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A Prudent Central Banker

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This paper studies the role of prudence in modern central banking. To that end, it relaxes the usual assumption of quadratic preferences and adopts instead an asymmetric preference specification whereby positive deviations from a target can be weighted more, or less, severely than negative deviations. It is shown that prudence with respect to inflation (unemployment) reduces (increases) equilibrium inflation. The overall effect depends on the relative magnitude of the preference parameters and the conditional variances of inflation and unemployment. The implications of the model are examined using cross-section data from OECD countries. [JEL E58, E61]

This paper studies the role of prudence in modern central banking. To that end, it relaxes the usual assumption of quadratic preferences and adopts instead a specification that is asymmetric around the inflation and unemployment targets. In particular, positive deviations from the target can be weighted more or less severely than negative deviations. Under quadratic preferences, the loss associated with a deviation depends only on its magnitude. In contrast, under asymmetric preferences both the magnitude and sign of a deviation matter to the central banker. This more general preference specification has nontrivial implications for monetary policy and modifies some of the previous conclusions derived under the

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assumption of symmetry. The point is illustrated here in the simplest possible setup, where the central banker and the public play a one-shot game without private information.

Relaxing the assumption of quadratic preferences means that certainty equivalence no longer holds. When the central banker attaches a larger loss to positive than negative inflation deviations from its target, uncertainty raises the expected marginal cost and induces a prudent behavior on the part of the monetary authority. Prudence then moderates the inflation bias associated with discretionary monetary policy. When the central banker attaches a larger loss to positive than negative unemployment deviations from its target, uncertainty raises the expected marginal benefit of surprise inflation. In this case, prudence exacerbates the inflation bias associated with discretionary policy. In contrast to the Barro-Gordon model, the bias arises even if the central banker targets the natural unemployment rate. In summary, prudence with respect to inflation reduces equilibrium inflation, while prudence with respect to unemployment increases equilibrium inflation. The outcome depends on the relative magnitude of the preference parameters and the conditional variances of inflation and unemployment.

This paper forms part of a growing literature in monetary policy games that relaxes the usual linear-quadratic framework.[1] Although some of the points made here have been recognized elsewhere in the literature, the reader can benefit from seeing previous results in a coherent framework and as special cases of more general models. This paper is closely related to an earlier contribution by Nobay and Peel (1998), who study optimal commitment and discretion in monetary policy using the same loss function employed here. This paper extends and complements their analysis in several directions. First, this paper solves the more general model with asymmetric preferences on both inflation and unemployment, and derives conditions for the existence and uniqueness of the Nash equilibrium. Second, this paper characterizes and solves numerically the problem of optimal delegation. Third, instead of using simulations (as Nobay and Peel), this paper derives the empirical predictions of the model and tests the null hypothesis of quadratic preferences against the alternative of asymmetric preferences using cross-section data from OECD countries.

Other important contributions include Cukierman (2000), Gerlach (2000), and Orphanides and Wilcox (1996). Cukierman assumes that the central banker cares about unemployment only when it is above the natural rate. Under this asymmetric specification of preferences, there is an inflation bias proportional to the probability of a recession even if the central banker targets the natural unemployment rate. Although the functional form is different, this result parallels the one reported below in Section II. This paper shows that Cukierman's results are robust to the precise functional form of the central banker's loss function (provided the unemployment asymmetry is preserved), and constructs an econometric framework to examine whether his hypothesis is supported by the data. Gerlach assumes that the

[1]Early attempts to allow nonquadratic preferences in this type of model are Barro and Gordon (1983a) and Cukierman and Meltzer (1986), where the loss function in output is linear. For some drawbacks of this modeling strategy, see Walsh (1998, ch. 8).

central banker preferences are quadratic but the output target is nonlinear on the supply shock. His model predicts that countries subject to more volatile supply shocks have higher average inflation rates. Gerlach presents preliminary evidence supporting this hypothesis.

