The Clash of Central Bankers with Labor Market Insiders, and the Persistence of Unemployment and Inflation in the Main Industrial Economies

by

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Abstract

This paper analyzes the implications of optimal monetary policy for the dynamic behavior of inflation in a “natural rate” model characterized by endogenous unemployment persistence. We analyze a dynamic “insider outsider” model of the “Phillips Curve”, that accounts for the persistence of unemployment following nominal and real shocks. We derive optimal monetary policy under both discretion and commitment to an inflation target. We demonstrate that under discretion, because of the endogenous persistence of deviations of unemployment from its “natural” rate, deviations of inflation from target display the same degree of persistence as unemployment. Under full commitment to an inflation target there is no inflation persistence. An empirical investigation for the main industrial economies suggests that the persistence of deviations of inflation from a constant inflation target is of the same order of magnitude as the persistence of deviations of unemployment from its “natural” rate. This finding is consistent with the hypothesis put forward in this paper, of a clash between central bankers and labor market insiders, that cause both unemployment and inflation to persist.

Keywords: unemployment persistence, inflation, monetary policy, insiders outsiders, central banks

JEL Classification: E3, E4, E5

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The analysis of monetary policy usually focuses on policy rules that seek to stabilize inflation around a low inflation target and unemployment around its “natural” rate, even if the “natural” rate of unemployment is inefficiently high. As demonstrated by Kydland and Prescott (1977) and Barro and Gordon (1983), if central banks seek to use monetary policy to reduce unemployment below its “natural” rate, the outcome is a positive steady state inflation bias, as the inflationary expectations of labor market participants rise to ensure that the central bank has no incentive to systematically raise inflation above inflationary expectations.

Delegating monetary policy to an independent central banker who does not seek to reduce unemployment below its “natural” rate, as first suggested by Rogoff (1985), can address this steady state inflation bias problem, and still allow a central bank to seek to stabilize deviations of unemployment from its “natural” rate in response to unanticipated shocks.

This paper analyzes the role of monetary policy in a dynamic stochastic model of the Phillips curve, characterized by unemployment persistence. It is shown that, in the presence of persistent deviations of unemployment from its “natural” rate, optimal discretionary monetary policy results in persistent deviations of inflation from the target of the monetary authorities. A monetary policy rule that focuses only on inflation does not result in inflation persistence, but, in the presence of productivity shocks, implies a sub-optimally large variance of fluctuations of unemployment around its “natural” rate.

Evidence from the main industrial economies in the post war period suggests that monetary policy has indeed been discretionary in all the main industrial economies, as deviations of inflation from central bank targets display the same degree of persistence as the persistence of unemployment rates around their “natural” rates.

The main distinguishing characteristic of the model put forward in this paper is a dynamic “insider outsider” version of the “Phillips Curve”, which accounts for the persistence of unemployment following nominal and real shocks. The model combines and extends two strands of the literature.

The first strand is the Gray-Fischer model of predetermined nominal wages, according to which nominal wages are set periodically, and remain fixed between periods. Because shocks to inflation are not known when nominal wages are set, unanticipated inflation reduces real wages and causes employment to increase along a downward sloping labor demand curve.1

The second strand of the literature is the insider-outsider theory of wage determination of Lindbeck and Snower (1986), Blanchard and Summers (1986) and Gottfries (1992). According to this theory, there is an asymmetry in the wage setting process between “insiders”, who already have jobs, and “outsiders” who are seeking employment. “Outsiders” are disenfranchised from the labor market, and wages are set by “insiders”, who seek to maximize the expected real wage consistent with their own employment, and are not concerned with the employment of “outsiders”.

The two strands were first combined by Blanchard and Summers (1986), who alluded to the dynamics of “insider” membership to explain the gradual adjustment of employment and the persistence of unemployment following unanticipated shocks. Their argument was that “shocks that lead to reduced employment change the number of insiders and thereby change the subsequent

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1 In the Gray (1976) model, the one we utilize, nominal wages are fixed in the beginning of each period, whereas in the Fischer (1977) model they are fixed in the beginning of alternate periods.
equilibrium wage rate, giving rise to hysteresis”. Thus, in their model unemployment displays persistence following nominal and real shocks. In the original Gray (1976) and Fischer (1977) models, there are only short lived deviations of unemployment from its “natural” rate. Such deviations only last for one period in the one period contract model of Gray (1976), and for two periods in the two period contract model of Fischer (1977).

Our model extends the Blanchard and Summers setup, to a linear quadratic setup of full inter-temporal optimization on the part of “insiders”. We thus derive a dynamic stochastic model of the “Phillips Curve”, in which unanticipated shocks to inflation and productivity have persistent effects on unemployment which are compatible with the forward looking behavior of such “insiders”. The number of “insiders” in each period depends on an exogenous number of “core” insiders, with long term ties to existing firms, but also on the current employees of the firm. Current “insiders” realize that shocks to employment will affect the future number of “insiders”, and will thus affect future wages. Thus, they are assumed to take this fact into account in their periodic wage setting decisions. As a result, current wages depend not only on the current number of “insiders”, which is a function of past employment, but also on the expected future number of “insiders”, which depends on expected future employment. Thus, the persistence of employment and unemployment depends on expectations about the future evolution of employment and unemployment.

The dynamic “Phillips Curve” that we derive provides an alternative to the “new keynesian Phillips Curve”, and suggests an alternative source of unemployment persistence, compared to “new keynesian” models based on imperfect competition and staggered price and wage contracts.\(^2\)

The propagation mechanism that causes unanticipated nominal and real shocks to produce persistent deviations of unemployment from its “natural” rate is the gradual adjustment of employment to shocks, and not the staggered adjustment of wages and prices. Nominal wages are assumed to be fixed only for one period in our model, and are assumed to be renegotiated every period. Thus, nominal wage stickiness would not be able to account for the persistent effects of nominal shocks in the absence of the gradual adjustment of employment.

The distortions that matter for the fluctuations of unemployment and other real variables in our model arise in the labor market, because of one period nominal wage contracts, and the market power of “insiders” in the wage determination process. The product market is assumed competitive, although it would be relatively straightforward to introduce product market imperfections as well.

We first derive optimal monetary policy under discretion, by assuming that the central bank minimizes an inter-temporal quadratic loss function that depends on deviations of inflation from a fixed inflation target, and unemployment from its “natural” rate. We demonstrate that under the optimal discretionary monetary policy, productivity shocks and shocks to monetary policy cannot be neutralized by monetary policy. Since productivity shocks are supply shocks, and their real effects can only be partially offset through unanticipated inflation, there is a tradeoff between deviations of inflation from target, and unemployment from its “natural” rate, even under the optimal policy.

