involved mainly the industrial sector in the second half of the 1980s, in the 1990s it included the service sector, particularly the ¯nancial, transport, communication and telecommunication sectors. Several important public companies were privatized, which helped reduce the public-sector de¯cit. As a result, the pronounced increase in employment in the second half of the 1990s was accompanied by a reduction in in°ation. However, the labor force expanded and thus Spain's unemployment rate responded only moderately; by the end of the 1990s, it was still above 15%.

[3] This second wave was a response to the ¯rst. The main ¯xed-term contract in the 1984 reform was the `employment promotion contract,' which was used heavily by employers to cover both temporary and permanent tasks, and it gave Spain the highest rate of temporary employment in the EU. Thus, in the second wave of labor market reform of 1994, the government tried to restrict the use of this contract by attempting substitute it for other temporary contracts such as the `contract per task or service' and the `contract for launching new activities'. These were originally targeted towards some groups of hard-to-place workers, but in fact they were used in the same way as the previous contract. As a result, the third wave of reform in 1997 was implemented to favor permanent contracts.

[4] The share of temporary employment on total dependent employment had reached 33.7% in 1994, remained at 33.6% in 1997, and reduced to 32.1% in 2000.

# Appendix B: OLS estimates and misspecification tests

Table A1: Wage equation, OLS, 1966-1998.

Dependent variable: $W_t$

| | coefficient | t-stat. | Misspecification tests$^{\times *}$ | |
|---|---|---|---|---|
| Cnt | $4.85$ | $(4.11)$ | SC$^{\times}$ $\chi^2(1)^{*}$ | 4.19[0.055] |
| $W_{t-1}$ | $0.68$ | $(5.79)$ | LIN$^{\times}$ $\chi^2(1)^{*}$ | 0.34[0.56] |
| $W^{74}_{t-1}$ | $-0.002$ | $(-1.73)$ | NOR$^{\times}$ $\chi^2(2)^{*}$ | 0.34[0.84] |
| $W^{84}_{t-1}$ | $-0.003$ | $(-3.57)$ | ARCH$^{\times}$ $\chi^2(1)^{*}$ | 0.89[0.35] |
| $W^{87}_{t-1}$ | $-0.005$ | $(-5.41)$ | HET $\chi^2(14)$ | 0.58[0.86] |
| $W^{97}_{t-1}$ | $-0.001$ | $(-2.19)$ | | |
| $W_{t-2}$ | $-0.46$ | $(-4.70)$ | | |
| $P_t$ | $0.66$ | $(5.83)$ | | |
| $P^{89}_t$ | $-0.009$ | $(-3.34)$ | | |
| $M_t$ | $0.16$ | $(2.12)$ | | |
| $u_{t-1}$ | $-0.33$ | $(-2.32)$ | | |
| $\mu_t$ | $0.44$ | $(2.16)$ | | |
| $P^I_t$ | $0.07$ | $(2.50)$ | | |

+ LL=111.11, AIC=-5.95, SC=-5.36

++ $[F(1;20)] = 0.30\,[0.59]$

* Probabilities in square brackets

X Structural stability cannot be rejected at the 5% size of the test

+ Log likelihood (LL), Akaike (AIC) and Schwarz (SC) criteria

++ Wald test for long-run no money illusion

Table A2: Price equation, OLS, 1966-1998.

| Dependent variable: $P_t$ | coefficient | t-stat. | Misspecification tests* | |
|---|---|---|---|---|
| Cnt | $-5.56$ | $(-5.15)$ | $SC\left[\chi^2(1)\right]$ | $1.51\,[0.23]$ |
| $P_{t-1}$ | $0.78$ | $(4.38)$ | $LIN\left[\chi^2(1)\right]$ | $1.49\,[0.24]$ |
| $P^{79}_{t-1}$ | $-0.012$ | $(-2.74)$ | $NOR\left[\chi^2(2)\right]$ | $0.18\,[0.91]$ |
| $P^{87}_{t-1}$ | $-0.006$ | $(-2.08)$ | $ARCH\left[\chi^2(1)\right]$ | $0.26\,[0.62]$ |
| $P_{t-2}$ | $-0.39$ | $(-3.94)$ | $HET\ \chi^2(22)$ | $0.60\,[0.84]$ |
| $W_{t-1}$ | $0.32$ | $(3.07)$ | | |
| $M_t$ | $0.24$ | $(5.29)$ | | |
| $M^{88}_t$ | $0.002$ | $(2.70)$ | | |
| $M^{94}_t$ | $0.000$ | $(0.98)$ | | |
| $\mu_t$ | $-0.77$ | $(-4.19)$ | | |
| $P^{I}_t$ | $0.06$ | $(2.82)$ | | |
| $P^{I,77}_t$ | $0.010$ | $(3.58)$ | | |
| $P^{I,86}_t$ | $0.015$ | $(4.59)$ | | |