Orphanides and Wilcox (1996) assume a kink in the output component of the loss function and introduce path dependence by allowing the inflation target to depend on past inflation. These modifications lead to opportunistic behavior whereby the central banker reduces inflation when inflation is above/below given thresholds but waits for favorable shocks inside the thresholds.

I. The Model

Following the literature, the relation between inflation and unemployment is described by an expectations-augmented Phillips curve:[2]

$$\mu = \mu^n - \lambda(\pi - \pi^e) + \eta, \tag{1}$$

where $\lambda > 0$; u, u^n and π are (respectively) the rates of unemployment, natural unemployment, and inflation; π^e is the public's inflation forecast; and $\eta \sim N(0, \sigma_\eta^2)$ is a supply shock. The public is assumed to construct its expectations rationally:

$$\pi^e = E(\pi | I), \tag{2}$$

where E is the expectations operator and I is the public's information set.

The central banker affects π through a policy instrument. We can interpret this instrument as the rate of growth of a monetary aggregate or as a short-term nominal interest rate. The instrument is imperfect in the sense that in a stochastic world, it cannot determine inflation completely, as in:

$$\pi = f(i) + \varepsilon, \tag{3}$$

where $f(\cdot)$ is a monotonic, continuous, and differentiable function, i is the policy instrument, and $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ is a control error uncorrelated with η. Since there is

[2]An alternative would be to assume a Neo-Keynesian Phillips curve where output depends on future expected inflation and output. However, under discretion, the first-order condition of the central banker's problem is exactly the same as the one obtained using a Lucas-type supply curve. The reason is that, under discretion, the public's expectations are taken as given and future output and inflation do not depend on today's actions (see Clarida, Galí, and Gertler, 1999, p. 1672).

no private information in the model, the government's and central banker's information sets coincide with the public's and are also given by I. Since i is chosen in the previous period, $i \in I$.[3]

The central banker is assumed to have additively separable preferences over inflation and unemployment. Preferences are described by the function:

$$L(\pi,u)=\left[\exp\left(\alpha(\pi-\pi^*)\right)-\alpha(\pi-\pi^*)-1\right]/\alpha^2 \\ +\phi\left[\exp\left(\gamma(u-u^*)\right)-\gamma(u-u^*)-1\right]/\gamma^2, \tag{4}$$

where $\phi > 0$, π^* and u^* are the targeted rates of inflation and unemployment, and α, γ are nonzero preference parameters. The components of (4) are described by the linex function $g(x) = [\exp(\alpha x) - \alpha x - 1]/\alpha^2$ (Varian, 1974). This function has several important properties. *First*, it permits different weights for positive and negative deviations from the target. For example, in the case where $\alpha > 0$, positive inflation deviations from the target are weighted more severely than negative ones in the central banker's loss function, even if they are of the same magnitude. This means that both the size and sign of a deviation affect the central banker's loss. *Second*, it relaxes certainty equivalence and allows a prudence motive on the part of the central banker. Then, moments of higher order than the mean might play a role in the formulation of monetary policy. *Third*, it is analytically tractable and yields a closed-form solution when shocks are normally distributed. *Finally*, it nests the quadratic function commonly used in previous literature as a special case when the preference parameter tends to zero.[4] This result is important because it suggests that the hypothesis that the central banker's preferences are quadratic over inflation (unemployment) could be evaluated by testing whether $\alpha(\gamma)$ is significantly different from zero.

The unemployment target is $u^* = ku^n$, where $0 < k < 1$. This specification accommodates (i) the view that central bankers target the natural unemployment rate (that is, $k = 1$, see Blinder, 1998), and (ii) the usual assumption that labor market distortions make the natural unemployment rate higher than socially optimal and, consequently, $0 < k < 1$. Analytical results obtained under both assumptions are compared below.

The problem of the central banker is to choose the value of the instrument that minimizes her expected loss. Formally,

$$\min_{\{i\}} E\left[L(\pi,u)|I\right], \tag{4'}$$

[3]In some of the previous literature, it is assumed that the central banker observes the supply shock before the public does. Consequently, she makes monetary policy conditionally on the supply shock and an output stabilization bias arises. In this model, the central banker has no informational advantage over the public.