In addition, because of the endogenous persistence of deviations of unemployment from its “natural” rate, the inflation rate also displays persistence around the inflation target of the monetary

\(^2\) See Gali (2008), (2011a,b) for models of aggregate fluctuations in the presence of Calvo (1983) staggered price and wage contracts.
authorities. The persistence of inflation arises from the fact that the central bank seeks to minimize deviations of unemployment from its “natural” rate, which display endogenous persistence in this model. This is anticipated by the wage setting insiders, who base their inflationary expectations on past deviations of unemployment from its “natural” rate, and therefore neutralize the attempts of the monetary authorities to smooth these deviations. Thus, under the optimal discretionary policy, the resulting persistence in the fluctuations of the inflation rate does not affect the path of unemployment. It is only the unanticipated part of the inflation rate that can affect unemployment in this model.

One could interpret the persistence of inflation as arising from the lack of anti-inflationary credibility on the part of the central bank. If the central bank seeks to use inflation in order to minimize deviations of unemployment from its “natural” rate, and there is endogenous persistence in those deviations due to the behavior of wage setters, there will be persistence in inflationary expectations, which, in rational expectations equilibrium, translates into persistence of actual inflation.

The persistence of inflation in the presence of endogenous unemployment persistence arises for the same reasons as the inflationary bias in the Kydland and Prescott (1977) and Barro and Gordon (1983) models of the “natural” rate, when the central bank systematically seeks to reduce unemployment below its “natural” rate. Since the employment objectives of wage setters and the central bank differ under the discretionary policy, the only way for wage setters to ensure that the monetary authorities will follow the expected policy in the absence of shocks, is to raise their expectations of inflation to the level that will ensure that the central bank has no further incentive to deviate from the expected policy. It is exactly this mechanism, which is responsible for the persistence of inflation when there is endogenous unemployment persistence.

As a result, in the equilibrium under discretion, both the persistence of deviations of inflation from the central bank target, and the persistence of deviations of unemployment from its “natural” rate will imply social costs.

The lack of credibility that results in inflation persistence can be addressed if one were to amend the constitution of the central bank in order to make inflation the sole objective of monetary policy. This would result in a pre-commitment to achieving only an inflation objective. Such a policy would result in non persistent inflation, as expected inflation would always be equal to the target of the monetary authorities. However, in the presence of monetary policy and productivity shocks, such a policy would result in a sub-optimally high variance of the persistent deviations of unemployment from its “natural” rate.

We demonstrate that, in the context of our model, the optimal discretionary policy, despite its shortcomings, dominates the policy of pre-committing solely to the inflation target.

The predictions of the model are tested using post war annual data for the Group of Seven main industrial economies. The evidence suggests that the persistence of inflation is of the same order of magnitude as the persistence of unemployment rates around their “natural” rates in all of the main industrial economies. This is true for all three of the broad monetary policy regimes that have applied in the post war period. Thus, the evidence suggests that central banks have been following a discretionary monetary policy, not only in high inflation periods, such as the 1970s and early 1980s,
but also in low inflation periods such as the Bretton Woods period and the post-Volcker period of low inflation.

The rest of the paper is as follows: In section 1 we present our dynamic model of the “Phillips curve”, based on an “insider outsider” setup for the labor market. In section 2 we derive the implications of both the optimal discretionary inflation policy and the policy of full commitment to the inflation target. In section 3 we present the evidence for the main industrial economies. The last section sums up our conclusions.

1. “Insiders and Outsiders” in a Dynamic Model of the “Phillips Curve”

Consider an economy consisting of competitive firms, indexed by \( i \), where \( i \in \{0,1\} \).

The production function of firm \( i \) is given by,

\[
Y(i)_t = A L(i)_t^{1-\alpha}
\]  

(1)

where \( Y(i) \) is output, \( A \) is exogenous productivity, and \( L(i) \) is employment. \( t \) is a time index, where \( t=0,1,\ldots \).

Employment is determined by firms, who maximize profits, by equating the marginal product of labor to the real wage. Thus, employment is determined by the condition that,

\[
(1-\alpha)A L(i)_t^{\alpha} = \frac{W(i)_t}{P_t}
\]  

(2)

where \( W(i) \) is the nominal wage of firm \( i \), and \( P \) is the price for the product of firm \( i \). Since the product market is assumed competitive, all firms face the same price, and \( P(i)=P \) for all firms.

In log-linear form, (1) and (2) can be written as,

\[
y(i)_t = a_t + (1-\alpha)l(i)_t
\]  

(3)

\[
l(i)_t = \tilde{l} - \frac{1}{\alpha}(w(i)_t - p_t - a_t)
\]  

(4)

where \( \tilde{l} = \frac{\ln(1-\alpha)}{\alpha} \)

Lowercase letters denote the logarithms of the corresponding uppercase variables. (3) determines output as a positive function of employment and the stochastic shock to productivity, and (4) determines employment as a negative function of the deviations of real wages from productivity.

1.1 Wage Setting and Employment in a Linear Quadratic Insider Outsider Model

Nominal wages are set by “insiders” in each firm at the beginning of each period, before variables, such as current productivity and the current price level are known. Nominal wages remain constant
for one period, and they are reset at the beginning of the following period. Thus, this model is characterized by one period nominal wage stickiness of the Gray (1976), Fischer (1977) variety.

Employment is determined ex post by the firm, given the contract wage, the actual price level and actual productivity.

The number of “insiders”, who at the beginning of each period determine the contract wage, is assumed endogenous, as it depends on past employment. The key objective of firm “insiders” is to set a nominal wage which, given their rational expectations about the price level and productivity, will minimize deviations of expected employment from the pool of “insiders”. This pool depends on an exogenous number of core “insiders” in each firm, but also on all those who were employed in period t-1. Thus, this model is characterized by an endogenous pool of insiders, as in Blanchard and Summers (1986).

The expectations on the basis of which wages are set depend on information available until the end of period t-1, but not on information about prices and productivity in period t.

On the basis of the above, we assume that the objective of wage setters is to make expected employment satisfy a path that minimizes the following quadratic inter-temporal loss function,

\[
\min E_{t-1} \sum_{s=0}^{\infty} \beta^s \left[ \frac{1}{2} \left( l(i)_{t+s} - \bar{n}(i) \right)^2 + \frac{\theta}{2} \left( l(i)_{t+s} - l(i)_{t+s-1} \right)^2 \right] 
\]

(5) is minimized subject to the labor demand equation (4).

