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Abstract

We test the Barro-Gordon model extended to allow for persistence in unemployment. First, we build an index of central bank independence and measures of persistence, and then we compare them with inflation performance in OECD countries. Our results show, as theory predicts, a robust negative relationship between the degree of independence and the level and variance of inflation. However, the extended model is not strongly endorsed by the data since the link between inflation and unemployment persistence is weak. The reason is that there exists a strong correlation between unemployment persistence and independence. This may have important implications for the design of an antinflationary policy.

1.-INTRODUCTION

The introduction of rational expectations into economic analysis has deprived the Phillips curve of much of its attractiveness, since it implies that only inflation surprises can have effects on unemployment, and then only in the short run.

Strategic models of monetary policy under the new paradigm (Kydland & Prescott (1977) and Barro & Gordon (1983)) went further when they showed that, if monetary authorities care about unemployment, there exists an incentive to generate inflation, despite its ineffectiveness. This incentive, when internalised by agents, introduces an inflationary bias into the economy. Rogoff (1985) showed that this bias could be reduced if the government delegates monetary policy to an independent central bank with a greater preference for low inflation.

The attractiveness of an independent central bank has gradually come to permeate policymaking, supported by the antinflationary success of the Bundesbank, epitome of monetary independence. In recent years an institutional revolution has taken place in the way monetary policy is conducted, with central banks being given more independence. The design of the future European Central Bank is a good example of this.

Worries about inflation extend to high unemployment levels and their persistence. Intuitively, one would think that the more persistent is unemployment, the greater the ability of monetary policy to influence its level in the short and, even, in the long run. Thus, persistence may have important effects on monetary policy management, even if the roots of persistence lie mainly in the functioning of the labour market.

These considerations have been formalised by several authors (Lockwood & Phillipipoulos (1994), Jonsson (1995)) by extending the basic Barro-Gordon model to introduce unemployment persistence. However, their results show that monetary policy in the new context, far from being more effective, increases the inflationary bias. The reason is that agents perceive that unemployment persistence increases the incentive to generate

inflationary surprises, since persistence prolongs the effects of such surprises.

In this paper, we wish to explore empirically the link between unemployment persistence, central bank independence (CBI) and inflation derived from the extended Barro-Gordon model, which is presented in the next section. The analysis covers most of the OECD countries for the period 1973-91. By the end of the period central banks in many countries were being given more independence.

The negative correlation between CBI and inflation has been extensively and succesfully tested (see, for instance, Alesina & Summers (1993)). However, the concept of CBI is difficult to define and the measures designed to capture the effective degree of CBI, are necessarily subject to a large degree of arbitrariness. Therefore, our first goal has been to construct a 'index of indices' taking into account all the factors considered by the literature in order to obtain, if possible, a more objective measure.

By contrast, the effects of unemployment persistence on inflation have not, as yet, been explored, at least in the current context. In order to do so, we first need to construct a measure of persistence.

The empirical results are presented in section III. They show that the extended model is not endorsed by the empirical evidence, but an interesting relationship is unveiled between independence and unemployment persistence, whose implications will be developed in the conclusions.

2.-THE MODEL

The main consequence of introducing unemployment persistence into a strategic model of monetary policy is to transform the static setting of Barro and Gordon (1983) into a dynamic setting. The resolution of this model is attributable to Lockwood & Phillippopoulos (1994). They contemplate an infinite horizon, which results in strong restrictions on the parameters and in a highly complex solution. Hence, we have opted here, following Jonsson (1995), for a two-period model, which yields the basic intuitive features in a much simpler framework.

2.1.-Unemployment persistence

There are several models to explain unemployment persistence. They are usually based on labour market rigidity; in particular our specification derives from the 'insiders-outsiders' model of Blanchard & Summers (1986). In this model, wage bargaining is carried out by trade unions in wich employed workers insiders have more power. In the bargaining, trade unions unilaterally fix the nominal wage (w_t), and firms then choose the corresponding employment, according to the following labour demand curve:

$$n_t=-(w_t-p_t)+\eta_t \qquad [1]$$

where the variables are expressed in logs, n_t is employment, p_t is the price level and η_t is a supply disturbance. Rational expectations are assumed, so that for any variable x, $x_t^e=E_{t-1}x_t$.

The trade union will choose the nominal wage which minimises the expected deviations from the desired employment level, denoted by $\tilde{n}_t$:

$$\mathbf{Min}_w\ E(n_t-\tilde{n}_t)^2$$

subject to [1]. The resolution of this optimization problem yields a nominal wage of

$$w_t=p_t^e-\tilde{n}_t$$

Susbstituting this expression into [1] and adding and substracting p_{t-1}, equilibrium employment is:

$$n_t=\tilde{n}_t+(\pi_t-\pi_t^e)+\eta_t$$

where π is the inflation rate.

The co-existence of insiders and outsiders in the labour market influences the choice of the desired level of employment $\tilde{n}_t$. While outsiders worry exclusively about employment, insiders, who already have a job, tend to care more about the purchasing power of their wage. Since, as seen in the previous expression, the real wage is a decreasing function of the desired employment level, this group will simply aim to maintain the current level of employment. Therefore, $\tilde{n}_t$ is determined by the following expression.

$$\tilde{n}_t=\theta n_{t-1}+(1-\theta)l$$

where n_{t-1} is employment at the start of the previous period (i.e. the number of insiders), l is the workforce (assumed to be fixed) and $0\leq\theta\leq1$ is the power

of insiders in the bargaining process. When the desired employment level is substituted in the previous equation and we rewrite it in terms of unemployment ($u=1-n$), we get the following Phillips curve:

$$u_t=\theta u_{t-1}-(\pi_t-\pi_t^e)-\eta_t \qquad [2]$$

We note that persistence in unemployment depends positively on the value that θ takes. Secondly, we observe that the natural unemployment rate is determined by the past level of unemployment.