[4]To verify this claim, take the limit of $g(x)$ as $\alpha \to 0$ and use L'Hôpital's rule twice.

subject to the expectations-augmented Phillips curve and taking π^e as given. The first-order condition of this problem defines implicitly the central banker's reaction function in terms of the public's inflation forecast, π^e:[5]

$$\begin{aligned} h\left(E(\pi|I),\pi^e\right) \\ &= \left[\exp\left(\alpha\left(E(\pi|I)-\pi^*\right)+\sigma^2\sigma_\pi^2/2\right)-1\right]/\alpha \\ &\quad -\lambda\phi\left[\exp\left(\gamma(1-k)u^n-\lambda\gamma\left(E(\pi|I)-\pi^e\right)+\gamma^2\sigma_u^2/2\right)-1\right]/\gamma \\ &= 0. \end{aligned} \tag{5}$$

The terms σ_π^2 and σ_u^2 denote (respectively) the conditional variances of inflation and unemployment and are related to the variance of the structural disturbances as follows: $\sigma_\pi^2 = \sigma_\varepsilon^2$ and $\sigma_u^2 = \sigma_\varepsilon^2 + \lambda^2\sigma_\eta^2$. In writing equation (5), I have used the fact that when shocks are normal, the distributions of inflation and unemployment conditional on I are normal. Hence, the distribution of $\exp(\alpha(\pi-\pi^*))$ and $\exp(\gamma(u-u^*))$ are log normal.[6]

Following the literature, the rational expectations relation (equation 2) is interpreted as the public's reaction function. The Nash equilibrium is the (expected) rate of inflation where equations (5) and (2) intersect. Conditions for the existence and uniqueness of the Nash equilibrium are presented in the following proposition:

Proposition 1. *Provided that* $1+(\alpha\lambda\phi/\gamma)[\exp(\gamma(1-k)u^n+\gamma^2\sigma_u^2/2)-1] > 0$, *there exists a unique* $\pi^e = E(\pi|I)$ *such that* $h(E(\pi|I),\pi^e) = 0$

Proof. To prove existence, construct a

$$\begin{aligned} \pi^e &= E(\pi|I) \\ &= \pi^e-\alpha\sigma_\pi^2/2+(1/\alpha)\ln\left[1+(\alpha\lambda\phi/\gamma)\left(\exp\left(\gamma(1-k)u^n+\gamma^2\sigma_u^2/2\right)-1\right)\right]. \end{aligned} \tag{6}$$

Plugging (6) into (5) and using $\pi^e = E(\pi|I)$ delivers $h(E(\pi|I),\pi^e) = 0$. To show uniqueness, assume there exists a second inflation forecast, say

$$\hat{\pi}^e = \pi^* - \alpha\sigma_\pi^2/2 + (1/\alpha)\ln[1+(\alpha\lambda\phi/\gamma)(\exp(\gamma(1-k)u^n+\gamma^2\sigma_u^2/2)-1] + z,$$

[5]Strictly speaking, the reaction function relates the policy instrument, i, and π^e both of which are determined in the previous period. In what follows, however, it will be convenient to work with $E(\pi|I)$ rather than i. Since these two variables are monotonically related by the function $f(\cdot)$, this approach entails no loss of generality.

[6]See the working paper version of this article (Ruge-Murciá, 2001a) for detailed derivations and proofs. The functional form (equation (4)) is not the only one that would predict that the conditional variance enters the central banker's first-order condition. For example, one could assume that higher moments enter directly in the loss function. In principle, one could distinguish between both specifications if their first-order conditions are not identical.

that also lies on the 45° line on the plane ($\pi^e = E(\pi|I)$) and satisfies $h(E(\pi|I),\pi^e) = 0$. Replace $\hat{\pi}^e$ in (5) and simplify to obtain

$$[1 + (\alpha\lambda\phi/\gamma)(\exp(\gamma(1-k)u^n + \gamma^2\sigma_u^2/2) - 1](\exp(\alpha z) - 1)/\alpha = 0$$

Since $1 + (\alpha\lambda\phi/\gamma)(\exp(\gamma(1-k)u^n + \gamma^2\sigma_u^2/2) - 1) > 0$ and $\alpha \neq 0$, then it must be the case that $z = 0$.