\( \bar{n} \) is the logarithm of the number of core “insiders” assumed exogenous. \( \beta = 1/(1+\rho) \) is the discount factor, with \( \rho \) being the pure rate of time preference. \( \theta \) is the weight of those recently employed, relative to “core insiders”, in the wage setting process. As can be seen from (5), “outsiders”, i.e the unemployed, have no influence on the wage setting process.\(^3\)

We shall assume that the total number of core “insiders” in the economy is always strictly smaller than the labor force. This assumption ensures that the “natural” rate of unemployment is strictly positive. We thus assume that,

\[
\int_{i=0}^{1} \bar{n}(i) di = \bar{n} < n , \forall t 
\]

(6) where \( n \) is the log of the labor force.

From the first order conditions for a minimum of (5), wages are set so that expected employment for each firm satisfies,

\[
(1 + \theta(1 + \beta)) E_{t-1} l(i)_t - \beta \theta E_{t-1} l(i)_{t+1} - \theta l(i)_{t+1} = \bar{n}(i) 
\]

(7) A

\(^3\) An alternative interpretation of (5) would be in terms of “adjustment costs”. “Insiders” seek to minimize deviations of expected employment from their number, but there is a cost to adjusting employment. Then, \( \theta \) can be interpreted as the relative importance of adjustment costs relative to costs of deviations from the employment of “core insiders”.

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\( \)
Integrating over $i$, expected aggregate employment must then satisfy,

$$(1 + \theta(1 + \beta))E_{t-1}l_t - \beta \theta E_{t-1}l_{t+1} - \theta l_{t-1} = \ddot{n}$$

(8)

(8) is the same as (7) without the $i$ index.

(8) helps explain the differences of our wage setting model from Gray-Fischer contracts and Blanchard-Summers contracts.

With Gray-Fischer contracts, $\theta=0$, as past employment does not exert any separate influence in the wage setting process. Only core “insiders” would matter in Gray-Fischer type contracts. Setting $\theta=0$ in (8), nominal wages in Gray-Fischer contracts would be set in order to ensure that,

$$E_{t-1}l_t = \ddot{n}$$

(8a)

On the other hand, with Blanchard-Summers contracts, there is no consideration of the effects of current contracts on expected future employment. This is equivalent to setting $\beta=0$ in (8). This would imply from (8) that, with Blanchard-Summers contracts, nominal wages would be set in order to ensure that,

$$E_{t-1}l_t = \frac{1}{1 + \theta} n + \frac{\theta}{1 + \theta} l_{t-1}$$

(8b)

(8b) is identical to equation (3.2) in Blanchard and Summers (1986). Nominal wages with Blanchard-Summers contracts would be set so as to ensure that expected employment equals a weighted average of “core insiders” and those recently employed. The share of those recently employed depends positively on $\theta$, the weight attached to the employment of those recently employed.

In our more general dynamic model, expected employment is given by,

$$E_{t-1}l_t = \frac{1}{1 + \theta(1 + \beta)} n + \frac{\theta}{1 + \theta(1 + \beta)} l_{t-1} + \frac{\beta \theta}{1 + \theta(1 + \beta)} E_{t-1}l_{t+1}$$

(8c)

Thus, in our model, “insiders” set nominal wages in order to achieve an employment target which depends on “core insiders”, those previously employed, but also on expected future employment, as expected future employment will affect future wage setting behavior.

1.2 Wage Determination, Unemployment Persistence and the Phillips Curve

Subtracting (8) from the log of the labor force $n$, after some rearrangement we get,

$$(1 + \theta(1 + \beta))E_{t-1}u_t - \beta \theta E_{t-1}u_{t+1} - \theta u_{t-1} = \ddot{u}$$

(9)
where, \( u_t = n_t - l_t \) is the unemployment rate, and \( \tilde{u} = n - \tilde{n} > 0 \) is the “natural” unemployment rate. The “natural rate” of unemployment in this model is defined in terms of the difference between the labor force and the number of core “insiders” in the labor market. This is the equilibrium rate towards which the economy would converge in the absence of shocks.

To solve (9) for expected unemployment, define the operator \( F \), as,

\[
F^i u_t = E_{t+1} u_{t+1} \tag{10}
\]

We can then rewrite (9) as,

\[
\left( (1 + \theta (1 + \beta)) F^0 - \beta \theta F - \theta F^{-1} \right) u_t = \tilde{u} \tag{11}
\]

(11) can be rearranged as,

\[
-\beta \theta F^{-1} \left( F^2 - \frac{1 + \theta (1 + \beta)}{\beta \theta} F + \frac{1}{\beta} \right) u_t = \tilde{u} \tag{12}
\]

It is straightforward to show that if \( 0 < \beta < 1 \) and \( \theta > 0 \) and finite, the characteristic equation of the quadratic in the forward shift operator (in brackets) has two distinct real roots, which lie on either side of unity. The two roots satisfy,

\[
\lambda_1 + \lambda_2 = \frac{1 + \theta (1 + \beta)}{\beta \theta} \quad \text{and} \quad \lambda_1 \lambda_2 = \frac{1}{\beta} \tag{13}
\]

Using (13) we can rewrite (12), as,

\[
(F - \lambda_1)(F - \lambda_2) u_t = -\frac{1}{\beta \theta} \tilde{u} \tag{14}
\]

Assuming \( \lambda_1 \) is the smaller root, we can solve (14) as,

\[
E_{t-1} u_t = \lambda_1 u_{t-1} + \frac{\lambda_1}{\theta (1 - \beta \lambda_1)} \tilde{u} = \lambda_1 u_{t-1} + (1 - \lambda_1) \tilde{u} \tag{15}
\]

(15), which is the rational expectations solution of (9), determines the path of expected unemployment implied by the wage setting behavior of “insiders”.

Actual unemployment is determined through the employment decisions of firms, after information about prices, productivity and other shocks has been revealed.

Integrating the labour demand function over the number of firms \( i \), aggregate employment is given by,
Subtracting the aggregate employment equation (16) from the log of the labor force $n$, actual unemployment is determined by,

\[ u_t = n - \bar{l} + \frac{1}{\alpha} (w_t - p_t - a_t) \]  

(17)

Taking expectations on the basis of information available at the end of period $t-1$, the wage is set in order to make expected unemployment equal to the expression in (15), which defines the unemployment rate consistent with the employment objective of labor market “insiders”.