It is convenient at this point to show that wage rigidity is proportional to the degree of persistence in unemployment. Two different concepts of rigidity are relevant. Nominal wage rigidity (NWR) is defined as the increase in inflation required to reduce unemployment. In our context inflation increases are associated with monetary surprises, so that we can define nominal wage rigidity as $NWR=-\lim_{k\to\infty}\partial u_{t+k}/\partial(\pi_t-\pi_t^e)$. Usually, real wage rigidity (RWR) is measured by computing the reduction in real wages required to reduce the unemployment level, that is, $RWR=\lim_{k\to\infty}\partial u_{t+k}/\partial(w_t-p_t)$. The lower the inflation increase (real wage decrease) required to reduce unemployment, the higher will be nominal (real) wage rigidity.

In our model, the Phillips curve shows that monetary surprises reduce not only current but also future unemployment, due to persistence. Thus, the overall effect of an inflation surprise on unemployment is $-1-\theta-\theta^2-\theta^3-\ldots=-(1-\theta)^{-1}$, which -as an absolute value- constitutes the degree of nominal wage rigidity. Further, in the expression for the nominal wage above, we can observe that a monetary surprise reduces real wages in the same proportion. Thus, computing the implicit derivative in the case of the real rigidity we get

$$RWR=NWR=\frac{1}{1-\theta}$$

where wage rigidity (both nominal and real) is an increasing function of

unemployment persistence[1].

2.2.-Model solution

The arguments of the Government's loss function are its objectives: inflation (π) and unemployment (u). The Government chooses the inflation rate in each period (π_1, π_2) to minimise the value of its loss function, where we have assumed -without loss of generality- a discount rate equal to unity:

$$\text{Min}_{\pi 1 \pi 2} \; L_1 = L_1 + L_2 = [\pi_1^2 + \lambda u_1^2] + [\pi_2^2 + \lambda u_2^2]$$

subject to the Phillips curve.

As stressed above, past inflationary surprises affect current unemployment and the loss function, so that we face an intertemporal optimising problem[2]. The solution procedure consists in solving backwards. At the beginning of the second period, trade unions fix their wage, taking into account their expected inflation for $t=2$ and once the supply disturbance is observed, the Government chooses the inflation level. Trade unions inflation expectations are obtained by optimising the expected loss function for the Government in the second period (L_2), subject to [2]. Since expectations are rational, expected inflation is

$$\pi_2^e = \lambda \theta u_1$$

Substituting this expression in L_2 and optimising, we arrive at the optimal inflation in period 2:

$$\pi_2^* = \lambda \theta u_1 - \frac{\lambda}{1+\lambda} \eta_2 \qquad [3]$$

where the asterisk refers to optimal values. Optimal unemployment is obtained by substituting this expression into the Phillips curve:

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[1]-Labour market models usually contain a link between real wage rigidity and persistence (Alogoskoufis & Manning (1988)), but the link between nominal wage rigidity and persistence is not straightforward. In our model, with no nominal inertia, these two concepts are equivalent (See Layard et al. (1991), p.98, for a more detailed exposition of these concepts).

[2]-With no unemployment persistence $\theta=0$, the solution is identical for each period and the problem becomes a game repeated period by period.

$$u_2^* = \theta u_1 - (1+\lambda)^{-1}\eta_2 \qquad [4]$$

Since optimal inflation in period 2 depends on first period unemployment, optimal policy in period one must take this into account, and trade unions will form their expectations accordingly, by minimising the expected loss function for both periods. Since $E_1[L_2]=E_1[E_2[L_2]]=E_1[\pi^{*2}_2+\lambda u^{*2}_2]$, it follows that:

$$\text{Min}_{\pi_1} \; E_1[L_1+L_2]=E_1[(\pi_1^2+\lambda u_1^2)+(\pi^{*2}_2+\lambda u^{*2}_2)]$$

Substituting **(2-4)** into the loss function, we can derive the first order conditions. Substituting again **(3,4)** and applying rational expectations, we obtain expected inflation for the first period:

$$\pi^e_1 = \lambda\theta(1+\theta^2(1+\lambda))u_n \qquad [5]$$

The Government chooses the inflation rate after observing the supply shock and taking into account **[5]**:

$$\text{Min}_{\pi_1} \; L_1+E_1[L_2]=\pi_1^2+\lambda u_1^2+E_1[\pi^{*2}_2+\lambda u^{*2}_2]$$

Substituting **(2-5)** and minimising, optimal inflation at **t=1** is determined by the following expression[3]:

$$\pi_1^* = \lambda\theta[1+\theta(1+\lambda)]u_n - \frac{\lambda}{1+\lambda}\left[1+\frac{\theta^2}{1+\lambda\theta^2}\right]\eta_1 \qquad [6]$$

When $\theta=0$ (corresponding to the model with no persistence) the inflationary bias drops out. The existence of persistence creates an incentive to generate inflation, arising from the fact that current reductions in unemployment have lasting effect on future unemployment levels. This incentive is perceived by agents when forming their expectations, as we can observe by noting that the optimal expected inflation is equal to the agents' expectation, π^e_1 (the inflationary bias of the economy). Further, unemployment persistence also involves higher inflation variability.

