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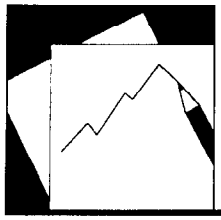

IMF Working Paper

Monetary Policy Credibility and the Unemployment-Inflation Trade-Off: Some Evidence from 17 Industrial Countries

Douglas Laxton and Papa N'Diaye

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Monetary Policy Credibility and the Unemployment-Inflation Trade-Off: Some Evidence from 17 Industrial Countries

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Abstract

Using data on long-term interest rates for 17 industrial countries, this paper develops some simple measures of monetary policy credibility and then tests if such measures improve the out-of-sample forecasts of conventional models of the inflation-unemployment process. The results provide some evidence in favor of the Lucas critique by showing that the short-run unemployment-inflation trade-off tends to improve in countries that are successful in providing low and stable inflation.

JEL Classification Numbers: C51; E31; E52

Keywords: Phillips Curve; Unemployment; Monetary Policy; Lucas Critique

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I. INTRODUCTION

Over the last decade, many countries have been successful in implementing monetary policies that have reduced inflation to within a fairly narrow corridor relative to earlier periods that were characterized by high and variable inflation rates. As a direct consequence, many of these countries have benefited from lower long-term interest rates as bond market participants have developed confidence over time that these countries will remain committed to monetary policy regimes that will maintain low and stable inflation. Despite the fact that views about policy credibility have played a central role in determining the design of these improved monetary policy regimes, there exists very little empirical work that supports the notion that credibility effects are at all important in influencing the short-run unemployment-inflation trade-off.[2] This paper contributes to filling this void in the empirical literature by showing that models that exploit information about policy credibility produce out-of-sample forecasts that are significantly better than conventional reduced-form models of inflation that impose a stable and time-invariant link between inflation expectations and inflation.[3]

The remainder of this paper is organized in the following way. Section II provides a model where the short-run unemployment-inflation trade-off depends on the degree of policy credibility. It is shown that when credibility is high, shocks that result in a persistent boom in the economy will result in a smaller buildup in inflationary pressures over time than during periods when credibility is low. After the history of the unemployment-inflation process in the United Kingdom is reviewed in Section II, Section III presents some empirical evidence for several industrial countries that shows that exploiting information in long-term interest rates to construct proxies of policy credibility can result in a significant reduction in out-of-sample forecast errors

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[2] Freedman (1989) argues that the short-run unemployment-inflation trade-off should improve under a monetary policy regime that is successful in providing an anchor for inflation expectations. Ericsson and Irons (1994) and Fischer (1996) argue that while the Lucas critique is true in principle, policymakers still rely heavily on reduced-form Phillips-curve models because there is very little empirical evidence that proves convincingly that the Lucas critique is important in practice. Some recent evidence based on data for Australia and the United States suggests that inflation persistence may have declined in countries that have been successful in providing an anchor for inflation expectations. See Debelle and Wilkinson (2002) and Erceg and Levin (2001).

[3] The methodology for evaluating alternative models in terms of real-time out-of-sample forecasts instead of in-sample fits provides a more challenging test because estimates of unobservable variables such as the non-accelerating-inflation-rate-of-unemployment (NAIRU) and potential output contain significantly greater uncertainty at the end of the sample than over periods in the distant past when analysts have the benefit of hindsight to help estimate their models. See Orhpanides and van Norden (2001) and Boone and others (2002) for a discussion of the difference between fitting and forecasting.

for inflation.[4] Section IV outlines how the models might be extended and improved over time. Section V concludes.

II. A Simple Model of the Unemployment-Inflation Process

There has been an enormous amount of effort expended in policymaking institutions seeking to estimate expectations-augmented Phillips curves with backward-looking autoregressive representations for inflation expectations. This long-standing tradition of relying upon such models has stood as a sharp contradiction to the Lucas (1976) critique, which suggests that the parameters of such models are unlikely to be stable over different monetary policy regimes.[5] Indeed, Ericsson and Irons (1994) and Fischer (1996) suggest that the paucity of evidence supporting the Lucas critique may indicate that it may still be valid for policymakers to rely upon estimated reduced-form models. This view is supported more directly by Fuhrer (1995, 1997), which has shown that there is little empirical evidence from the U.S. data that suggests that inflation expectations have an important forward-looking component and that backward-looking reduced-form Phillips curves perform significantly better in fitting the historical data.

The remainder of this section presents a general model of the unemployment-inflation process that nests the class of conventional constant-parameter reduced-form models that have been used extensively in previous empirical work. The conventional model is generalized by allowing the short-run unemployment-inflation trade-off to depend on the degree to which inflation expectations are anchored to the monetary authorities' long-run objectives for inflation. The equations of the models are presented in Table 1.

A. Alternative Models for the Phillips Curve

Equation (1) in Table 1 is a simple expectations-augmented Phillips curve. Inflation (π), which is measured as 400 times the first-difference (quarter-to-quarter change) of the log of the CPI, is assumed to depend on inflation expectations (π^e), the unemployment gap ($ugap$) and the change in the gap ($\Delta ugap$). Equation (2) is a simple definition of the unemployment gap, which is defined as the NAIRU minus the unemployment rate measured in percentage points. The model predicts that there will be a tendency for inflation to rise relative to expected inflation in response to a positive unemployment gap, but it also incorporates the notion of accelerator effects by assuming that the change-in-the gap also enters the equation.

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[4] We focus on data from the United Kingdom in Section II because this is one of the few countries in our sample that has a fairly long time series on inflation expectations derived by comparing yields on conventional and indexed bonds.

[5] The Lucas (1976) critique has been embraced for some time now in academic circles in the United States without any significant body of empirical evidence to show that it is important empirically. See Ericsson and Irons (1994).

B. Alternative Models for Inflation Expectations

Equation (3) in Table 1 is a more general model of inflation expectations [π^e] than what is usually encountered in empirical work on inflation dynamics. In particular, the model is a generalization of a backward-looking autoregressive model (which assumes c = 0) that has been employed extensively to estimate the parameters of reduced-form expectations-augmented Phillips curves.[6] Under the assumption that $c = 0$ inflation expectations are modeled as a pure distributed lag of past inflation with a restriction that the coefficients sum to one. As mentioned above, this model of inflation expectations has been employed extensively in empirical work in policymaking circles despite the fact that its modeling assumptions are a direct contradiction of the most basic objective of monetary policy regimes which aim to provide an anchor for inflation expectations.[7] Therefore, at least in principle, the generalized model of the unemployment-inflation process in Table 1 eliminates the contradiction between central-banking theory and practice by allowing for the possibility that expectations of inflation [π^e] can become partially anchored to the monetary authorities' long-term objectives for inflation [π^{**}].