From (17), the wage is thus set in order to satisfy,

\[ w_t = E_{t-1}p_t + E_{t-1}a_t + \alpha \left( E_{t-1}u_t - n + \bar{l} \right) \]  

(18)

where $E_{t-1}u_t$ is determined by (15).

Substituting (18) for the nominal wage in (17), the unemployment rate evolves according to,

\[ u_t = E_{t-1}u_t - \frac{1}{\alpha} (p_t - E_{t-1}p_t + a_t - E_{t-1}a_t) \]  

(19)

Substituting (15) in (19) thus gives us the solution for the unemployment rate.

\[ u_t = \lambda_1 u_{t-1} + (1 - \lambda_1)\bar{u} - \frac{1}{\alpha} (p_t - E_{t-1}p_t + a_t - E_{t-1}a_t) \]  

(20)

From (20), unemployment is equal to expected unemployment, as determined by the behavior of “insiders” in the labor market, and depends negatively on unanticipated shocks to the price level and productivity which affect labor demand by altering the relationship between ex post real wages and productivity.

We can express (20) in terms of inflation, by adding and subtracting the lagged log of the price level in the last parenthesis. Thus, (20) takes the form of a dynamic, expectations augmented “Phillips Curve”.

\[ u_t = \lambda_1 u_{t-1} + (1 - \lambda_1)\bar{u} - \frac{1}{\alpha} (\pi_t - E_{t-1}\pi_t + a_t - E_{t-1}a_t) \]  

(21)

where $\pi$ is the inflation rate.

Unanticipated shocks to inflation reduce unemployment by a factor which depends on the elasticity of labor demand with respect to the real wage, as unanticipated inflation reduces real wages.
Unanticipated shocks to productivity reduce unemployment, as they reduce the difference between real wages and productivity and increase labor demand.

(21) can be expressed in terms of deviations of unemployment from its “natural” rate, as,

\[ u_t - \bar{u} = \lambda_1 (u_{t-1} - \bar{u}) - \frac{1}{\alpha} (\pi_t - E_{t-1} \pi_t + a_t - E_{t-1} a_t) \]  

(22)

(22) is the dynamic “Phillips curve” in this model. Deviations of unemployment from its “natural” level depend negatively on unanticipated shocks to inflation and productivity, as these cause a discrepancy between real wages and productivity, due to the fact that nominal wages are predetermined in every period.

Unanticipated shocks to inflation reduce real wages and induce firms to increase labor demand and employment beyond their “natural” level. Thus, unemployment falls relative to its own “natural” rate. Unanticipated shocks to productivity, given inflation, cause an increase in productivity relative to real wages, and also cause firms to increase labor demand, employment and output, beyond their “natural” levels. This reduces unemployment.

It can easily be confirmed from (22) that following a shock to inflation or productivity, unemployment will converge gradually back to its “natural” rate, with the speed of adjustment being \((1-\lambda_1)\) per period.

It is straightforward to show that an increase in \(\theta\), the relative weight of recent employees in the wage setting process, results in an increase in \(\lambda_1\), the coefficient that determines the persistence of unemployment. From the conditions which define the two roots, it follows that,

\[ \frac{\partial \lambda_1}{\partial \theta} = \left( \frac{\lambda_1}{\theta} \right)^2 > 0 \]

Thus, the higher the weight of recent employees relative to core “insiders” in the wage setting process, the higher the persistence of unemployment. For example, assuming \(\beta=0.99\), with \(\theta=1\), \(\lambda_1=0.38\). With \(\theta=2\), \(\lambda_1=0.50\), with \(\theta=10\), \(\lambda_1=0.73\), and with \(\theta=100\), \(\lambda_1=0.91\). It is also straightforward to show that as \(\theta\) tends to infinity, that is if recent employees are the only ones affecting the wage setting process, \(\lambda_1\) tends to unity, and unemployment displays “hysteresis”.

1.3 The Relation between Output and Unemployment

The persistence of employment and unemployment, will also be translated into persistent output fluctuations.

Aggregating the firm production functions (3), the aggregate production function can be written as,

\[ y_t = a_t + (1-\alpha)l_t \]  

(23)

Adding and subtracting \((1-\alpha)(n-\bar{n})\), the production function can be written as,
\[ y_t = \tilde{y}_t - (1 - \alpha)(u_t - \tilde{u}) \tag{24} \]

where,

\[ \tilde{y}_t = (1 - \alpha)\bar{n} + a_t \tag{25} \]

is the log of the “natural” level of output.

(24) is an Okun (1962) type of relation, which suggests that fluctuations of output around its “natural” level will be negatively related to fluctuations of the unemployment rate around its own “natural” rate.

From (23) and (22), deviations of output from its “natural” level will be determined by,

\[ y_t - \tilde{y}_t = \lambda_t(y_{t-1} - \tilde{y}_{t-1}) + \frac{1 - \alpha}{\alpha}(\pi_t - E_{t-1}\pi_t + a_t - E_{t-1}a_t) \tag{26} \]

(26) shows that deviations of output from its “natural” level, also display persistence, because of the persistence of employment and unemployment.

(26) is the dynamic output supply function in this model. Deviations of output from its “natural” level depend positively on unanticipated shocks to inflation and productivity, as these cause a discrepancy between real wages and productivity, due to the fact that nominal wages are predetermined. Unanticipated shocks to inflation reduce real wages and induce firms to increase labor demand, employment and output. Unanticipated shocks to productivity, given the inflation rate, cause an increase in productivity relative to real wages, and also cause firms to increase labor demand, employment and output, beyond their “natural” levels. On the other hand, anticipated shocks to productivity increase both output and its “natural” level by the same proportion.

1.4 The Evolution of Productivity Shocks and the Dynamic Phillips Curve

In what follows, we shall assume that the productivity shock \( a \) follows a first order autoregressive process of the form,

\[ a_t = \eta_a a_{t-1} + \epsilon^A_t \tag{27} \]

where \( \epsilon^A_t \) is a white noise process, satisfying,

\[ \epsilon^A_t \sim N(0, \sigma^2_A) \]

Under this assumption, the dynamic Phillips curve takes the form,

\[ u_t - \tilde{u} = \lambda_t(u_{t-1} - \tilde{u}) - \frac{1}{\alpha}(\pi_t - E_{t-1}\pi_t + \epsilon^A_t) \tag{28} \]
Only unanticipated inflation and unanticipated shocks to productivity can affect deviations of the unemployment rate from its “natural” rate in this model. In the absence of shocks to inflation and productivity, the unemployment rate gradually converges to its “natural” rate, and, from (26), so does real output.