Finally, it is worth stressing that the effects of persistence in unemployment are qualitatively equivalent to those of λ: the larger the relative weight of unemployment in the government loss function, the higher the inflationary bias and inflation variability. Taking the first and second

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[3] -Substituting **(6)** into the Phillips curve we can also obtain unemployment in the initial period:

$$u_1^* = \theta u_n - [(1+\lambda)(1+\lambda\theta^2)]^{-1}\eta_1$$

moments in (6) and differentiating with respect to the relevant parameters, we get:

$$\frac{\partial E[\pi_1]}{\partial \lambda} = [\theta + \theta^2(\lambda + \theta(1+\lambda))]u_0 > 0 \qquad \frac{\partial \sigma_\pi^2}{\partial \lambda} = \frac{2\lambda(1+2\theta^2+3\lambda\theta^2+\theta^4+2\lambda^2\theta^4)}{(1+\lambda)^3(1+\lambda\theta^2)^3}\sigma_\eta^2 > 0$$

$$\frac{\partial E[\pi_1]}{\partial \theta} = 2\lambda\theta(1+\lambda)u_0 > 0 \qquad \frac{\partial \sigma_\pi^2}{\partial \theta} = \frac{4\lambda^3\theta(1+\theta^2+\lambda\theta^2)^2}{(1+\lambda)^2(1+\lambda\theta^2)^3}\sigma_\eta^2 > 0$$

To sum up, the extension of the Barro-Gordon model in order to introduce persistence in unemployment shows that higher levels of persistence increase the inflationary bias of the economy and the variability of inflation, in much the same way as λ, the relative weight of unemployment in the Government loss function.

3.-EMPIRICAL EVIDENCE

The model is tested using a cross-section analysis of nineteen OCDE countries for the period 1973-91[4], with quarterly data. Data on inflation levels, the degree of unemployment persistence (θ) and the value of λ are required.

3.1-CBI as a proxy for λ

The parameter λ is not directly observable and it must be proxied by a measurable variable which is closely related to it. Rogoff (85) showed in the Barro-Gordon context, that an independent Central Bank would choose a lower value for λ than the Government. There are good reasons for this besides the theoretical reasons advanced in his work. A Central Bank whose explicit goal is price stability and with enough formal and effective independence to isolate itself from the political cycle, will naturally have a higher relative aversion to inflation (lower λ) than a Government which must in a relatively short period satisfy voters for whom employment is a primary

[4]-The excluded OECD countries are Mexico, Turkey (hyperinflation would be problematic to deal with), New Zealand and Greece (their unemployment series is too short robusta de persistencia), and Portugal, whose labour market is peculiar (ver Blanchard & Jimeno (1995)).

concern.

Therefore, the degree of CBI becomes an adequate proxy for λ, and we expect to find a negative relationship between CBI and inflation. When one attempts to test this relationship empirically , the first problem is the definition and measurement of CBI. The literature provides a battery of indices, but none of them is free from criticism, because they are intrinsically arbitrary[5].

Our solution to this problem has been to construct an index of indices which allows all the factors considered to be taken into account. Table 1 sums up our approach, presenting the values for every country, homogenised according to the criterion described in the annex; higher degrees of independence are associated with higher values. The last column displays the mean value of these measures, which we will use in our analysis.

For the considered sample which, as we have underlined, does not convey the institutional changes in the beginning of the nineties, we can observe that Germany always appears at the top of the league and Spain is usually placed at the bottom[6]. In general, the indices are fairly consistent, but some countries (Australia, Canada, Italy) show a large dispersion. This fact reflects the arbitrariness of the measures and justifies our approach.

3.2.-Unemployment persistence

A series is said to be persistent when shocks in one period affect the level of the series for several periods. We can find in the literature various measures based on two different approaches: the gain function in the differenced series (Campbell & Mankiw, 1987) and the limit of the variance ratio, proposed by Cochrane (1988).

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[5]-The annex contains a a description of each index.

[6]-As Fernández de Lis (1996) shows, after the Law of Autonomy for the Bank of Spain in 1994, the position of Spain shifts to the top of the league.

Table 1.	HOMOGENISED MEASURES AND MEAN VALUE									
	Ck(L)	ES	BP	CK(T)	A	GMT(P)	GMT(E)	HS	CK(Q)	MEAN
	19	18	18	17	16	15	15	15	10	
Germany	18,00	18,47	17,94	18,44	18,40	18,36	17,07	19,00	19,00	18,30 (19)
Australia	9,50	2,06	1,53		2,80	9,36	12,57	13,21	13,00	8,00 (9)
Austria	17,00	12,65	7,88			9,36	12,57	10,64		11,68 (15)
Belgium	3,00	12,65	7,88	8,31	9,40	2,29	12,57	4,21	3,00	7,03 (5)
Canada	14,00	2,06	7,88	12,25	9,40	13,21	17,07	13,21		11,14 (13)
Denmark	15,00	16,35	17,94	18,44	9,40	9,36	8,07	8,07	11,00	12,63 (16)
Spain	4,00	2,06	1,53	1,56	2,80	5,50	2,29	1,00		2,59 (1)
Finland	6,50	12,65	14,76	8,31	9,40				15,00	11,10 (12)
France	8,00	6,82	7,88	4,38	9,40	5,50	8,07	4,21	7,00	6,81 (2)
Netherlands	13,00	16,35	7,88	18,44	9,40	18,36	4,21	15,79		11,49 (14)
Ireland	12,00			4,38		9,36	4,21	10,64	1,00	6,93 (3)
Italy	5,00	6,82	7,88	15,63	1,00	13,21	1,00	4,21	17,00	7,97 (8)
Japan	2,00	12,65	14,76	1,56	16,00	2,29	8,07	4,21		7,69 (6)
Luxemburg	11,00	6,82	7,88	15,63					9,00	10,07 (11)
Norway	1,00	6,82	7,88	15,63	9,40					8,15 (10)
United Kingdom	9,50	6,82	7,88	12,25	9,40	2,29	8,07	8,07	5,00	7,70 (7)
Sweden	6,50	6,82	7,88	4,38	9,40					7,00 (4)
Switzerland	19,00	18,47	17,94	8,31	18,40	15,79	17,07	15,79		16,35 (18)
United States	16,00	12,65	14,76	8,31	16,00	15,79	17,07	17,71		14,79 (17)