II. Theoretical Implications, Special Cases

The Barro-Gordon Model

The Nash equilibrium under asymmetric preferences can be specialized to the one obtained using a quadratic loss function. Take the limit of equation (6) when $\alpha,\gamma \to 0$ to obtain

$$E(\pi|I) = \pi^* + \lambda\phi(1-k)u^n. \tag{7}$$

This equation corresponds to the one originally derived by Barro and Gordon (1983b, p. 597). In this case the inflation bias, $\lambda\phi(1-k)u^n$, strictly positive and, consequently, the realized inflation rate is systematically above π^*. In the special case where the central banker targets the natural unemployment rate ($k = 1$), the inflation bias is zero. Then, monetary policy is not temporally inconsistent under discretion and the theory cannot explain suboptimally high rates of inflation as the result of the lack of a commitment technology. When $0 < k < 1$, quadratic preferences predict a linear and positive relationship between inflation and the natural unemployment rate.

We will see below that asymmetric preferences (i) generate a positive nonlinear relation between π and u^n, (ii) predict that the conditional variances of inflation and unemployment help forecast the inflation rate, and (iii) allow either an inflationary or a deflationary bias depending on the central banker's preference parameters.

Asymmetric Inflation Preferences Only

Consider the case where $\gamma \to 0$ and $\alpha \to 0$. Then, equation (6) becomes:

$$E(\pi|I) = \pi^* - \alpha\sigma_\pi^2/2 + (1/\alpha)\ln(1 + \alpha\lambda\phi(1-k)u^n). \tag{7'}$$

Depending on the sign of the preference parameter α, inflation is an increasing or decreasing function of its conditional variance. In the plausible case where α is positive,[7] the term $-\alpha\sigma_\pi^2/2 < 0$ reduces and could overcome the inflation bias associated with discretionary policy. The intuition of this result is straightforward. When preferences are asymmetric, certainty equivalence no longer holds. When $\alpha > 0$, the marginal cost of deviating from π^* is not linear in inflation, but convex. Then, uncertainty increases the expected marginal cost and induces a prudent behavior on the part of the central banker. Prudence then moderates and could eliminate the inflation bias associated with discretionary policy. Asymmetric inflation preferences could explain, for example, why the Bundesbank raises the day-to-day interest rate when inflation is above its steady-state trend value but barely responds when it is below (see Clarida and Gertler, 1997), and why financial markets perceive the Canadian inflation target zone to be asymmetrically distributed around the official target of 2 percent per year (Ruge-Murciá, 2000).

There are values of $\alpha > 0$ for which realized inflation is below its socially optimal level. Hence a deflationary (rather than an inflationary) bias could arise in equilibrium. This means that asymmetric preferences can provide a theoretical foundation for Stanley Fischer's observation (Fischer, 1994) that a deflationary bias can be a possible outcome in the practice of monetary policy.[8]

Asymmetric Unemployment Preferences Only

Consider the case where $\alpha \to 0$ and $\gamma \neq 0$ Then, equation (6) becomes:

$$E(\pi|I) = \pi^* + (\lambda\phi/\gamma)\left(\exp\left(\gamma(1-k)u^n + \gamma^2\sigma_u^2/2\right) - 1\right). \qquad (7'')$$

Since $\lambda\phi(\exp(\gamma(1-k)u^n+\gamma^2\sigma_u^2/2) - 1)$ is always positive, there is a bias whose sign depends on whether $\gamma \gtrless 0$. In the case where $\gamma > 0$, there is a positive inflation bias. The inflation bias is increasing on both the natural unemployment rate and the conditional variance of unemployment. To understand why the bias is proportional to σ_u^2, note that the marginal benefit of surprise inflation is not linear in unemployment, but convex when $\gamma > 0$. Thus, an increase in uncertainty raises the expected marginal benefit of surprise inflation. The inflation bias is positive, even if the unemployment target is the natural rate ($k = 1$, on this see also Cukierman, 2000). Hence, the view that the inflation bias associated with discretionary policy disappears when the unemployment target is the natural rate (see McCallum, 1995, 1997) does not seem robust to the generalization of the central banker preferences. Asymmetric unemployment preferences could explain, for example, the finding by Dolado, María-Dolores, and Naveira (2000) and Gerlach (2000) that the U.S. Federal Reserve reacts more strongly, in terms of changes to the Federal Funds rate, to negative than positive output gaps.