2. Optimal Monetary Policy under Unemployment Persistence

We next turn to the determination of inflation. We assume that inflation is determined by the central bank, after the realization of current shocks to productivity. Thus, we assume that the central bank has an informational advantage over wage seters in the determination of monetary policy. Monetary policy, and thus inflation, is chosen after nominal wages have been set, and after the central bank has observed current productivity shocks.

2.1 Optimal Inflation Policy under Discretion

We shall assume that the central bank, acting as a government agency, uses its policy instruments, i.e either the money supply or nominal interest rates, in order to select a path for inflation that minimizes an inter-temporal quadratic loss function that depends on deviations of inflation from a fixed target $\pi^*$, and deviations of unemployment from its “natural” rate. Thus, the central bank chooses inflation in order to minimize, $^4$

$$\Lambda^D_t = E_t \sum_{s=0}^{\infty} \beta^s \left( \frac{1}{2} (\pi_{t+s} - \pi^*)^2 + \frac{\zeta}{2} (u_{t+s} - \bar{u})^2 \right)$$  \hspace{1cm} (29)$$

subject to the dynamic expectational Phillips curve (28). Superscript $D$ denotes “discretion”. $\beta$ is the discount factor $\beta=1/(1+\rho)$, where $\rho$ is the pure rate of time preference, and $\zeta$ is the relative weight attached by the central bank to deviations of unemployment from its “natural” rate, relative to deviations of inflation from target.$^5$

We term the policy that results from the minimization of (29) subject to (28), as discretionary, because the central bank target for unemployment differs from the current unemployment target of “insiders” in the labor market. Thus, under this policy, there is a conflict between the objectives of the monetary authorities and the objectives of wage setting “insiders”. The central bank seeks to minimize deviations of unemployment from its “natural” rate, whereas wage setters seek to minimize deviations of unemployment from a weighted average of the “natural” rate and past unemployment.

From the first order conditions for a minimum of (29) subject to (28), we get,

$$\pi_t = \pi^* + \frac{\zeta}{\alpha} (u_t - \bar{u}) + \frac{\zeta \beta \lambda}{\alpha} E_t (u_{t+1} - \bar{u})$$  \hspace{1cm} (30)$$

$^4$ We bypass the demand side of the model, by assuming that the central bank can use either the money supply, or, more plausibly, nominal interest rates to achieve its inflation target. In Alogoskoufis (2015) I have analyzed a full dynamic stochastic general equilibrium version of the model, without unemployment persistence though, to analyze the effects of both a money supply rule and a Taylor (1993) interest rate rule, and compare them with the optimal monetary policy.

$^5$ We assume here that the central bank does not seek to reduce unemployment below its “natural” rate. Thus, we abstract from the systematic inflation bias that would result in case the government also sought to reduce unemployment below its “natural rate”, as in Kydland and Prescott (1977) and Barro and Gordon (1983).
Using (28) to substitute for current and expected future deviations of the unemployment rate from its “natural” rate, after some rearrangement, we get,

\[ \pi_t = \lambda_1 \pi_{t-1} + (1 - \lambda_1) \pi^* - \frac{\zeta(1 + \beta \lambda_1^2)}{\alpha^2} \left( \pi_t - E_{t-1} \pi_t + \varepsilon_t^A \right) \]  

(31)

The rational expectations solution of (31) is given by,

\[ \pi_t = \lambda_1 \pi_{t-1} + (1 - \lambda_1) \pi^* - \frac{\zeta(1 + \beta \lambda_1^2)}{\alpha^2 + \zeta(1 + \beta \lambda_1^2)} \varepsilon_t^A \]  

(32)

From (32), deviations of the optimal discretionary inflation rate from the inflation target \( \pi^* \) display the same degree of persistence, as the persistence of deviations of unemployment from its “natural” rate. The reason is that the central bank seeks to use inflation in order to minimize deviations of unemployment from its “natural” rate. Since these deviations display persistence, deviations of inflation from target also display persistence under the optimal discretionary policy.\(^6\)

The persistence of inflation under the optimal discretionary monetary policy does not affect the persistence of unemployment. The reason is that wage setters can anticipate the persistent part of the inflation process, incorporate it in their expectations, and neutralize the effects of persistent inflation on unemployment. Thus, the only element of monetary policy that matters for unemployment is the unanticipated part, which is a function of the current productivity shock.

Note from (32) that anticipated inflation is given by,

\[ E_{t-1} \pi_t = \lambda_1 \pi_{t-1} + (1 - \lambda_1) \pi^* \]  

(33)

Thus, from (32) and (33), unanticipated inflation is given by,

\[ \pi_t - E_{t-1} \pi_t = - \frac{\zeta(1 + \beta \lambda_1^2)}{\alpha^2 + \zeta(1 + \beta \lambda_1^2)} \varepsilon_t^A \]  

(34)

Substituting (34) in the dynamic expectational Phillips curve (28), we get,

\[ u_t = \lambda_1 u_{t-1} + (1 - \lambda_1) u - \frac{\alpha}{\alpha^2 + \zeta(1 + \beta \lambda_1^2)} \varepsilon_t^A \]  

(35)

Optimal discretionary monetary policy results in persistent inflation, but it is only the unanticipated part of inflation that helps mitigate the impact of productivity shocks on unemployment. The

\(^6\) Note from (32) that if deviations of unemployment from its “natural” rate did not persist, i.e in the case \( \lambda_1 = 0 \), the optimal discretionary monetary policy would not result in persistent deviations of inflation from target. There would be deviations of inflation from \( \pi^* \) only in response to unanticipated shocks to productivity.
anticipated persistent part of inflation cannot affect unemployment, as it is neutralized by the adjustment of the expectations of the wage setting “insiders”.\footnote{In Alogoskoufis (2016) we demonstrate that the same results follow in the context of a full dynamic stochastic general equilibrium model with periodic wage contracts determined by labor market “insiders”, if the central bank follows a Taylor (1993, 1999) rule. Adjusting the central bank policy interest rate in response to deviations of inflation from target and deviations of unemployment from its “natural” rate, results in persistent deviations of inflation from the central bank’s target. The degree of persistence of such deviations is equal to the degree of persistence of deviations of unemployment from its “natural” rate. Thus, it is sufficient to assume a central bank that follows a Taylor rule for the results of the present paper to apply. See also Clarida, Gali and Gertler (1999) and Woodford (2003) on the properties of the Taylor rule. There is no need to assume that the central bank necessarily follows the optimal discretionary policy.}

Under the optimal discretionary policy, the variances of inflation and unemployment are given by,

\[ \text{Var}(\pi_t) = E_t (\pi_t - \pi^*)^2 = \frac{1}{(1-\lambda_t)^2} \left( \frac{\zeta^2 (1 + \beta \lambda_t^2)^2}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)^2} \right) \sigma_A^2 \] (36)

\[ \text{Var}(u_t) = E_t (u_t - \bar{u})^2 = \frac{1}{(1-\lambda_t)^2} \left( \frac{\alpha^2}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)^2} \right) \sigma_A^2 \] (37)

where \( \sigma_A^2 \) is the variance of the innovation in productivity \( \epsilon_t^A \).