The case of perfect policy credibility

In the case of perfect policy credibility [c=1] the model posits that inflation expectations would become regressive and at long horizons would become completely anchored to the monetary authorities long-term inflation objectives [π^{**}]. One of the best examples of a sudden and sustained increase in policy credibility, where long-term measures of inflation expectations became anchored to the monetary authorities' long-term objectives for inflation [π^{**}], can be found in the United Kingdom following the introduction of a new monetary policy framework in May 1997.

Example from the United Kingdom of a fairly sudden and sustained increase in policy credibility

Before May 1997, the Bank of England did not have instrument independence and the Chancellor of the Exchequer governed monetary policy with a goal of achieving an inflation rate that was less than 2½ percent. The present forecast-based inflation targeting framework was established in May 1997, when responsibility for making interest rate decisions was transferred from the Chancellor of the Exchequer to the Monetary Policy Committee (MPC) of the Bank of

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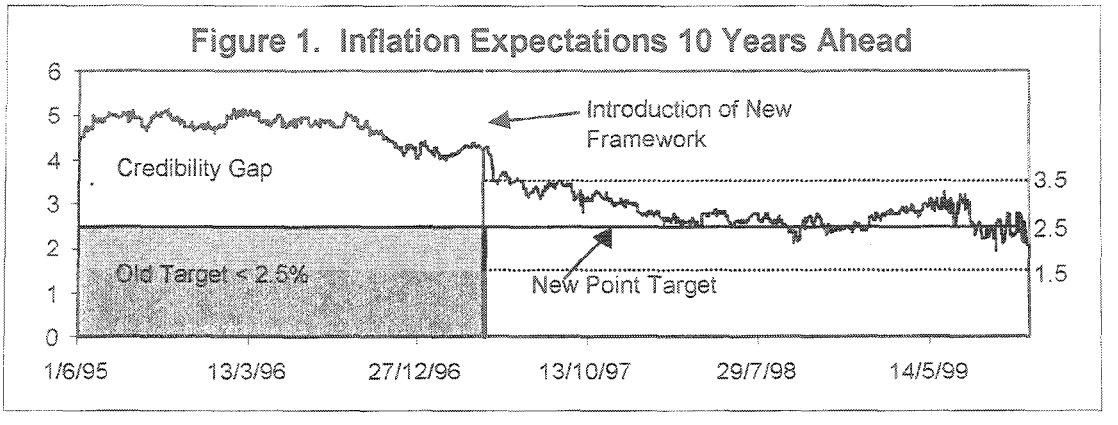
[6] The restricted model, which ignores credibility effects, is usually referred to as the "accelerationist model." For just a few empirical applications of this basic model see Boone and others (2002), Coe and McDermott (1997), Cozier and Wilkinson (1990), Fuhrer (1995,1997), Gordon (1997,1998), Kuttner (1994), Orhpanides and van Norden (2001), and Turner and Seghezza (1999). It is also sometimes referred to as the "integral gap model" because it imposes some very restrictive conditions on the role of stabilization policies—see Summers (1998).

[7] See Freedman (1989).

England (BoE). The goals of monetary policy are now formally spelled out; the primary objective that the MPC must pursue is a well-defined point target of 2½ percent for inflation. In practice, the MPC implements its objective by aiming to keep its two-year-ahead forecast for inflation approximately on target.[8] As shown in Figure 1 long-term (10-year-ahead) inflation expectations in the United Kingdom, based on comparisons of the yields on indexed and non-indexed bonds, dropped markedly following the introduction of the new framework in May 1997.[9] Subsequently, this measure of long-term inflation expectations has become anchored to the 2 ½ percent target, suggesting that bond-market participants have a high degree of confidence that the MPC will remain committed to its basic policy objective of achieving an inflation rate of 2 ½ percent on average.



[8] Transparency and accountability are regarded as central to the system. Minutes of the monthly MPC meetings are published within two weeks of each meeting and the BoE also publishes a quarterly *Inflation Report* that describes the MPC's analysis of the U.K. economy and explains the factors underlying its policy decisions.

[9] This measure of inflation expectations has been created at the Bank of England and is derived by comparing the yields on conventional and indexed bonds—for a description of the methodology for constructing these data see Deacon (1994) and Deacon and Derry (1994).

Table 1. A Simple Model of the Unemployment-Inflation Process

(1) Simple Linear Phillips Curve Equation

$$\pi_t = \pi_t^e + \beta\, ugap_t + \Omega \Delta ugap_t + \varepsilon_t^{\pi}$$

(2) Unemployment Gap Definition:

$$ugap_t = \bar{u}_t - u_t$$

(3) Inflation Expectations Equation

$$\pi_t^e = c_t \pi^*_t + (1 - c_t)\left[\alpha_1 \pi_{t-1} + \alpha_2 \pi_{t-2} + \alpha_3 \pi_{t-3} + (1 - \alpha_1 - \alpha_2 - \alpha_3)\pi_{t-4}\right]$$

with $\pi_t^* = \lambda \pi^{**} + (1 - \lambda)\pi 4_{t-1}$

(4) Simple Measure of Policy Credibility

$$c_t = \frac{\left[RL_t - RL^{HIGH}\right]^2}{\left[RL_t - RL^{HIGH}\right]^2 + \left[RL_t - RL^{LOW}\right]^2}$$

(5) Unemployment Gap Dynamics

$$ugap_t = \phi\, ugap_{t-1} - \rho\left[\pi 4_{t-1} - \pi^{**}\right] + \varepsilon_t^{ugap}$$

(6) Stochastic Process for the NAIRU

$$u_t^* - u_{t-1}^* = \varepsilon_t^{u^*}$$

(7) Critical Hyper-Parameters

$$\Psi_{ugap,\,\Delta\bar{u}} = \frac{\sigma_{ugap}}{\sigma_{\Delta u^*}}$$ fixed at 7.5.