Key (see Annex): CK(L), CK(T), CK(Q)=Cukierman (1992), according to various criteria; ES=Eijffinger & Schalling (1993); BP=Bade & Parkin (1988); A=Alesina (1983); GMT(P), GMT(E)=Grilli, Masciandaro, Tabellini (1991). Haan & Sturm (1992).
The shaded cells contain the highest and lowest values of each index.

Table 2. STANDARISED MEASURES OF PERSISTENCE				
	ARIMA	A20	V20	AVERAGE
Spain	1 (1)	1 (1)	1(1)	1 (1)
United Kingdom	.88 (2)	.88 (2)	.51 (3)	.70 (2)
Ireland	.66 (3)	.76 (3)	.49 (4)	.60 (4)
Germany	.56 (4)	.59 (5)	.37 (6)	.47 (5)
Belgium	.55 (5)	.71 (4)	.65 (2)	.64 (3)
Denmark	.52 (6)	.43 (8)	.20 (9)	.34 (8)
Canada	.50 (7)	.41 (8)	.18 (10)	.32 (9)
USA	.49 (8)	.38 (10)	.15 (11)	.29 (10)
Netherlands	.47 (9)	.49 (7)	.37 (7)	.42 (6)
Finland	.44 (10)	.32 (13)	.15 (12)	.27 (12)
Australia	.37 (11)	.34 (12)	.14 (13)	.25 (13)
France	.34 (12)	.52 (6)	.38 (5)	.40 (7)
Sweden	.33 (13)	.37 (11)	.22 (8)	.28 (11)
Luxemburg	.29 (14)	.17 (19)	.04 (19)	.14 (17)
Austria	.25 (15)	.31 (14)	.14 (13)	.21 (14)
Norway	.22 (16)	.22 (16)	.08 (16)	.15 (16)
Italy	.20 (17)	.21 (17)	.07 (17)	.14 (18)
Japan	.17 (18)	.29 (15)	.14 (14)	.19 (15)
Switzerland	.00 (19)	.18 (18)	.05 (19)	.07 (19)

Note: The cells give the value of each measure for each country. The ranking of each country according to each measure is given in brackets (1 correspons to the country with most persistence and 19 that with least). The final column gives a weighted average of this three measures.

Since none of the approaches is superior to the rest we present our results for three different indicators (ARIMA, A20, V20) and we will use the mean of the three. The first two indicators are biased in the gain function and the third in the variance ratio. The theoretical concepts relating to persistence and a description of the indicators appear in the annex.

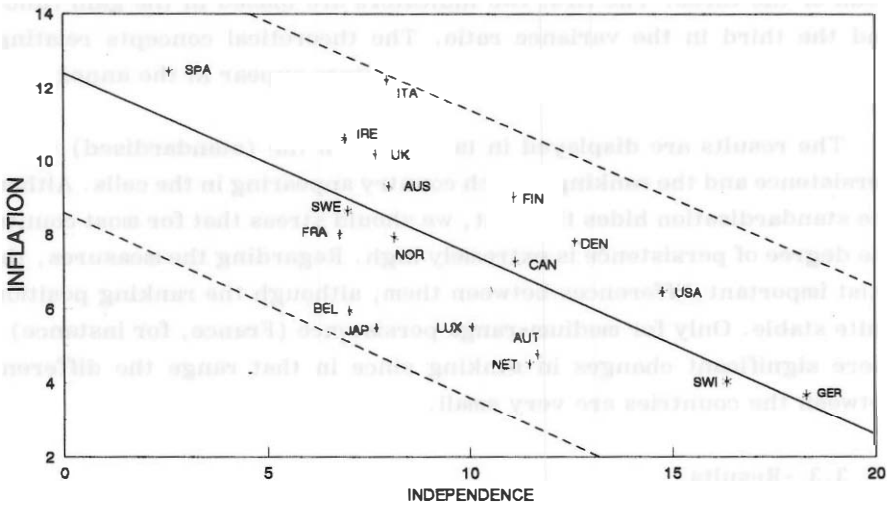
The results are displayed in table 2, with the (standardised) value of persistence and the ranking of each country appearing in the cells. Although the standardisation hides this fact, we should stress that for most countries the degree of persistence is extremely high. Regarding the measures, there exist important differences between them, although the ranking position is quite stable. Only for medium-range persistence (France, for instance) are there significant changes in ranking since in that range the differences between the countries are very small.

3.3.-Results

Before presenting our results, it is convenient to make some remarks about the nature of our data set. Firstly, each measure is subject to important limitations: inflation measures are just sample approximations, since the series are non-stationary; persistence values are not free from problems, as we have pointed out; finally, the ordinal CBI measure of an ordinal nature will be compared with two cardinal measures. Secondly, cross-section analysis implies a small number of observations (19 in total). Both factors advise caution in the interpretation of our results.