+ LL=119.04, AIC=-6.43, SC=-5.84

++ $[F(1;20)] = 2.56\,[0.13]$

* Probabilities in square brackets

+ Log likelihood (LL), Akaike (AIC) and Schwarz (SC) criteria

++ Wald test for long-run no money illusion

Table A3: Labor force equation, OLS, 1966-1998.

| Dependent variable: $L_t$ | coefficient | t-stat. | Misspecification tests* | |
|---|---|---|---|---|
| Cnt | $-0.54$ | $(-1.74)$ | $SC\left[\chi^2(1)\right]$ | $0.12\,[0.74]$ |
| $L_{t-1}$ | $0.84$ | $(18.3)$ | $LIN\left[\chi^2(1)\right]$ | $1.39\,[0.25]$ |
| $\Delta L_{t-2}$ | $-0.34$ | $(-2.16)$ | $NOR\left[\chi^2(1)\right]$ | $0.46\,[0.79]$ |
| $w_t$ | $-0.03$ | $(-2.42)$ | $ARCH\left[\chi^2(1)\right]$ | $1.74\,[0.20]$ |
| $\Delta u_t$ | $-0.12$ | $(-2.04)$ | $HET\ \chi^2(1)$ | $1.42\,[0.24]$ |
| $Z_t$ | $0.20$ | $(3.76)$ | | |

+ LL=133.99, AIC=-7.76, SC=-7.48

++ $[F(1;27)] = 3.34\,[0.08]$

* Probabilities in square brackets

+ Log likelihood (LL), Akaike (AIC) and Schwarz (SC) criteria

++ Wald test for unit long-run elasticity of L w.r.t. Z

Table A4: Employment equation, OLS, 1966-1998.

| Dependent variable: $N_t$ | coefficient | t-stat. | Misspecification tests* | |
|---|---|---|---|---|
| Cnt | $0.47$ | $(0.38)$ | SC $\chi^2(1)$ | $1.43\,[0.25]$ |
| $N_{t-1}$ | $0.84$ | $(6.93)$ | LIN $\chi^2(1)$ | $1.51\,[0.24]$ |
| $N^{74}_{t-1}$ | $-0.001$ | $(-2.31)$ | NOR $\chi^2(1)$ | $1.27\,[0.53]$ |
| $N^{84}_{t-1}$ | $-0.001$ | $(-1.28)$ | ARCH $\chi^2(1)$ | $0.01\,[0.91]$ |
| $N^{93}_{t-1}$ | $-0.002$ | $(-6.65)$ | HET $\chi^2(1)$ | $0.69\,[0.80]$ |
| $k_t$ | $0.64$ | $(2.94)$ | | |
| $k_{t-1}$ | $-1.35$ | $(-4.33)$ | | |
| $k_{t-2}$ | $0.83$ | $(3.64)$ | | |
| $w_t$ | $-0.15$ | $(-4.50)$ | | |
| $\mu_{t-1}$ | $0.34$ | $(2.42)$ | | |
| $\mu^{79}_{t-1}$ | $0.02$ | $(1.98)$ | | |
| $\Delta L_t$ | $0.65$ | $(3.02)$ | | |
| $b_t$ | $-0.21$ | $(-9.16)$ | | |
| $\tau_t$ | $-0.34$ | $(-1.33)$ | | |
| $d^{71}$ | $0.01$ | $(2.22)$ | | |

$^{+}$ LL=141.97, AIC=-7.69, SC=-7.01
$^{++}$ $[F(1;18)] = 0.35\,[0.56]$

* Probabilities in square brackets
$^{+}$ Log likelihood (LL), Akaike (AIC) and Schwarz (SC) criteria
$^{++}$ Wald test for constant returns to scale

Table A5: Capital stock equation, OLS, 1966-1998.