The expected loss of the government and the monetary authorities under the optimal discretionary policy is thus given by,

\[ \Lambda_t^D = E_t \sum_{s=1}^{\infty} B_t^s \left( \frac{1}{2} (\pi_{t+s} - \pi^*)^2 + \frac{\zeta}{2} (u_{t+s} - \bar{u})^2 \right) = \frac{1 + \rho}{2} \frac{\zeta}{\rho (1-\lambda_t)^2} \left( \frac{\alpha^2 + \zeta (1 + \beta \lambda_t^2)^2}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)^2} \right) \sigma_A^2 \] (38)

The question that arises is whether the central bank can do better than the optimal discretionary policy. Is it possible that the central bank can do better than the optimal discretionary policy by following a policy of full commitment to its inflation target, without being concerned about deviations of unemployment from its “natural” rate?

2.2 Full Commitment to the Inflation Target

In response to the credibility problems arising in the context of the “natural” rate models of Kydland and Prescott (1977) and Barro and Gordon (1982), Rogoff (1985) has suggested that the constitution of the central bank should be such that instead of the central bank seeking to minimize a social loss function such as (29), the central bank should be instructed to minimize a different more “conservative” objective.

One such solution would be an objective that only depends on inflation. This would ensure full commitment to the inflation target \( \pi^* \).

In the case of full commitment to the inflation target, the central bank constitution would instruct it to minimize,
The optimal full commitment policy implies that,

$$\pi_t = \pi^* \quad \forall \ t$$  \hspace{1cm}(40)$$

Under this policy, unemployment would evolve according to,

$$u_t = (1 - \lambda_t)\bar{u} + \lambda_t u_{t-1} - \frac{1}{\alpha} \varepsilon^A$$  \hspace{1cm}(41)$$

as there would be no unanticipated inflation to mitigate the effects of productivity shocks on unemployment. Under full commitment to the inflation target monetary policy plays no role in the stabilization of unemployment around its “natural” rate. This would be the result of a policy of full credibility but no flexibility.

Under this policy, the variance of inflation would be equal to zero, and the variance of unemployment around its natural rate would be given by,

$$\text{Var}(u_t) = E_t(u_t - \bar{u})^2 = \frac{1}{(1 - \lambda_t)^2} \sigma_A^2$$  \hspace{1cm}(42)$$

The expected loss for a government, which cares about deviations of unemployment from its “natural” rate, would, under the policy of full commitment, be given by,

$$\Lambda^t_{FC} = E_t \sum_{s=0}^{\infty} \beta^s \left( \frac{1}{2} (\pi_{t+s} - \pi^*)^2 + \frac{\zeta}{2} (u_{t+s} - \bar{u})^2 \right) = \frac{1 + \rho}{\rho} \frac{\zeta}{(1 - \lambda_t)^2} \sigma_A^2$$  \hspace{1cm}(43)$$

where superscript $FC$ denotes “full commitment” to the inflation target $\pi^*$.

The expected loss would be higher under full commitment to the inflation target than under discretion, if,

$$\frac{1}{\alpha^2} > \left( \frac{\alpha^2 + \zeta (1 + \beta \lambda_t)^2}{(\alpha^2 + \zeta (1 + \beta \lambda_t^2))^2} \right)$$  \hspace{1cm}(44)$$

which requires that,

$$\zeta^2 (1 + \beta \lambda_t^2)^2 + \alpha^2 \zeta (1 + \beta \lambda_t^2) (1 - \beta \lambda_t^2) > 0$$  \hspace{1cm}(45)$$

This condition is always met for a positive $\zeta$, since the discount factor is less than one ($\beta < 1$). Thus, for a positive $\zeta$ the policy of full commitment to the inflation target results in higher social losses than the optimal discretionary policy.
Despite the persistence of inflation under the discretionary policy, and thus the higher variance of inflation, the discretionary policy always dominates in this model over the policy of full commitment to the inflation target.

Whereas the full commitment policy results in inflation always being equal to its target, this policy does not react at all to deviations of unemployment from its “natural” rate, and results in the maximum “social” losses from fluctuations in unemployment.

2.3 Inflation and Unemployment in the Presence of Non Systematic Monetary Policy Errors

Our results so far have been derived under the assumption that there are no errors in the implementation of the optimal monetary policy. The results can be generalized for the case where monetary policy is characterized by a non systematic “white noise” error. Such errors may arise because of imperfect information about current developments in unemployment, errors in the transmission of monetary policy or simply because of imperfect implementation of monetary policy.

In this case the optimal inflation policy rule (30) under discretion would be transformed to,

$$\pi_t = \pi^* + \frac{\zeta}{\alpha} (u_t - \bar{u}) + \frac{\zeta \beta \lambda}{\alpha} E_t (u_{t+1} - \bar{u}) + \epsilon_t^M$$

where $\epsilon_t^M$ is a “white noise” shock to monetary policy, satisfying,

$$\epsilon_t^M \sim N(0, \sigma_M^2)$$

Using the dynamic Phillips curve (28) to substitute for the unemployment terms in (30'), and solving for inflation under the assumption of rational expectations, we get that under the optimal discretionary monetary policy, inflation follows,

$$\pi_t = (1 - \lambda_t) \pi^* + \lambda_t \pi_{t-1} - \frac{\zeta (1 + \beta \lambda_t^2)}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)} \epsilon_t^A + \frac{\alpha^2}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)} (\epsilon_t^M - \lambda_t \epsilon_{t-1}^M)$$

As in the case of (32), the persistence of deviations of inflation from the target of the central bank is equal to the persistence of deviations of unemployment from its “natural” rate.