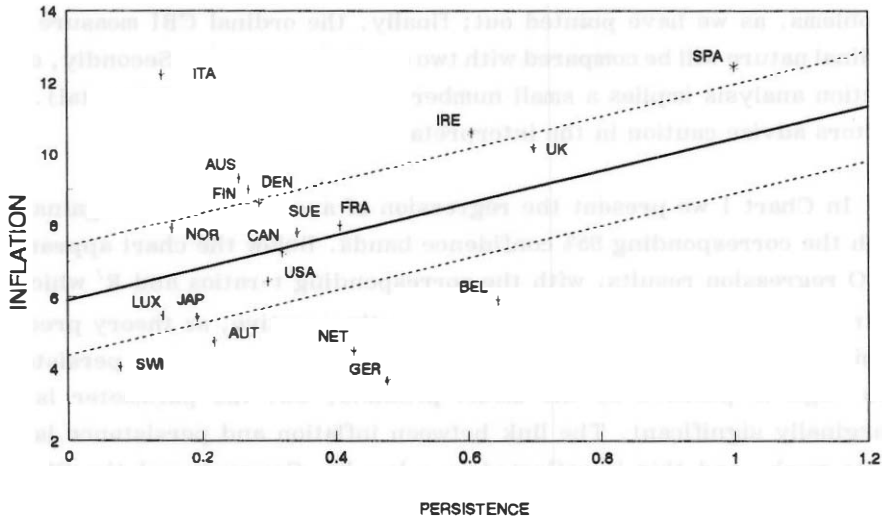
In Chart 1 we present the regression of average inflation against CBI with the corresponding 95% confidence bands. Below the chart appear, the MCO regression results, with the corresponding t-ratios and R^2 which are extremely high. The relationship is robustly negative, as theory predicts. Similarly, chart 2 presents the regression of inflation against persistence. The sign is positive as the model predicts, but the parameter is only marginally significant. The link between inflation and persistence is thus quite weak, and this is reflected in a low R^2. Germany and the DM-zone countries are important outliers, presenting low inflation relative to their degree of persistence, as is Italy, which represents the opposite case.

Chart 1



$$\Pi_i = 12.39 - 0.48\ BCI + u_i \qquad \bar{R}^2 = 0.46$$
$$(-4.09)$$

Chart 2



$$\Pi_i = 5.91 + 4.56\ \Theta_i + u_i \qquad \bar{R}^2 = 0.15$$
$$(1.79)$$

The main objective of our exercise is to test whether the Barro-Gordon model with unemployment persistence better explains the inflationary process than its simpler, no persistence version. Thus, the extended model will be endorsed by the data if, when considering persistence, the explanatory power of the regression -measured by (corrected) R^2 is significantly improved relative to our initial regression. The results are as follows:

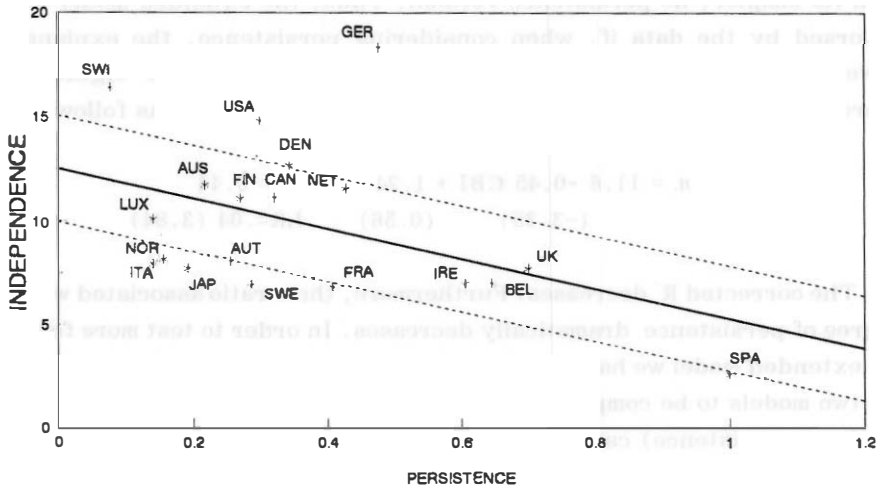
$$\pi_t = 11.6 - 0.45\ CBI + 1.24\ \theta \qquad R^2 = 0.44$$
$$\qquad\qquad (-3.35) \qquad (0.56) \qquad LR=.04\ (3.84)$$

The corrected R^2 decreases. Furthermore, the t-ratio associated with the degree of persistence dramatically decreases. In order to test more formally the extended model we have applied a Likelihood ratio test (LR) which allows the two models to be compared. Its value indicates that the restricted model (with no persistence) cannot be rejected by the data (the value of the chi-square, beyond which the restricted model would be rejected, is given in brackets). Therefore, the results of this regression not only reject the model, but they reveal that the link between inflation and persistence may be due to the fact that persistence and independence are somehow related.

Chart 3 presents the relationship between the two variables. A significant negative correlation between persistence and CBI may be observed (correlation coefficient 0.44). This fact reconciles the significance of the persistence parameter when regressed alone on inflation and its lack of significance when the regression includes CBI. Apart from the afore mentioned measurement problems with the data, these results could be criticised because of the non-linearity of the regression implied by the model (equation (6)). We have, consequently, performed some non-linear transformations in the regressions but none has substantially improved the results of the regression.

For completeness, we have repeated the exercise with the sample variance of inflation; the signs of the parameters should be the same as when using the sample mean, namely, a negative correlation of inflation variance

Chart 3



$$CBI = 12.5 - 7.1\,\Theta_i + u_i \qquad \bar{R}^2 = 0.14$$
$$(-2.03)$$

(σ_π^2) with CBI and a positive correlation with persistence[7]. The results are indeed very similar to those obtained with the mean.