Even if monetary policy were perfectly credible it could be entirely rational—because of lags in the monetary transmission mechanism or different views about the fundamentals—for there to be persistent differences between near-term inflation expectations in the bond market and the central bank's long-term inflation objectives. This will be the case, for example, if the short-term outlook for the economy by bond-market participants differs from the official forecast of the central bank. Given the uncertainty surrounding any particular short-term point forecast, it will in general be rational for bond market participants to have a different near-term forecast at any point in time even if they believe that the central bank is truly committed to achieving its long-term inflation objectives. Differences in near-term point forecasts will generally be the case if bond market participants have a different view than the central bank about the fundamentals that are driving the inflation process in the short run. In that case, monetary policy could still be credible as long as the public believes that the central bank will remain committed to achieving its long-term inflation objectives by revising its forecast and adjusting its instrument settings in response to new information.[10]

This view about policy credibility is reflected in Equation (3) in Table 1. Under perfect policy credibility bond market's inflation expectations will gradually converge toward π^{**} as the forecast horizon lengthens. Under perfect policy credibility [c=1 in Equation 3] near-term inflation expectations are assumed to be equal to π_t^*, which is a linear combination of the observed headline 4-quarter rate of inflation $[\pi 4_{t-1}]$ and some measure of the monetary authorities long-term inflation objectives π^{**}.[11] For the sample of industrial countries studied here the values for π^{**} vary between 1.5 and 2.5 percent, but for most countries in the sample the

[10] Given uncertainty it will generally be the rule that the short-term point forecast of bond-market will differ from the central bank's short-term point forecast. Obviously, in situations where there have been persistent and systematically large differences between the central bank's inflation forecasts and inflation outcomes, there may be a risk that the central bank may suffer a loss in credibility. In such circumstances the medium-term forecast of inflation by bond market participants may deviate from the target over both the medium and long term. However, in cases where monetary policy is credible, inflation expectations in the bond market will converge on the target at longer forecast horizons even though the two inflation forecasts might differ significantly over the near term. In this case a logically consistent medium-term forecast by bond market participants will assume that the central bank will eventually revise its views about the fundamentals in response to new data and empirical evidence. By the same token, in cases of divergent views about the near-term outlook for inflation a consistent forecast scenario inside a central bank will involve estimating how long it will take for bond market participants to learn the fundamentals behind the central bank's internal forecast.

[11] For consistency, since quarterly inflation $[\pi]$ is measured as 400 times the first-difference (quarter-to-quarter change) in the log of the CPI, the year-on-year inflation rate $[\pi 4]$ is measured as 100 times the year-on-year change in the log of the CPI.

target is assumed to be 2.0 percent.[12] The parameter λ reflects the time it should take on average for the monetary authorities to eliminate any deviation between the observed headline inflation rate [$\pi 4_{t-1}$] and its long-term inflation objectives π^{**}. Given the lags in the monetary transmission mechanism it is quite common for central bankers in industrial countries to believe that it should take somewhere around six to eight quarters—in response to typical shocks—to steer inflation back toward their long-term objectives. This suggests that a reasonable value for λ might lie somewhere between 0.3 and 0.5.

C. Some Implications of Alternative Values for Policy Credibility

An important implication of the model is that the inflationary consequences of both demand and supply shocks will depend on the degree of policy credibility. When credibility is high, periods of persistent excess demand will result in a smaller buildup in inflationary pressures than what would be usually observed when policy credibility is low. Figure 2 provides some illustrative simulated responses to a shock that raises the unemployment gap (lower panel) at its peak by 2 percentage points after 4 quarters.[13] The simulated effects on year-on-year inflation (upper panel) are reported for various values of policy credibility that vary from no policy credibility [c=0] to a case of perfect policy credibility [c=1]. For the case of zero policy credibility, the temporary increase in the unemployment gap results in a permanent increase in the inflation rate of about 1.5 percentage points. In all other cases the increase in the unemployment gap results in a temporary rise in inflation because inflation expectations are assumed to remain partially anchored to π^{**}. For the case of perfect policy credibility it can be seen that the peak response in inflation is observed after 6 quarters and is approximately 2/3 of the response observed under the case of $c = 0$.

Figure 3 repeats the two cases reported in Figure 2 for $c = 0$ and $c = 1$, but it also provides some inflation responses for the case where credibility is initially equal to 1 and then declines to zero over 8 quarters as inflation rises systematically above the target π^{**}. This last case provides an illustrative example of what might be applicable in situations where the monetary authorities have developed a good track record in keeping inflation in the neighborhood of its long-term inflation objectives. For example, this may have been the case in several countries in the late 1960s and early 1970s when inflation expectations were partially anchored by the low and stable inflation regimes of earlier periods, but then eventually became untethered when monetary policies failed to contain the inflationary consequences of inflationary impulses.[14]