[7]In principle $\alpha, \gamma \gtrless 0$. However, it seems theoretically more likely that positive deviations from the inflation and unemployment targets would be more costly to the central banker than negative deviations. Estimates of the model in Section III do not impose constraints on α and γ.

[8]To my knowledge, this result was first reported in Nobay and Peel (1998).

General Case

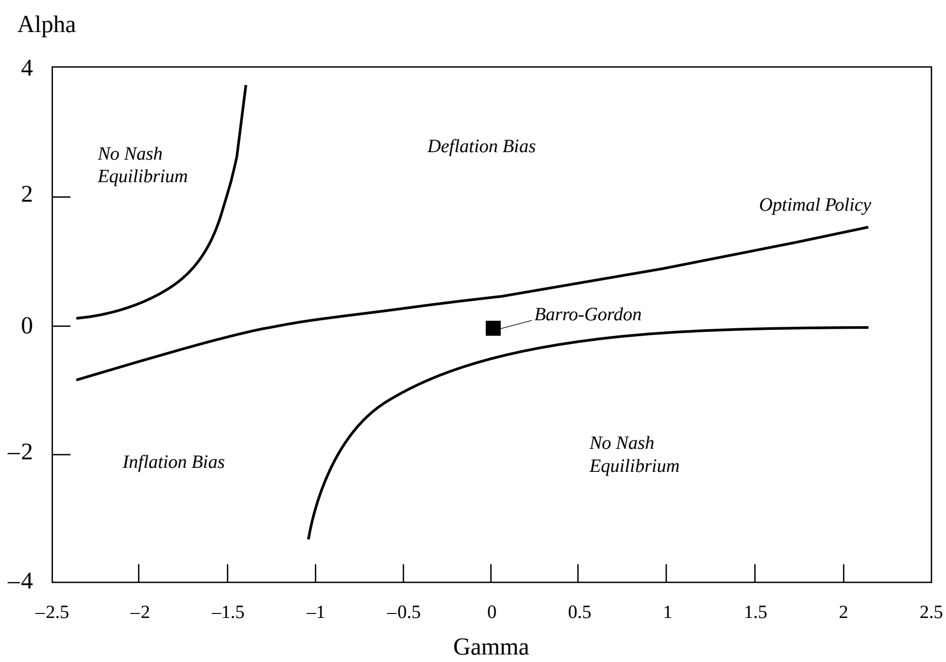
These results indicate that prudence has two opposite effects on monetary policy under discretion. Prudence with respect to inflation ($\alpha > 0$) reduces the inflation bias. Prudence with respect to unemployment ($\gamma > 0$) increases the inflation bias. The overall effect of prudence on equilibrium inflation is ambiguous. For given parameters values, the Nash equilibrium is unique (if it exists), but depending on the values of the preference and model parameters the equilibrium inflation rate will be different.

Consider the set of parameters values for which optimal monetary policy is an equilibrium outcome. A government that delegates monetary policy to a "prudent" central banker would obtain $E(\pi|I) = \pi^*$ if and only if the preference parameters (α,γ) solve

$$h(\alpha,\gamma) = -\alpha\sigma_\pi^2/2 + (1/\alpha)\ln\left[1 + (\alpha\lambda\phi/\gamma)\left(\exp\left(\gamma(1-k)u^n + \gamma^2\sigma_u^2/2\right)-1\right)\right] = 0. \quad (7''')$$