4.-CONCLUSIONS

Introducing persistence in unemployment has allowed us to evaluate jointly two fundamental sources of the inflationary process: monetary factors and the characteristics of the labour market.

The model of monetary policy which we have used in this work reveals that the inflationary bias disappears only when there is no persistence since, as we have remarked, not even a completely independent central bank would choose to exclude unemployment from its loss function. This fact would suggest that a successful antinflationary strategy rests on Central Bank independence but it must be complemented with reforms in the labour market in order to reduce rigidites in wages and persistence in unemployment.

However, empirical testing of the extended model turned out to be unsatisfactory. Adding persistence in unemployment to the original and indeed very robust inflation-CBI cross-country regression is irrelevant from a statistical point of view. The underlying model implicitly assumes that CBI and persistence are unrelated variables. This assumption is challenged by the empirical evidence which uncovers a significant negative correlation between these two variables. Moreover, this correlation was behind the empirical rejection of the model.

These results notwithstanding, the negative correlation between CBI and persistence may enhance, albeit through alternative channels, the importance of persistence in the explanation of inflationary processes and,

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[7]- The results of the regressions using the variance are the following:

$$\sigma_\pi^2 = 30.9 - 1.58\ CBI \qquad R^2 = 0.27$$
$$(-2.78)$$
$$\sigma_\pi^2 = 7.69 + 20.72\ \theta \qquad R^2 = 0.15$$
$$(2.08)$$
$$\sigma_\pi^2 = 23.54 - 1.26\ CBI + 11.6\ \theta \qquad R^2 = 0.28$$
$$(-2.02) \quad (1.13)$$

at the same time, it raises some intriguing normative issues. More precisely, we could think that CBI and labour market flexibility are indeed related in practice. In other words, we wish to stress that the ability of the government to generate inflationary surprises may not be irrelevant for the functioning of labour market adjustment mechanisms.

In what follows we develop this hypothesis. First of all, it should be recalled that unemployment persistence is positively related to wage rigidity[*], which is in turn determined by the institutional mechanisms in the labour market (in our case the existence of an insider-outsider framework). We could then advance two alternative interpretations of the observed correlation between persistence and CBI.

On the one hand, we might think than the lower the CBI, the more reluctant trade unions will be to make wage mechanisms more flexible (and thus, to induce reductions in unemployment persistence), since the government could take advantage of this to curtail real wages in order to boost employment. In this respect, we should emphasise that, both theoretically and empirically, lower CBI is also associated with greater inflation volatility. The rational response of trade unions to prevent inflation variability generating real wage variability is to protect themselves through rigid wages.

On the other hand, it could alternatively be thought that the more rigid wages are, the lower the incentive for governments to delegate monetary policy to an independent CBI; since labour markets are unable to adjust through price changes on their own, unanticipated inflation becomes an extremely useful instrument to curb unemployment in the short run, so that governments are reluctant to surrender it.

Unfortunately, our cross-country analysis does not allow us to explore in which direction causality runs and therefore we are not able to ascertain

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[*]-We have confirmed this result empirically by comparing our persistence measures with the measures of wage rigidity obtained by Layard et al. (191) and Viñals and Jimeno (1996). The correlation coefficienta are 0.36 and 0.26, respectively.

which interpretation is more accurate. An alternative empirical framework would be necessary for this. From a theoretical point of view, the revealed interdependence between the variables should be incorporated into the model. In our framework λ is a variable determined by the government so that it would be relatively easy to think of λ as an increasing function of the degree of persistence θ. However, the analysis would become more complex if we assumed that the degree of wage rigidity (and θ) is a function of the degree of Central Bank independence, since in this case the decision variables for the trade unions would be two: the level of nominal wages and θ.

From a normative point of view, it is important which is the right interpretation because it allows us to evaluate the effectiveness of delegating monetary policy to an independent Central Bank. The most favourable interpretation is the following: if the institutional change brings about more flexibility in wages, reducing unemployment persistence labour market, the inflationary gains would be further increased. Therefore, the antinflationary effects of Central Bank independence would be enhance by the induced effects on the functioning of the labour markets. By contrast, if causality ran the other way, delegation would entail lower inflation gains, since the institutional change would not affect the underlying inflationary mechanisms in the labour market.

ANNEX

Central Bank Independence

As pointed out by Fernández de Lis (1996), the construction of indices of central bank independence runs up against major practical obstacles:

- First, the concept of independence is not clearly defined, so that its measurement will depend on the definition adopted.

- Second, the interpretation and standardisation of legal questions on which the indices are based and their subsequent aggregation are highly subjective.

- Finally, periods must be chosen with a certain degree of stability as regards the legal questions affecting the central bank, but also sufficiently long to be empirically relevant.

Despite these problems some authors have prepared measures of independence for use in empirical studies. The main aspects on which the various measures of independence have been based may be grouped into:

1. Questions relating to legal or statutory independence, of which two types can be distinguished: those relating to political independence (the formal dependence of the central bank, its objectives, the features of its governing bodies etc.); and those relating to economic independence (everything relating to the financing of the government).

2. Questions relating to actual independence, which attempt to quantify the extent to which the central bank is in practice more or less independent than its statutes state.

A brief description follows of the indices most widely used:

BADE & PARKIN (1988) [BP]

Aspects considered:

- Is the central bank the ultimate monetary authority?
- Are there government representatives on the bank's council?
- Are there appointments which the government does not control?

Each question has two possible answers, which gives six possible permutations. Each question is given the same weight.
It analyses the period 1972-1986 for 12 countries.