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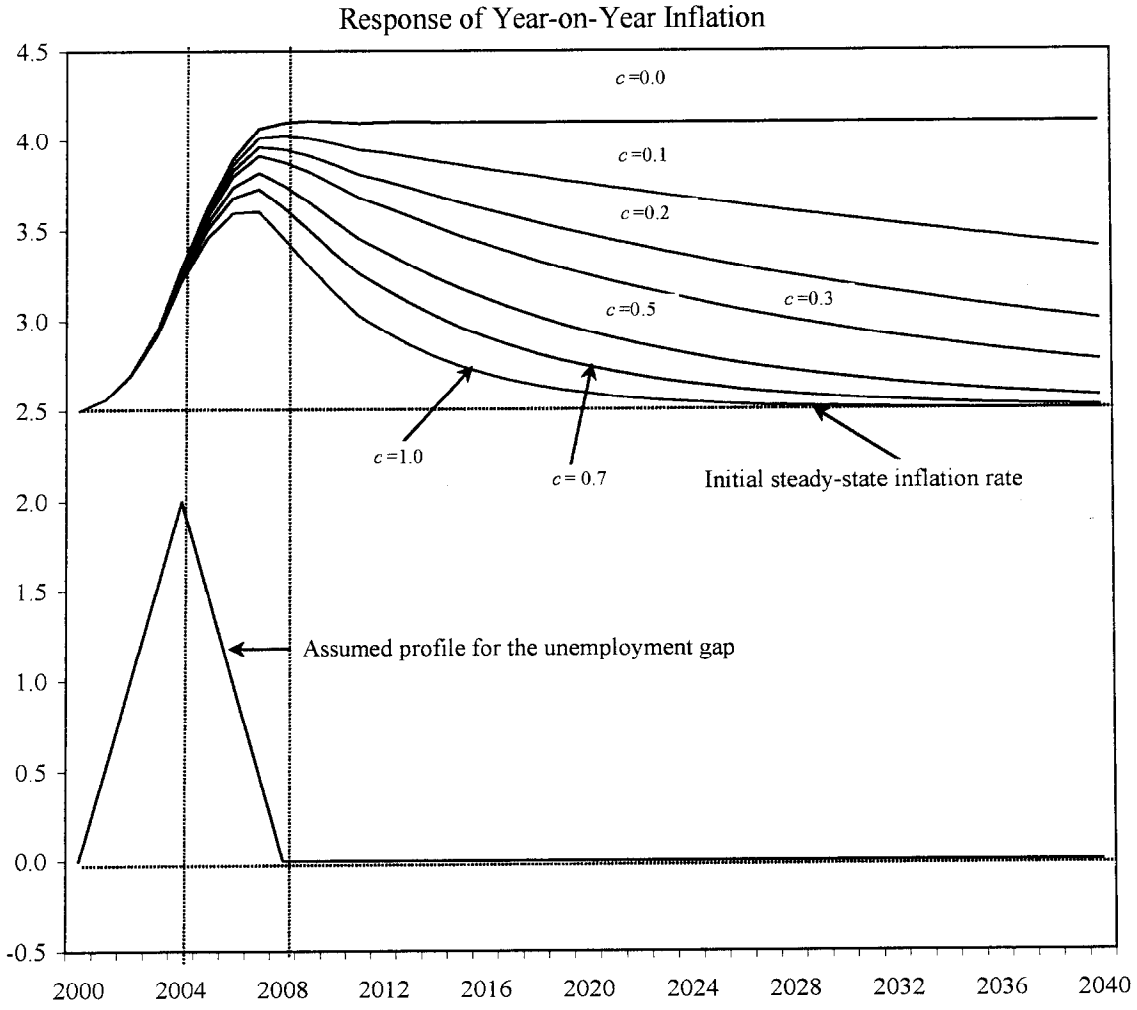
[12] The estimates of long-term inflation objectives for each country in the sample were taken from Boone and others (2002).

[13] These simulated responses are based on solving Equations (1) and (3) in Table 1 assuming that the unemployment gap (gap) takes on the values (0.5, 1.0, 1.5, 2.0, 1.5, 1.0, 0.5) between quarter 1 and quarter 7 of the simulation.

[14] See Laxton, Ricketts, and Rose (1994) and Isard, Laxton, and Eliasson (2001).

Figure 2. Response of Inflation to Unemployment Gaps
Under Various Degrees of Constant Policy Credibility (c)



D. Inflation, Unemployment, and A Measure of Policy Credibility: An Example from the United Kingdom

The paucity of empirical evidence supporting the Lucas (1976) critique and the continued practice of relying upon empirically-based fixed-parameter reduced-form models in policymaking institutions may not be surprising given that very few reliable measures of inflation expectations exist for many countries. The measure reported earlier, which is based on a comparison of the yields on indexed and conventional bonds in the United Kingdom, exists only back to the early 1980s and for other industrial countries where returns on indexed bonds do exist, the data sample would be even shorter. However, long time series on returns of nominal bonds are available in the OECD database for 17 out of the 19 countries studied by Boone and others (2002) and in most cases they tell a similar story about the unemployment-inflation-credibility process in these countries.

Figure 4 provides plots for headline consumer price inflation (the Retail Price Index in the United Kingdom), the unemployment rate and the yield on a conventional nominal bond in the United Kingdom. In addition, the bottom panel of Figure 4 provides a plot of a measure of policy credibility that is based on a transformation of long-term interest rates using Equation (4) in Table 1.[15] The details behind the specific assumptions used to create the measures for policy credibility are explained below but the basic intuition behind Equation (4) is based on the notion that long-term bond yields contain an inflation premium that may be useful for identifying periods of high, moderate and low credibility. Equation (4) tells us that when long-term interest rates are low ($RL = RL^{LOW}$) the credibility of a low and stable inflation regime is likely to be high and when long-term interest rates are high ($RL = RL^{HIGH}$) credibility is likely to be low. The specific functional form has been chosen so that the credibility variable is a continuous variable that varies between zero and one and is equal to the limiting cases of zero and one when RL is in the relative neighborhood of RL^{HIGH} and RL^{LOW}, respectively. The functional form is symmetric and assumes, for example, that credibility will be equal to 0.5 when RL is half way between RL^{LOW} and RL^{HIGH}.[16]

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[15] The other 16 OECD countries in our sample are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, and the United States. Figures that report estimates of policy credibility for the other 16 countries in our sample tell a similar story about the unemployment-inflation-credibility process in these countries. We focus here on the story that emerges for United Kingdom simply because it is a country where there is a fairly long time span of data on inflation expectations that has been derived by comparing the returns on indexed and conventional bonds. Consequently, based on the U.K. data it is possible over part of our sample to verify the stories about credibility that emerges from our credibility proxy variable in Table 1, which is based on nominal yields, with the inflation expectation data derived from the indexed bond market.

[16] Goodfriend (1993) argues that variation in long-term interest rates have provided a good proxy for inflation scares. This was likely to be the case over periods when there was no clear anchor for monetary policy because a high proportion of the variation in long-term interest rates was probably driven by variation in the inflation premium rather than variation in the real interest rate

The top panel provides a plot of the year-on-year headline inflation rate in the United Kingdom. For convenience we have also included a line to indicate the 2 ½ percent estimate for π^{**} as well as two additional lines that are plus and minus two percentage points away from the estimate of π^{**}. The second panel provides a plot of the unemployment rate as well as some estimates of the NAIRU.[17]

The third panel provides a plot of long-term interest rates as well as some measures of equilibrium long-term interest rates (lines at 3, 5, and 7 percent respectively) that would be associated with a credible inflation-targeting regime that had a long-term goal of 2½ percent inflation. These alternative measures are constructed under the assumption that a reasonable estimate of the equilibrium long-term real interest rate might be somewhere between 0.5 and 4.5 percent. The last panel provides a plot of a measure of policy credibility using equation (4) in Table 1 under the assumption that RL^{LOW} is equal to 5 percent and RL^{HIGH} is equal to the maximum value of the long-term interest rate series for the United Kingdom.[18]

According to these assumptions the following story emerges about the unemployment-inflation process in the United Kingdom.