This equation has no closed-form solution, but it can be solved numerically for given parameter values. In order to develop some intuition, Figure 1 plots $h(\alpha,\gamma) = 0$ for the case where $\lambda = 2$, $\phi = 0.8$, $\pi^* = 0$, $k = 0.75$, $u^n = 5$, $\sigma_\pi^2 = 6$, and $\sigma_u^2 = 2$. From the discussion above, points below (above) $h(\alpha,\gamma) = 0$

Figure 1. Possible Equilibrium Outcomes



correspond to Nash equilibria with an inflation (deflation) bias. Figure 1 also plots the Nash equilibrium predicted by the Barro-Gordon model and the set of values (α,γ) for which the Nash equilibrium does not exist (see Proposition 1, p. 460). Recall that the Barro-Gordon model corresponds to the case where $(\alpha,\gamma) \rightarrow (0,0)$. Figure 1 indicates that the original inflation-bias result due to Barro and Gordon (1983b) is only one of the possible outcomes in a more general model with asymmetric preferences. No claim is made that the parameters used to construct this graph are realistic, but the basic point is that we cannot rule out a priori other Nash outcomes where monetary policy is optimal, there is a deflation bias, or there is an inflation bias that arises from different central bank objectives than in Barro and Gordon. In this sense, the econometric analysis of time series or cross-section data might be useful to obtain estimates of the central banker's preference parameters and to assess the relative merits of different game-theoretical models.

III. Empirical Analysis

This section reports the results of an exploratory analysis of the model predictions using data from developed economies during the 1990s. Since the static nature of the model invites the cross-section analysis of the data, this paper uses observations from 21 OECD countries. The countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.[9] The raw data were taken from *OECD Main Economic Indicators*. Average inflation was calculated using quarterly CPI inflation from 1990:1 to 1999:2. The conditional variances of inflation (unemployment) were computed from a regression of the first-difference of quarterly inflation (unemployment) on four of its lags. For reasons to be made clear below, I used two samples to compute the conditional variances: 1980:1 to 1989:4 and 1990:1 to 1999:2.

The simple game-theoretical model developed in Section I predicts that the conditional variances of inflation and unemployment help explain the rate of inflation. Linearize the Nash equilibrium (equation (6)) by means of a first-order Taylor series expansion and write it in reduced form as:[10]

$$\pi_j = a + b\sigma^2_{\pi,j} + c\sigma^2_{u,j} + \zeta_j, \tag{8}$$

[9]The sample excludes the countries that joined the OECD in the mid-1990s, namely the Czech Republic, Hungary, Korea, Mexico, and Poland. It also excludes Greece and Turkey, which are typically considered moderate- to high-inflation countries (see Dornbusch and Fischer, 1991) and where monetary factors are likely to be nonnegligible. Finally, the sample excludes Iceland because there were many observations missing for this country in the OECD database. Except for the fact that this study excludes Greece and Iceland and includes Luxembourg, these are essentially the same countries examined by Gerlach (1999).

[10]Given the small number of data points and the identification issue described below, I did not attempt to estimate the nonlinear model. Since the model is roughly linear (note that equation (6) involves taking the logarithm of an exponential function), the approximation error is likely to be small.

where $a = \pi^* + \lambda\phi(1-k)u^n$ is a positive intercept; $b = -\alpha/2$ and $c = \lambda\phi\gamma/2$ are constant coefficients; $j = 1, 2, ..., 21$, indexes the country; π_j is the average inflation rate in country j; $\sigma^2_{\pi,j}$ and $\sigma^2_{u,j}$ are the conditional variances of inflation and unemployment in country j; and ζ_j is a country-specific error term. In the absence of measurement error and heterogeneity, the Ordinary Least Square (OLS) projection of π on σ^2_π and σ^2_u delivers consistent and unbiased estimates of a, b, and c. Recall that $\sigma^2_\pi = \sigma^2_\varepsilon$ and $\sigma^2_u = \sigma^2_\varepsilon + \lambda^2\sigma^2_\eta$ are model parameters included in the information set I, and note that ζ can be interpreted as an average of rational-expectations forecast errors. It follows that σ^2_π and σ^2_u are uncorrelated with ζ. From the estimate of b, one could recover an estimate of α as $\hat{\alpha} = -2\hat{b}$. From the estimate of c, it is not possible to recover an estimate of γ, but the sign of c is informative about the sign of γ because $\lambda,\phi > 0$, by assumption. For example, a positive estimate of c implies $\gamma > 0$ and is consistent with the idea that the central banker weights more heavily positive than negative unemployment deviations from the natural rate.