ALESINA (1989) [A]

It uses the three Bade & Parkin criteria and adds a fourth:

- Is the central bank obliged to purchase short-term Treasury debt?

This question also has two possible answers and is included in the measure with the same weight as the other three.
It analyses the period 1972-1986 for 17 countries.

GRILLI, MASCIANDARO & TABELLINI (1991) [GMT]

They prepare two measures, one which attempts to measure political independence [GMT (P)] and the other economic independence [GMT (E)].

The degree of political independence is determined using eight criteria:

- Is the governor appointed by parliament?
- Is his term of office more than 5 years?
- Is the whole council appointed by the government?
- Is the council's term of office more than 5 years?
- Is there any obligation for the government to be represented on the council?
- Is it necessary for the government to approve monetary policy?
- Is the bank required by its statutes to pursue price stability?
- Are there legal provisions to clarify the position of the bank in the event of conflict with the government?

The index of economic independence is based on another eight criteria:

- Are there any automatic credit facilities?
- Are market interest rates applied to direct credit facilities?

- Are these facilities temporary?
- Does the central bank participate in the primary public debt market?
- Is the discount rate determined by the central bank?
- Is banking supervision a function of the central bank?
- Is banking supervision exclusively a matter for the bank?

Each entry can take two values and in both cases they all have the same weight.
It analyses the period 1950-1989 for 18 countries.

CUKIERMAN (1992) [CUK]

Cukierman prepares three measures, the first attempts to measure legal independence [CUK(L)] and the other two the gaps between legal and actual independence [CUK(Q),[CUK(T)].

Cukierman's legal independence index is based on four groups of legal characteristics represented by several variables which take values between 0 and 1:

1. The governor's appointment, removal and term of office:
- How long is his term of office?
- Who appoints the governor?
- Who removes the governor?
- Can the governor perform other duties in the government?

2. Policy formulation:
- Who formulates monetary policy?
- Who has the last word in the event of conflict?
- What is the bank's role in the government budget?

3. Central bank objectives.

4. Limits on the central bank's capacity to lend to the public sector:
- Limits on advances
- Limits on securities lending
- Lending terms

- Potential borrowers from the bank
- Definition of these limits
- Maturity of loans
- Interest rates on loans
- Prohibition on central bank participation in the primary government debt market.

The second measure reflects governor turnover. It measures the difference between the legal and actual duration of the governor's term of office.

The third measure is based on the replies of specialists on monetary policy in the respective countries to a questionnaire to identify the factors causing divergence between what the central bank's statutes say monetary policy should be and what happens in practice.

The questions included in this questionnaire are:

- The overlap between the governor's and the government's terms of office
- Limits on lending to the government in practice
- Conflict resolution
- Who determines the central bank's budget?
- Who determines the wages of senior officials and the distribution of profits?
- Are there any money supply targets?
- Are there any formal or informal interest rate targets?
- What is the effective priority given to price stability?
- Does the central bank operate as a development bank granting loans at subsidised rates?

Both for the legal independence index and for that based on the questionnaire Cukierman proposes two measures, one in which all points have the same weight and another in which the weights vary.

Period of analysis:

- The legal index and the turnover one are prepared for the period 1950-1989 and for four sub-periods: 1950-59, 1960-71, 1972-79 and 1980-89.
- The index based on the questionnaire refers solely to the last sub-period (1980-89).

Number of countries included:

- The legal index is prepared for 68 countries.
- The turnover index for 58 countries.
- The index based on the questionnaire for 24 countries.

HAAN & STURM (1992) [HS]

Aspects considered:

- This measure is based on all the entries in the Grilli (91) tables (political and economic independence), except those relating to banking system supervision.

Method of computation: The same weights are used.
It analyses the period 1959-1989 for 18 countries.

EIJFFINGER & SCHALLING (1993) [ES]

- This is an asymmetric index in the sense that the first question has three possible answers and the other two only two:
- Is the central bank solely responsible for monetary policy? Is this responsibility shared or does the bank have no influence at all?
- Are there government representatives on the bank's council?
- Is more than half of the council appointed independently of the government?

It analyses the period 1950-89 for 12 countries in an initial study. In a later study by Eijffinger & Van Keulen (1995) the number of countries for which this measure is calculated is increased by 11.

In view of the variety of criteria considered by each index we propose preparing an index of indices to capture in some way the different aspects considered by each index individually. When preparing this measure, we encounter a number of practical problems, such as the fact that the various classifications have different criteria and scales, and that the country coverage of the various indices differs.

Mindful of these problems, we have taken the following steps when

preparing our measure:

1. For each measure of independence, we take the original values assigned to the countries in our sample, rank the countries from less to more independent, and then replace the original values with the corresponding ordinal numbers (the higher the number the greater the independence). Often several countries have the same value, since they are normally discrete measures which can take less values than the number of countries in the sample. In this case, following Fernández de Lis, they are all assigned the value of the median of the interval they form in the classification.

2. The number of countries considered by each measure differs so that we have different ranges for the different measures. This may lead to distortion when preparing an aggregate measure, in the sense that the positions of countries in the lowest positions are distorted upwards solely due to their appearing in classifications covering fewer countries. To avoid this we have homogenised the measures so that all of them have the same range from 1 to N, N being the total number of countries in our sample. This transformation is carried out as follows:

Let n_i be the number of countries in our sample for which we have the measure **i**. Each measure will take values from 1 to n_i although in practice this will only be the case when no countries take the same value. Thus, if measure i takes values v_{ij}, $j=1,\ldots,n_i$, with intervals of unit width, the rescaled values of the index $\hat{v}_{ij}$ will take values between 1 and N in intervals of width d_i where:

$$d_i = (N-1)/(n_i-1)$$

such that:

$$\hat{v}_{ij} = 1+d_i(v_{ij}-1)$$

where it is observed that

$$v_{ij}=1 \rightarrow \hat{v}_{ij}=1; \quad v_{ij}=n_i \rightarrow \hat{v}_{ij}=N; \quad 1\leq\hat{v}_{ij}\leq N$$

and the distance between each value (given by d_i) is constant.