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component. For this paper we assume that RL^{LOW} is 5 percent and for RL^{HIGH} we use the maximum value of RL in the OECD historical database for each country. The specific assumptions behind these choices are explained below as well as some sensitivity analysis that shows that the basic conclusions of this paper are not very sensitive to these specific choices. This paper does not claim to have found the perfect forecasting model for inflation and unemployment. But, it does show that using such measures of credibility can provide a much better statistical and economic interpretation of the unemployment-inflation process in many OECD countries than what can be provided by conventional constant-parameter reduced form models that impose a time-invariant link between past inflation and inflation expectations.

[17] These estimates for the NAIRU were constructed from the best model of inflation and unemployment that is reported in Section III. By "best" we mean the model that produces the smallest out-of-sample forecasting errors.

[18] The base-case econometric results reported in the next section assume that RL^{LOW} is 5 percent for each country and that and RL^{HIGH} is equal to the maximum value of the long-term interest rate series for each country. However, we also show that the results are not sensitive to these assumptions and that the model out-performs conventional fixed-parameter models under alternative plausible estimates for RL^{LOW} and RL^{HIGH}.

Figure 3. Response of Inflation to Unemployment Gaps
Under Time-Varying Degrees of Policy Credibility (c)

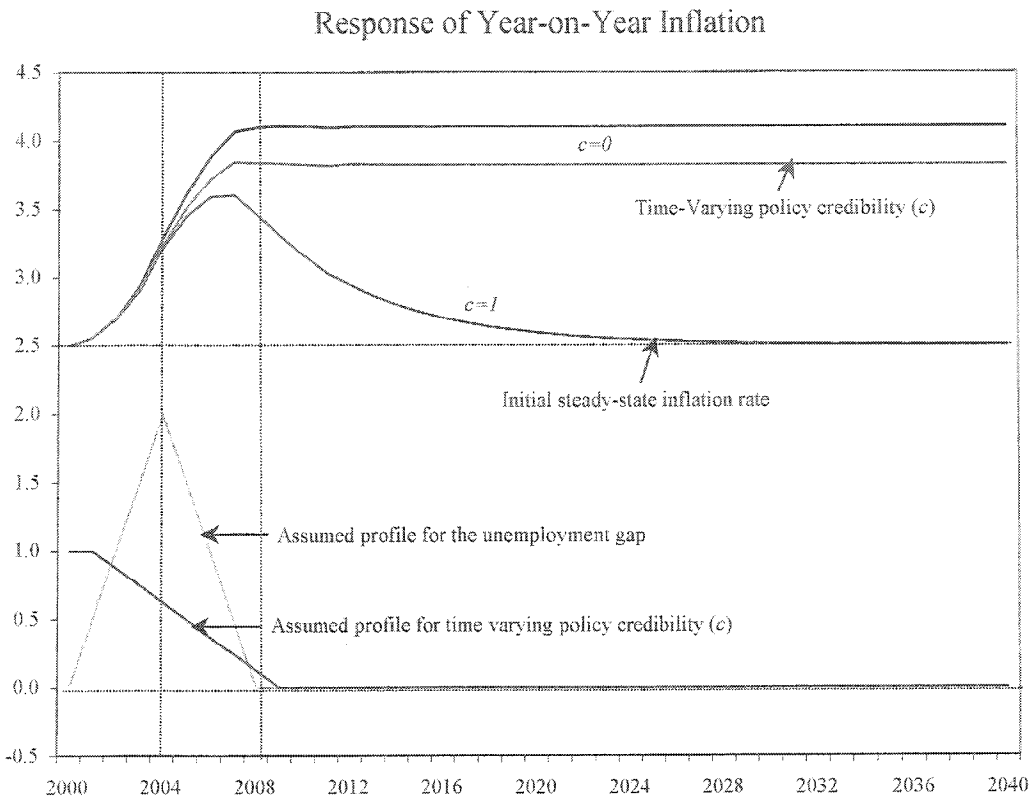
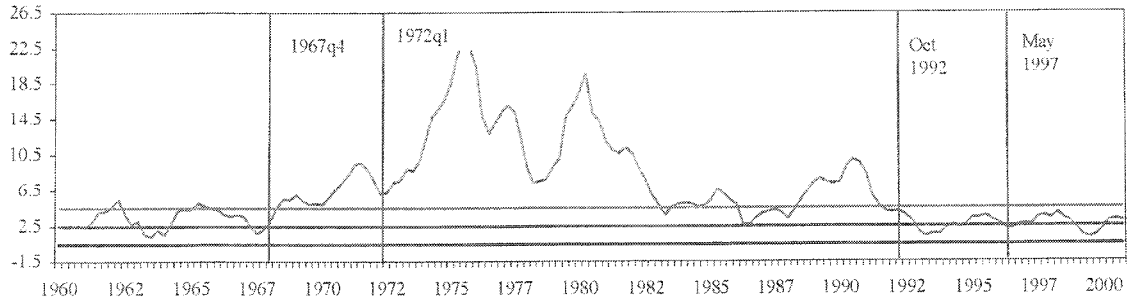
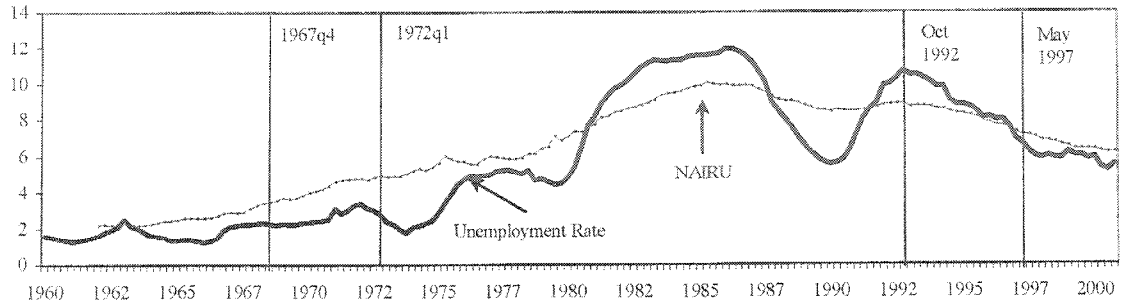