| Dependent variable: $k_t$ | coefficient | t-statistic | Misspecification tests* | |
|---|---|---|---|---|
| Cnt | $-1.24$ | $(-1.76)$ | $SC[\chi^2(1)]$ | 1.13 [0.30] |
| $k_{t-1}$ | 1.34 | (10.5) | $LIN[\chi^2(1)]$ | 0.33 [0.57] |
| $k_{t-2}$ | $-0.67$ | $(-4.66)$ | $NOR[\chi^2(1)]$ | 2.64 [0.27] |
| $k_{t-3}$ | 0.23 | (3.16) | $ARCH[\chi^2(1)]$ | 0.75 [0.39] |
| $N_t$ | 0.26 | (5.38) | $HET[\chi^2(1)]$ | 0.68 [0.78] |
| $N_{t-1}$ | $-0.13$ | $(-1.66)$ | | |
| $N_{t-2}$ | 0.03 | (0.74) | | |
| $\theta_t$ | 0.22 | (3.40) | | |
| $\theta_{t-1}$ | $-0.11$ | $(-1.81)$ | | |
| $m_t$ | 0.03 | (1.74) | | |
| $w_{t-1}$ | $-0.02$ | $(-0.92)$ | | |
| $c_{t-1}$ | $-0.01$ | $(-2.19)$ | | |
| $\tau_{t-1}$ | $-0.30$ | $(-2.11)$ | | |
| $d^{71}$ | $-0.013$ | $(-4.55)$ | | |

+ LL=164.73, AIC=-9.13, SC=-8.50
++ $[F(1;19)] = 2.82$ [0.11]

* Probabilities in square brackets
+ Log likelihood (LL), Akaike (AIC) and Schwarz (SC) criteria
++ Wald test for constant returns to scale

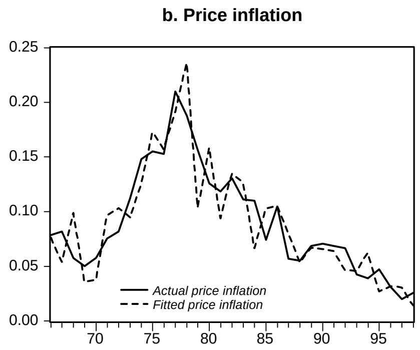
Table A6: Production function, OLS, 1966-1998.

| Dependent variable: $y_t$ | coefficient | t-statistic | Misspecification tests* | |
|---|---|---|---|---|
| Cnt | $-1.78$ | $(-1.22)$ | $SC[\chi^2(1)]$ | 0.09[0.76] |
| $y_{t-1}$ | 0.36 | (1.60) | $LIN[\chi^2(1)]$ | 1.62[0.22] |
| $y_{t-2}$ | $-0.27$ | (1.75) | $NOR[\chi^2(1)]$ | 0.66[0.84] |
| $k_t$ | 0.45 | (4.68) | $ARCH[\chi^2(1)]$ | 0.00[0.96] |
| $k_t^{75}$ | $-0.001$ | $(-2.20)$ | $HET[\chi^2(1)]$ | 1.47[0.23] |
| $N_t$ | 0.58 | (4.04) | | |
| $N_t^{84}$ | 0.003 | (3.32) | | |
| $t$ | 0.003 | (1.23) | | |
| $t^{78}$ | $-0.001$ | $(-2.22)$ | | |

+ LL=105.25, AIC=-5.83, SC=-5.42
++ $[F(1;24)] = 1.77$ [0.20]

* Probabilities in square brackets
+ Log likelihood (LL), Akaike (AIC) and Schwarz (SC) criteria
++ Wald test for constant returns to scale

**Figures A2: Actual and Fitted Values of the Unemployment and Inflation Rates**

# Appendix C: Kernel Density Analysis for Money Growth

**Figure A3. Money supply growth Kernel density function. 1966-1998.**

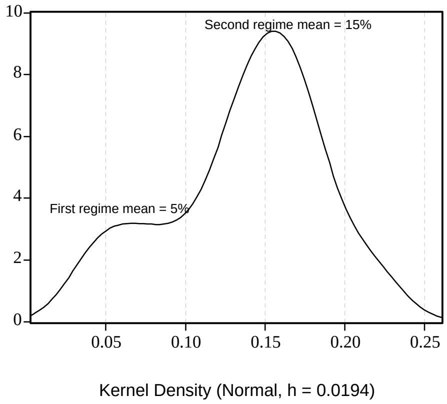
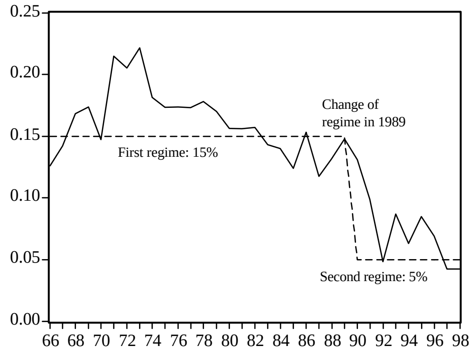



**Figure A4. Money supply growth. Spain, 1966-1998.**



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