Consider first the results for all countries in the sample, reported in column (1) of Table 1. The OLS estimate of b is numerically small and insignificantly different from zero at standard levels. This result suggests no systematic relation between the mean and the conditional variance of inflation during the period considered. An estimate of the (average) asymmetry preference parameter on inflation for OECD member countries is $\hat{\alpha} = -0.04(0.14)$. Thus, the null hypothesis of quadratic inflation preferences ($\alpha = 0$) cannot be rejected at standard levels. On the other hand, the estimate of c is positive and significantly different from zero at the 10 percent level. Although the asymmetry preference parameter on unemployment is not identified, the finding that $c > 0$ supports the view that (on average) OECD central bankers weight more heavily positive than negative unemployment deviations from their target.

Table 1. Results of Least-Squares Regressions

σ^2_π,σ^2_u Constructed Using Data	All Countries				EU Only			
	Post-1990		Pre-1990		Post-1990		Pre-1990	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	2.07*	2.11	2.15*	2.17*	2.17*	2.25*	1.97*	2.19*
	(0.21)	(0.20)	(0.33)	(0.27)	(0.29)	(0.25)	(0.27)	(0.25)
σ^2_π	0.02	0	0.07	0	0.05	0	0.88	0
	(0.07)		(0.48)		(0.09)		(0.66)	
σ^2_u	6.86†	7.29*	4.53	5.01	6.86*	7.94*	4.72	9.63†
	(3.30)	(2.97)	(4.27)	(4.57)	(3.02)	(3.03)	(5.85)	(4.86)
R^2	0.21	0.20	0.13	0.13	0.26	0.24	0.49	0.38

Notes: The figures in parentheses are White heteroskedasticity-consistent standard errors. The superscripts * and † denote the rejection of the null hypothesis that the coefficient is zero at the 5 percent and 10 percent significance levels, respectively, using the exact t distribution.

There are at least three difficulties in interpreting the above results. *First*, despite similarities in the economies in the sample, there might well be substantial heterogeneity in the natural rate of unemployment and preference parameters across countries. As it is well known, pooled least-squares estimates can be biased when the intercepts and slopes are heterogeneous. *Second*, since the conditional variances are estimated using inflation and unemployment data, σ_u^2 and σ_π^2 are generated regressors. Pagan (1984) and Pagan and Ullah (1988) examine the implications of generated regressors in estimation and inference. In many cases, generated regressors can be problematic because they measure with noise the true, but unobserved, regressor. The problem is that measurement error in σ_u^2 and σ_π^2 forms part of the residual ζ, and orthogonality conditions required for the consistency of OLS might not hold. *Third*, using estimates of σ_u^2 and σ_π^2 based on the same sample period as π might lead to biased estimates of the slope parameters if the inflation distribution is skewed (see Flood and Marion, 2001). If the inflation distribution is skewed positively (negatively), there will be an upward (downward) bias. In this case, the problem is that measurement error in π is correlated with σ_u^2 and σ_π^2. Hence the OLS estimate of the slope not only reflects the correlation between (the true) π and the conditional variances, but also includes a term capturing the correlation between measurement error and the explanatory variables. The latter term is proportional to the skewness of the independent variable and is only zero in the special case where π is not skewed.