Figure 4. United Kingdom: Credibility Measures and Regime Classifications

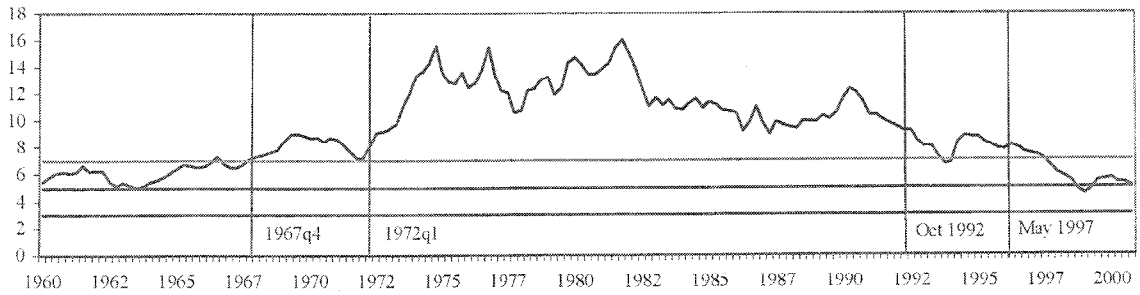
CPI Year-on-Year Inflation



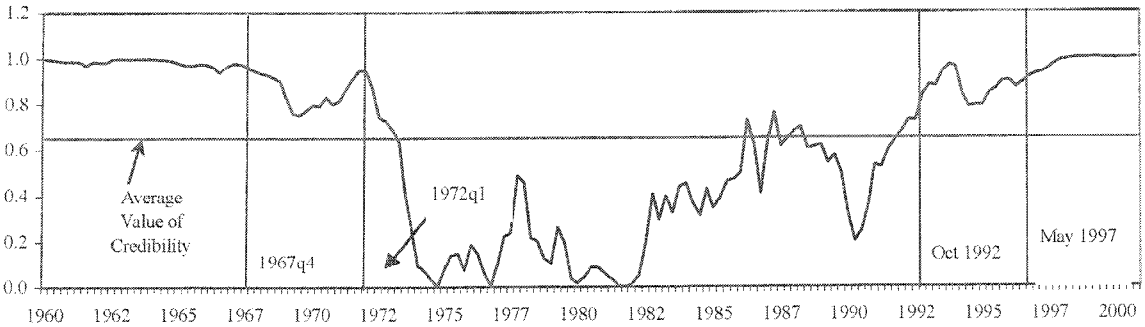
Unemployment Rate and NAIRU



Long-Term Interest Rates



Measure of Credibility: Probability of Low Inflation Regime



1960–67: Low unemployment, stable inflation, and high policy credibility

This is a period of high policy credibility. Inflation remains in a close proximity to π^{**} despite the fact that unemployment is low and systematically below a NAIRU which is trending upward over time. Long-term interest rates are gradually creeping upwards but may have been anchored by a fairly long series of low inflation outcomes.

1968–71: Rising inflation and lower policy credibility

Inflation rises significantly—more than 2 percentage points—above π^{**} and there are some signs that policy credibility is starting to be eroded. However, inflation starts to decline in 1971 and this is associated with a decline in long-term interest rates. While policy credibility is still fairly high in this period, it is significantly lower than in periods in the early 1960s when inflation was low and stable.

1972–91: Stagflation and low Levels of policy credibility

The decline in headline inflation in 1971 is short-lived and inflation soon becomes untethered in response to a persistently positive unemployment gap. Unemployment starts to trend upward but not sufficiently to contain inflationary forces until the early 1980s. In the early 1980s monetary policy is directed aggressively toward disinflation; this results in a dramatic increase in unemployment rates to double-digit levels. Inflation declines fairly rapidly over a few years, but it is a long and slow process to re-establish credibility in the bond market. Unemployment remains high on average and policy credibility improves but remains far from perfect.

October 1992–May 1997: Inflation targeting delivers low and stable inflation

The United Kingdom adopted a strategy of inflation targeting in October 1992, shortly after the summer exchange market crisis led to its withdrawal from the Exchange Rate Mechanism of the European Monetary System. However, between October 1992 and April 1997, the Bank of England does not have independence to determine monetary policy and decisions about interest rates are the responsibility the Chancellor. In addition, the target for inflation is expressed as a range rather than as a well-defined point target of 2.5 percent. As can be seen in Figure 4, while this policy regime is successful in producing low and stable inflation, policy credibility remains far from perfect and unemployment remains at high levels. There is also some anecdotal evidence that suggests that inflation expectations did not become centered, on average, at the mid-point of the inflation range but may have been biased toward the upper end of the range.[19]

[19] See Haldane (1999).

May, 1997—2001Q2: Full-fledged inflation targeting delivers stable inflation and high levels of policy credibility

In May 1997, the United Kingdom adopted a full-fledged inflation-targeting framework that featured instrument independence for the Bank of England as well as a well-defined point target of 2.5 percent for inflation. Inflation continues to stay low and stable, but in addition both unemployment and long-term interest rates fall towards levels not experienced since the early 1960s. Indeed, the increase in policy credibility shown in Figure 4 is consistent with the measure of long-term inflation expectations in Figure 1 that shows long-term inflation expectations becoming anchored to the 2.5 percent inflation target.[20]

E. How Reliable Are the Measures of Credibility Based on Long-Term Nominal Bond Yields Likely to Be?

The measure of policy credibility reported in the bottom panel of Figure 4 is based on an implicit assumption that most of the variation in long-term government bond yields between low, moderate, and high inflation regimes was probably a result of variation in inflation expectations rather than variation in the real interest rate. This certainly appears to be the case based on an examination of returns on indexed and conventional bonds. For example, based on data from the U.K. bond market that goes back to the early 1980s, it appears that inflation variability has been at least three times higher than variability in the real interest rate component when moving from moderate to low inflation regimes.[21]

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[20] It may be tempting to attribute all of the increase in policy credibility after May 1997 to the adoption of a full-fledged inflation targeting regime that featured central bank independence and well-defined objectives. An alternative view to explain such a sudden increase (by historical standards) in policy credibility is that it represented the final stages of a broader reform agenda that may have made the task of monetary policy easier to conduct. Indeed, the current full-fledged targeting regime had the benefit of inheriting a fairly significant track record of achieving low inflation from the earlier regime as well as other reforms—fiscal and labor market policies for example—that may have reduced potential conflicts between monetary policy and other real objectives such as unemployment and government debt.