From (32') it follows that unanticipated inflation is given by,

$$\pi_t - E_{t-\infty} \pi_t = - \frac{\zeta (1 + \beta \lambda_t^2)}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)} \epsilon_t^A + \frac{\alpha^2}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)} \epsilon_t^M$$

From (34') unanticipated inflation depends on the current monetary policy error or shock.

Substituting (34') in the dynamic expectational Phillips curve (28), we get,

$$\pi_t - E_{t-\infty} \pi_t = - \frac{\zeta (1 + \beta \lambda_t^2)}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)} \epsilon_t^A + \frac{\alpha^2}{\alpha^2 + \zeta (1 + \beta \lambda_t^2)} \epsilon_t^M$$
Under the optimal discretionary monetary policy deviations of unemployment from its “natural” rate are driven by both productivity and monetary policy shocks, and they display the same degree of persistence as inflation.

Again, it is only the unanticipated part of inflation that helps mitigate the impact of productivity and monetary policy shocks on unemployment. The anticipated persistent part of inflation cannot affect unemployment, as it is neutralized by the adjustment of the expectations of the wage setting “insiders”.

Under full commitment to the inflation target inflation and unemployment follow,

\[ \pi_t = \pi^* + \varepsilon_t^M \]  \hspace{1cm} (40')

\[ u_t = (1 - \lambda_t)\dot{u} + \lambda_t u_{t-1} - \frac{1}{\alpha} (\varepsilon_t^A + \varepsilon_t^M) \]  \hspace{1cm} (41')

It is straightforward to demonstrate that even in the presence of monetary policy shocks, the optimal discretionary policy dominates the policy of full commitment to the inflation target.

The theoretical predictions of this model suggest that if a central bank follows the optimal discretionary policy, deviations of inflation from target should display the same degree of persistence as deviations of unemployment from its “natural” rate.

In the next section of this paper we proceed to investigate the validity of this theoretical prediction.

3. The Persistence of Unemployment and Inflation in the G-7 Economies

In attempting to test the predictions of the model, we shall estimate the set of equations (32') and (35') and test it against the set of equations (40') and (41'). If deviations of inflation from a constant target display the same degree of persistence as deviations of unemployment from its “natural” rate, then we shall take it as evidence that central banks have been following a discretionary monetary policy. If deviations of unemployment from its “natural” rate display persistence, but inflation deviations do not, then we shall take it as evidence that central banks have been following a policy of full commitment to their inflation target.

The problem in implementing this test is that one has to make assumptions about the evolution of latent variables such as the “natural” rate of unemployment and the targets of central banks with regard to inflation.

In the tests that we present below, the “natural” rate of unemployment is approximated by a Hodrick Prescott (1997) filter. With regard to the fixed inflation targets of central banks, we allow these to differ between the Bretton Woods period, 1952-1971, the first period of flexible exchange rates 1972-1982, and the post-Volcker period, 1983-2014. It turns out, from the evidence presented below, that with the exception of Japan, there is no difference in steady state inflation between the Bretton Woods period and the post-Volcker period, but that there is a significant difference between these and the first ten years of flexible exchange rates 1972-1982, which are characterized by a significantly higher average inflation rate than the other two sub-periods.
Our results for the main industrial economies of the USA, Japan, Germany, France, Italy, the United Kingdom and Canada, using annual data for the post war period are presented in Tables 1 and 2. Table 1 presents the results for deviations of unemployment from its “natural” rate, modeling the “natural” rate through a Hodrick Prescott (1997) filter. Table 2 presents the results for deviations of inflation from fixed targets, allowing for different targets between 1972-82 and the other two sub-periods.

A number of observations are worth making concerning the estimates in Tables 1 and 2.

First, both deviations of unemployment from its “natural” rate and deviations of inflation from target appear to be 2nd order and not 1st order autoregressive processes. We thus calculate the degree of persistence of unemployment and inflation as the sum of the estimated parameters on the two lagged dependent variables, and report the relevant standard error of estimate of this sum.

Second, neither deviations of unemployment from its Hodrick Prescott “natural” rate, nor deviations of inflation from a constant target appear to be characterized by a unit root. The relevant ADF statistics do not indicate the presence of a unit root at conventional levels of significance for any of the countries concerned. This is somewhat surprising in view of previous results, especially the results of Blanchard and Summers (1986). Using the Hodrick Prescott filter for the “natural” rate of unemployment results essentially removes the unit root, attributing to the “natural” rate of unemployment. Thus, fluctuations of unemployment rates around their “natural” rates appear to be stationary stochastic processes.

Third, the degree of persistence, i.e the sum of the two autoregressive parameters, is positive and statistically significant for all countries, both in the unemployment and the inflation equations. The degree of persistence of deviations of unemployment from their “natural” rate ranges from 0.311 in the case of the USA, to 0.596 in the case of Italy. It is about one half for the remaining countries. The degree of persistence of inflation ranges from 0.374 in the case of France, to 0.595 in the case of Italy. For the remaining countries it is also about one half. Thus, on the basis of these estimates, there does not seem to be prima facie evidence of significant differences in the degree of persistence of deviations of unemployment from its “natural” rate and deviations of inflation from the target of the monetary authorities.

This is confirmed by joint estimation of the unemployment and the inflation equations. The hypothesis of the same degree of persistence of deviations of unemployment and inflation cannot be rejected for any of the G-7 countries at conventional significance levels. The relevant Wald tests, for an equal degree of persistence of unemployment and inflation, when the unemployment and inflation equations are estimated jointly as a system, are equal to 0.24 for the USA, 0.05 for Japan, 0.09 for Germany, 0.43 for France, 0.0001 for Italy, 0.37 for the UK and 0.005 for Canada. The critical values of $\chi^2(1)$ are 6.635 at the 1% significance level, 3.841 at the 5% significance level and 2.706 at the 10% significance level. Thus, the hypothesis that unemployment and inflation display the same degree of persistence in all of the G-7 economies cannot be rejected at conventional significance levels.

Fourth, there appears to have been a significant upward shift in the inflation target of all central banks following the collapse of the Bretton Woods system and the initial shift to flexible exchange rates. However, the inflation target of central banks has been roughly constant in the rest of the post war period, with the exception of Japan. On the basis of the estimates in Table 2, it has been around
2.5% percent per annum in the USA, 2.1% per annum in Germany, 2.2% per annum in Canada, and slightly higher in France, Italy and the UK. For the case of Japan, one cannot reject the hypothesis that in the post-1982 period the inflation target of the Bank of Japan has actually been zero.