In order to address the first issue, I examine a subsample that consists of members of the European Union (EU). Although there might still be substantial heterogeneity, it can be argued that these countries share a number of labor market features (e.g., EU work legislation) and have attempted in recent years to harmonize monetary policy through explicit institutional arrangements like the Exchange Rate Mechanism and Monetary Union. Hence, the data points could be regarded as separate realizations of the same data-generating process. Estimates using this subsample are reported in column (5) in Table 1. Results are essentially the same as those obtained for the full sample. The estimate of b is not significantly different from zero at standard levels. The estimate of the (average) asymmetry preference parameter on inflation for EU member countries is $\hat{\alpha}$ only –0.10 (0.18). The null hypothesis of quadratic inflation preferences cannot be rejected. The estimate of c is positive and significantly different from zero at the 5 percent level.

The possible bias that could be caused by measurement error in the explanatory variables could be addressed by using an instrumental variable procedure. Unfortunately, it is not easy to find instruments for the conditional variances of inflation and unemployment in the cross-section dimension. In preliminary work, I considered using the conditional variances of energy prices and detrended Solow residuals as instruments, but they proved weak in the sense that their correlation with the variables they were meant to instrument for was too low to yield reliable results.

A strategy to address the third issue is to construct estimates of the conditional variances using pre-1990 data.[11] In particular, I use quarterly data from 1980:1 to

[11]This approach was suggested by Bob Flood.

1989:4. Provided that measurement error in π is not serially uncorrelated and the measure of σ_u^2 and σ_π^2 is perfect, OLS delivers consistent estimates of b and c. Results are reported in column (3) for the full sample and column (7) for the EU subsample. Results are similar to the ones previously obtained. The null hypothesis that $b = 0$ cannot be rejected at standard levels. The estimate of c is positive in both cases but is not statistically different from zero. Since the number of data points is limited, more precise estimates of c could be obtained if the restriction that inflation preferences are quadratic ($\alpha = 0$) is imposed. All specifications were reestimated and results reported in columns (2), (4), (6), and (8) in Table 1. Estimates are consistent with the ones previously obtained but, as expected, standard errors are smaller. The null hypothesis $c = 0$ cannot be rejected at the 5 percent level in two cases, at the 10 percent level in one case, and is rejected in only one case.

In summary, the empirical analysis of the game-theoretical model indicates that the hypothesis that preferences are quadratic in inflation cannot be rejected. On the other hand, estimates of the coefficient on σ_u^2 are always positive and in most cases significantly different from zero. Although the preference parameter cannot be identified, this result is consistent with a positive value of γ meaning that the (average) central banker attaches a larger loss to positive than negative unemployment deviations from its target. For the reasons discussed below, however, these empirical results should be interpreted with caution and are best regarded as exploratory.

IV. Conclusion

This paper presents initial results in a larger research project that examines monetary policy under asymmetric preferences. The relevance of this generalization of the central banker's loss function is illustrated here in the simplest possible setup where the central banker and the public play a one-shot game without private information. It is shown that although the central banker's reaction function is nonlinear on the public's inflation forecast, there are conditions under which the Nash equilibrium exists and is unique. More importantly, relaxing certainty equivalence means that uncertainty can induce a prudence motive on the part of the monetary authority, which has two distinct and contradictory effects on equilibrium inflation. Prudence on inflation moderates the incentive to create surprise inflation, while, in unemployment, prudence increases the expected benefit of surprise inflation. The overall effect depends on the relative magnitude of the preference parameters and the conditional variances of inflation and unemployment.

While the empirical results are suggestive of asymmetric unemployment preferences, they are best regarded as exploratory for at least two reasons. First, results depend very obviously on the estimation procedure and on the countries included in the sample. Second, although this paper allows for the strategic interaction of the central banker and the public, equilibrium concepts other than Nash might be empirically important. Current and future research by the author seeks to address these observations. For example, Ruge-Murciá (2001b) focuses on inflation targeting regimes and estimates the central banker preferences parameters for

Canada, Sweden, and the United Kingdom using the time series of inflation and unemployment. Ruge-Murciá (2001c) examines time series data from G-7 economies to test whether an inflation bias could arise even when central bankers target the natural unemployment rate. Still, given our limited understanding of central bankers' behavior and preferences, it is probably premature to dismiss the notion that prudence can play a role in modern monetary policymaking.

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