[21] The variability in long-term real interest rates in the industrial countries was probably seriously overestimated in studies that have relied upon proxies that involve subtracting ad hoc backward-looking proxies for inflation expectations from long-term nominal yields. Measures of ex ante real interest rates derived from indexed bond markets suggest that variability in real interest rates are considerably smaller than measures that have been derived from simple backward-looking proxies for inflation expectations—see Bleaney and Laxton (2002). In addition, these market-based measures of inflation expectations are much more consistent with the expectations-theory of the term structure and uncovered-interest parity—see Campbell (1995) and Bleaney and Laxton (2002).

The first column of Table 2 reports measures of variability (standard deviations) for UK 10-year bond yields since the early 1980s and then separates this variation into a component that is based on inflation expectations and the real interest rate. As can be seen in the Table, variability in inflation expectations over this whole period accounts for most of the variation in nominal bond yields and this principally reflects a fall in the average level of the inflation premium across the three regimes that were described earlier—see the bottom panel of Table 2 for estimates of the mean values of these variables and how their average values changed across these regimes. It can also be seen in the table that variability in nominal bond yields before the two inflation-targeting regimes was accounted for principally by variation in inflation expectations and that variability in inflation expectations has declined considerably in these two inflation-targeting regimes.

The estimates reported in Table 2 are based on a different measure of inflation expectations (expected inflation over the next 10 years) than Figure 1, which plots the market's forecast of inflation 10 years ahead but they tell a very similar story about the credibility of the new full-fledged inflation targeting regime. As can be seen in the table, there was a 226 basis point reduction in the inflation premium on 10-year government bonds during the first IT regime and a further 154 basis point reduction in the inflation premium after the adoption of the full-fledged inflation targeting regime in May 1997.

Table 2. Sources of Variability in 10-Year Government Bond Yields: Some Evidence from Data Derived from Conventional and Indexed Bonds in the United Kingdom

Standard Deviation of:	Total Sample	Pre-Inflation Targeting	Initial Inflation Targeting Regime	Full-Fledged Inflation Targeting Regime
	82:03–99:10	82:03–92:09	92:10–97:04	97:5–99:10
Nominal Yields	2.01	1.15	0.60	0.84
Inflation Expectations	1.82	1.38	0.38	0.37
Real Interest Rate Component	0.57	0.49	0.30	0.58

Mean of:	Total Sample	Pre-Inflation Targeting	Initial Inflation Targeting Regime	Full-Fledged Inflation Targeting Regime
	82:03–99:10	82:03–92:09	92:10–97:04 (Change from 82:03–92:09)	97:5–99:10 (Change from 92:10–97:04)
Nominal Yields	9.02	10.33	7.89 (-244 basis points)	5.55 (-234 basis points)
Inflation Expectations	5.55	6.67	4.41 (-226 basis points)	2.87 (-154 basis points)
Real Interest Rate Component	3.47	3.66	3.48 (-18 basis points)	2.69 (-79 basis points)

A key principle of inflation-targeting regimes is to commit to adjusting the policy rate sufficiently aggressively in response to new information that real market-determined rates will become positively correlated with inflation expectations. As can be seen in this Table, there has been a strong positive correlation since May 1997 between real interest rates and expected inflation at horizons of two, five and ten years. This positive correlation structure also existed in the earlier IT regime, but real interest rates at horizons as short as 2 years were significantly less highly correlated with inflation expectations than they have been since May 1997. Thus, while under the first IT regime bond market participants believed that the real 90-day policy rate would eventually be increased in response to indications of higher inflation they now believe that the

adjustment in the real policy rate will occur much faster under the new IT regime. The increase in the positive correlation of 2-year real interest rates and 2-year inflation expectations in the recent IT regime reflects a much more activist monetary policy that has been designed to convince market participants that the MPC is committed to achieving the 2.5 percent inflation target.[22]

Table 3. Correlation Between Real Interest Rates and Inflation Expectations Derived from U.K. Conventional and Indexed Bonds at Different Maturities

	Total Sample	Pre-Inflation Targeting	Initial Inflation Targeting Regime	Full-Fledged Inflation Targeting Regime
	82:03–99:10	82:03–92:09	92:10–97:04	97:5–99:10
10 year	0.20	-0.62	0.53	0.51
5 year	0.27	-0.35	0.54	0.46
2 year	-0.01	-0.35	0.07	0.42

[22] It is interesting that in the period before the two inflation-targeting regimes that real interest rates at all horizons were negatively correlated with inflation expectations. The correlation structure after October 1992 reflects the shift from a monetary policy regime that emphasized exchange rate stability to a regime in which high real interest rates were used to reduce inflation and inflation expectations.

F. Unemployment Dynamics and Model-Consistent Measures of the NAIRU

Equation (5), (6) and (7) in Table 1 complete the model of the unemployment-inflation process by providing a stochastic model of unemployment dynamics. Equation (5) is a simple unemployment gap equation that depends on an inertial first-order unemployment gap term, a stochastic error term and a mechanism for inflation gaps to feed back onto unemployment gaps. This last term allows for the possibility that there might be mechanisms at work through monetary policies that will result in a tendency for inflation to adjust towards π^{**} even if credibility is zero. For example, this term in principle would pick up the disinflation policies of the early 1980s in the United Kingdom and other countries.[23]

Equation (6) provides a simple stochastic process for the NAIRU that has been found to work well in earlier research that has attempted to extend the conventional approach of estimating the Phillips curve (the case of c = 0) by constructing model-consistent measures of the NAIRUs.[24] This approach involves using Kalman-filtering algorithms to construct model-consistent measures of the NAIRU under a specific assumption of a critical hyper-parameter (Equation 7) that determines the variability in the unemployment gap relative to changes in the underlying NAIRU. Boone and others (2001) suggest that a reasonable assumption for this parameter is 7.5, but we also consider alternatives that fall within a plausible range for this parameter.[25]

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[23] For countries with flexible exchange rates we should think of ρ as measuring the aggressiveness of the feedback coefficients in an interest rate rule that was designed to control inflation by changing the state of demand conditions. Under fixed exchange rates, or monetary union, inflationary conditions would be tempered by an appreciation in the real exchange rate, which can only occur if inflation in a particular country is higher than average. It would be preferable in principle if ρ was time-varying to allow for the possibility that this feedback parameter could be lower during periods such as the 1970s and then higher during disinflation episodes like the early 1980s. The assumption of time-invariance may be a practical constraint given the size of the system and the limited data sets. However, this would be a very interesting extension that should be explored in the future.