To summarize, although there appear to be differences in the degree of unemployment persistence among the industrial economies, reflecting perhaps their different labor market structures, these differences are relatively small. In all cases, the degree of unemployment persistence is reflected in the degree of inflation persistence, as suggested by the model of optimal discretionary monetary policy presented in this paper. This is prima facie evidence that all the central banks concerned, despite their different steady state inflation targets, have been following a discretionary monetary policy in the post war period, trying to stabilize fluctuations in both inflation and unemployment. Had they only concentrated on an inflation target, inflation would not be characterized by the same degree of persistence as unemployment as suggested by our empirical results. The clash of central bankers with labor market insiders is responsible for the persistence of inflation according to our model.

4. Conclusions

This paper has analyzed the implications of optimal discretionary monetary policy for the behavior of inflation in a dynamic “natural rate” model, characterized by endogenous unemployment persistence.

The main distinguishing characteristic of the model put forward in this paper is a dynamic “insider outsider” version of the “Phillips Curve”, that accounts for the persistence of unemployment following nominal and real shocks.

We first derived optimal monetary policy under discretion, by assuming a central bank that minimizes an inter-temporal quadratic loss function that depends on deviations of inflation from an exogenous inflation target and unemployment from its “natural” rate.

We demonstrated that because of the persistence of deviations of unemployment from its “natural” rate, deviations of the inflation rate from target inflation also display persistence, related to the persistence of unemployment.

We next derived optimal monetary policy under full commitment to an inflation target, by assuming that the central bank minimizes an inter-temporal quadratic loss function that depends only on deviations of inflation from its exogenous inflation target. In such a case, there is no inflation persistence, as the central bank achieves its inflation target in every period. However, under such a policy, monetary policy cannot address fluctuations in unemployment caused by unanticipated productivity shocks.

We demonstrated that, in the context of our model, the optimal discretionary policy dominates the full commitment policy in the presence of real (productivity) shocks.

An empirical investigation for the main industrial economies the G-7 suggests that the persistence of deviations of inflation from a constant inflation target is of the same order of magnitude as the persistence of deviations of unemployment from its “natural” rate. This finding is consistent with
the hypothesis that central banks in all the main industrial economies, despite their differences, have been following discretionary monetary policies throughout the post-war period.
Table 1
The Persistence of Unemployment in the G7
Annual Data, 1952-2014

Dependent Variable: \((u-\bar{u})_t\)

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>Japan</th>
<th>Germany</th>
<th>France</th>
<th>Italy</th>
<th>UK</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>((u-\bar{u})_{t-1})</td>
<td>0.711</td>
<td>0.925</td>
<td>1.134</td>
<td>0.924</td>
<td>0.791</td>
<td>1.122</td>
<td>0.846</td>
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<td>(0.118)</td>
<td>(0.117)</td>
<td>(0.098)</td>
<td>(0.114)</td>
<td>(0.127)</td>
<td>(0.107)</td>
<td>(0.116)</td>
<td></td>
</tr>
<tr>
<td>((u-\bar{u})_{t-2})</td>
<td>-0.399</td>
<td>-0.425</td>
<td>-0.650</td>
<td>-0.455</td>
<td>-0.195</td>
<td>-0.637</td>
<td>-0.402</td>
</tr>
<tr>
<td>(0.118)</td>
<td>(0.118)</td>
<td>(0.098)</td>
<td>(0.115)</td>
<td>(0.127)</td>
<td>(0.107)</td>
<td>(0.115)</td>
<td></td>
</tr>
<tr>
<td>Persistence</td>
<td>0.311</td>
<td>0.500</td>
<td>0.484</td>
<td>0.468</td>
<td>0.596</td>
<td>0.485</td>
<td>0.444</td>
</tr>
<tr>
<td>(0.120)</td>
<td>(0.099)</td>
<td>(0.078)</td>
<td>(0.098)</td>
<td>(0.107)</td>
<td>(0.084)</td>
<td>(0.104)</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.377</td>
<td>0.523</td>
<td>0.694</td>
<td>0.529</td>
<td>0.451</td>
<td>0.653</td>
<td>0.476</td>
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<tr>
<td>s</td>
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<td>0.0022</td>
<td>0.0044</td>
<td>0.0038</td>
<td>0.0063</td>
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<tr>
<td>DW</td>
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<td>1.925</td>
<td>2.038</td>
<td>2.040</td>
<td>2.057</td>
<td>1.837</td>
<td>2.136</td>
</tr>
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</table>

Note: \(\bar{u}\) is approximated by a Hodrick-Prescott Filter. A constant is included but is not statistically significant.
Table 2
The Persistence of Inflation in the G7
Annual Data, 1952-2014

Dependent Variable: $\pi_t$

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>Japan</th>
<th>Germany</th>
<th>France</th>
<th>Italy</th>
<th>UK</th>
<th>Canada</th>
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<tr>
<td>Constant</td>
<td>0.015</td>
<td>0.004</td>
<td>0.012</td>
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<td></td>
<td>(0.004)</td>
<td>(0.005)</td>
<td>(0.002)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.005)</td>
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<tr>
<td>1972-1982</td>
<td>0.035</td>
<td>0.040</td>
<td>0.016</td>
<td>0.051</td>
<td>0.058</td>
<td>0.060</td>
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<tr>
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<td>$\pi_{t-1}$</td>
<td>0.564</td>
<td>0.557</td>
<td>0.907</td>
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<td>0.458</td>
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<td>(0.108)</td>
<td>(0.096)</td>
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<td>(0.092)</td>
<td>(0.104)</td>
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<td>$\pi^*$</td>
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<td>0.029</td>
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<td>$\pi^*$ (1972-82)</td>
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<td>0.082</td>
<td>0.050</td>
<td>0.110</td>
<td>0.172</td>
<td>0.133</td>
<td>0.097</td>
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<td></td>
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<td>(0.015)</td>
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<td>(0.017)</td>
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<td>-5.481</td>
<td>-5.009</td>
<td>-7.735</td>
</tr>
</tbody>
</table>

Data Appendix

The data set used in this study is as follows:

$u$ is the civilian unemployment rate, and $\pi$ is the rate of change of the Consumer Price Index.

The data set has been compiled from the AMECO Data Base of the European Union, for the period 1960-2014, and from the OECD data bases and the IMF *International Financial Statistics* for the period 1948-1959. The data set used is available upon request.
References