3.- We calculate the simple mean of the various homogenised measures.

Persistence

To measure persistence, the literature offers two theoretical approaches: the gain function, proposed by Campbell and Mankiw, and the limit of the variance ratio proposed by Cochrane.

The Campbell and Mankiw approach is based on the following argument. Assuming that the series x_t has a unit root, its representation in MA form would be:

$$\Delta x_t = \mu + \sum_{j=0}^{\infty} \phi_j \epsilon_{t-j} \qquad [A.1]$$

It is inferred from equation [1] that the impact of a shock in period t (where the shock is represented by ϵ_t) on the level of series in period t+k will be given by $\sum \phi_k$ (since ϵ_t will have affected the increase in the series in t, t+1, t+2, ..., t+k); therefore, the long-term impact of a shock in a specific time period will be captured by the gain function of the increase in the series $\phi(1)$, where:

$$\Phi(1) = \sum_{j=0}^{\infty} \phi_j \qquad [A.2]$$

If the series shows no persistence (e.g. white noise), the gain function will be close to 0; if the series shows persistence (e.g. random walk) the gain function will be close to 1; and if the series had more than one unit root the gain function would tend to infinity.

The Cochrane approach is perhaps less intuitive than that of Campbell and Mankiw. It is based on the limit of a "variance ratio" defined as:

$$V_k = \frac{Var(\Delta_k x_T)}{kVar(\Delta x_t)} \qquad [A.3]$$

The underlying argument is as follows: if $\phi(1)$ behaves in a stationary way, the variance of the series differentiated k times tends to a constant, while if the series behaves as a random walk, this variance grows linearly with k; hence the limit of equation [A.3] will tend to zero or one depending on whether the series follows a stationary or random-walk process, respectively[9].

From the theoretical measures it is proposed to derive three empirical measures of persistence:

·**ARIMA:** Campbell and Mankiw (1987) propose obtaining the gain function of the increase in the series $\phi(1)$ by estimating the ARMA(p,q) process that generates the first difference of the series and approximating $\phi(1)$ by the ratio of the estimated polynomial of the MA part to that of the AR part, with both evaluated at L=1. That is to say, let Δxt, be a stationary linear process whose estimated ARMA(p,q) representation is as follows:

$$\hat{\Psi}(L)\Delta x_t = \hat{\theta}_0 + \hat{\theta}(L)u_t \qquad [A.4]$$

Where ϕ(L) and θ(L) are two polynomials of a generic order in L. The circumflex reflects the fact that they are estimates.
If we express [4] in MA form, that gives:

$$\Delta x_t = \hat{\Psi}^{-1}(L)\hat{\theta}_0 + \hat{\Psi}^{-1}(L)\hat{\theta}(L)u_t \qquad [A.5]$$

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[9] A simple demonstration of these results can be found in Mills (1993), pp. 77-78.

Whence an estimation of the gain function would be the polynomials ratio in L=1:

$$\hat{\Phi}(1) = \hat{\Psi}^{-1}(1)\ \hat{\theta}(L) \qquad [A.6]$$

·**V20:** The limit of Cochrane's variance ratio can be estimated taking into account the result that Cochrane (1988) derives:

$$V=\lim_{k\to\infty} V_k = 1 + 2\sum_{j=1}^{\infty} \rho_j \qquad [A.7]$$

Where ρ_j is the j^{th} autocorrelation coefficient. Thus, calculating the sample autocorrelation function we can obtain an estimation of the limit of the variance ratio V.

The so-called "window size" problem arises in this measure, as it does in the following. The problem involves our not knowing the number of sample autocorrelations necessary to estimate the infinite sum appearing in [A.7]. Drawing on Montecarlo simulations, Campbell and Mankiw propose taking a number of sample autocorrelations equal to one-third of the sample. In our case this number is 20, hence our names V20 and A20 for this and the following measures, respectively.

·**A20:** Cochrane derives a relationship between the limit of the variance ratio V and the gain function $\phi(1)$. If we call $R^2 = 1-[Var(\epsilon_t)/Var(\Delta x_t)$, it can be shown that:

$$\Phi(1)=\sqrt{\frac{V}{1-R^2}} \qquad [A.8]$$

On this basis, Campbell and Mankiw (1987) propose using the result by replacing R^2 in [8] by the square of the first sample autocorrelation of the

increase in the series and replacing V by its derived estimation in [A.7].

Specifically, then, we have three practical measures of persistence that are valid for our purposes, these being summarised in [A.6], [A.7] and [A.8]. None is free from problems. The disadvantage with the measure based on the ARIMA estimation of the stochastic process generating the increase in the series is that this type of estimation has been designed in a short-run forecasting context. The measures V20 and A20 based on the variance ratio defined by Cochrane have the aforementioned window size problem.

The estimation of the ARIMA model necessary for [A.6] has been carried out with the SEATS econometric package.

Regarding the mean of the persistence measures, a mean between the ARIMA and A20 measures has been calculated previously since they are estimates of the same theoretical factor, and with this mean and the V20 measure a final mean has been produced.

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