[24] For examples see Gordon (1997,1998) and Boone and others (2001).

[25] The parameter $\Psi_{ugap,\,\Delta\bar{u}}$ determines the degree of variability in the NAIRU relative to variability in the unemployment gaps. Higher values for this parameter would result in smoother paths for the NAIRU while smaller values would allow more variability in the underlying NAIRU estimates. See Gordon (1997,1998) and Boone and others (2002) for a description of this methodology for estimating the NAIRU. It is not possible to reliably estimate this hyper-parameter with the types of small data sets studied here. See Boone and others (2002) and Stock and Watson (1996) for a discussion of the pitfalls with maximum-likelihood estimators for these types of models in the presence of small data samples.

III. Empirical Results

Table 4 presents a summary of our empirical results reported as averages of the estimates over the seventeen countries in our sample. The first 6 columns of Table 4 report measures of out-of-sample forecasting accuracy and in-sample measures of goodness of fit. The next five columns in Table 4 report average estimates of parameter values for each model. The last two columns report standard-deviation statistics that summarize the degree of variability in the NAIRU and the unemployment gaps.

The first row of Table 4 reports results for what we define as the conventional approach to estimating Phillips curves and unemployment gap models. This approach ignores issues related to time-varying policy credibility and involves pre-filtering unemployment data with a univariate filter such as the Hodrick-Prescott (1997) filter and then estimating equations (1), (3) and (5) in Table 1 with OLS under an assumption that $c = 0$. We refer to this approach as conventional because it imposes a fixed and time-invariant causal link from past inflation to inflation expectations and it uses a pre-filtering procedure to measure the unemployment gaps.[26] The second row in Table 4 presents results for the more general model that allows for time-varying measures of policy credibility as well as model-consistent measures of the NAIRU.[27] The third and fourth rows of Table 4 are included so that it is easy to see which particular assumption—time-varying policy credibility or model-consistent NAIRUs—is responsible for the superior forecasting performance of the general model. The last row of Table 4 provides some estimates of out-of-sample forecasting accuracy from a benchmark model that is based on an assumption that both inflation and unemployment follow a random walk.

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[26] Univariate filters such as the HP filter continue to be used extensively in policymaking institutions to create measures of the NAIRU and potential output. For the results reported in Table 4, the HP smoothing parameter has been set to 1600 but we also report below on alternative assumptions for this parameter that result in both greater and less variability in the estimated NAIRU estimates.

[27] The estimation approach that develops model-consistent measures of the unemployment gap is an extension of a kalman-filtering methodology suggested by Kuttner (1994) for measuring potential output in the United States. This paper goes beyond Kuttner (1994) and more recent extensions of his approach by studying the out-of-sample forecasting properties of alternative models on a fairly large set of industrial countries.

Table 4. Base-Case Average Model Results for the Four Models

	Diagnostic Statistics[1]						Parameter Estimates					Measures of Variability	
	$RMSE_{\pi 4,4}$	$RMSE_{\pi 4,12}$	$RMSE_{u,4}$	$RMSE_{u,12}$	R^2_{π}	R^2_{ugap}	λ	ρ	ϕ	β	Ω	$\hat{\sigma}_{\Delta \bar{u}}$	$\hat{\sigma}_{gap}$
#1 Conventional Approach: - No Credibility - HP NAIRU Estimates	1.23	1.92	1.30	3.52	0.62	0.82		0.01	0.91	0.58	1.55	0.12	0.60
#2 General Model: - Time-Varying Credibility - Model-Consistent NAIRUs	0.98	1.05	0.87	1.79	0.67	0.97	0.40	0.00	0.90	0.54	1.18	0.08	1.65
#3 Conventional Approach: + Plus Time-Varying Policy Credibility	0.97	1.13	1.30	3.51	0.62	0.82	0.40	0.01	0.91	0.70	1.34	0.12	0.60
#4 Conventional Approach: + Model-Consistent NAIRUs	1.09	1.51	0.89	1.60	0.67	0.96		0.02	0.89	0.14	1.62	0.07	1.58
#5 Benchmark Random Walk Forecasts:	1.57	1.85	0.84	1.93									

[1] Areas that are shaded indicate that the RMSE estimates are larger than the RMSE estimates for the random walk forecasts.

Post-sample forecast errors and in-sample fits: Conventional versus general approach

The first four columns of Table 4 report average root-mean-square-error (RMSE) statistics for both unemployment and year-on-year inflation derived from out-of sample 4-quarter-ahead and 12-quarter-ahead forecasts.[28] The RMSE estimates in Table 4 are obtained from averaging the RMSE statistics across countries.[29] Table 4 shows clearly that the general model produces a dramatic improvement in forecast accuracy at both the 4-quarter and 12-quarter horizons for both inflation and unemployment. This result may not be surprising given that the general model also is capable of explaining a larger proportion of the historical variability in both unemployment and inflation. As can be seen in Table 4, a comparison of the first two rows in Table 4 shows that the R^2 for the inflation equation rises from 0.62 to 0.67 and the R^2 for the unemployment gap equation rises from 0.82 to 0.97.[30]

These results should not be surprising given that Boone and others (2002) have reported results for a slightly larger group of industrial countries that show the conventional model performs worse than an even a pure random-walk model of inflation and unemployment. For the sample of countries considered here, Table 4 confirms this result by showing that the random-walk model generally out-performs the conventional model. By contrast, it can be seen in Table 4 that the general model significantly outperforms both the conventional and random-walk models.

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[28] The RMSE statistics are based on comparing out-of-sample forecasts with observed quarterly outcomes using data from the last 8 years of each country's historical data set. More precisely, each one of the RMSE statistics is based on 20 rolling dynamic k-step-ahead forecasts for both inflation and unemployment, where k varies between 1 and 12. No allowance is made for historical data revisions but this updating process is essentially equivalent to what would be obtained from real-time k-quarter-ahead forecasting because for most of the countries in the sample there have not been any major historical revisions to either unemployment or the CPI over the last decade. In addition, it is important to note that for all the countries in the sample that the peak in long-term interest rates, which determines RL^{HIGH}, occurs well before the start of the sample that is being used to study out-of-sample forecasting performance. The forecasts have been constructed by assuming that credibility over the forecast horizon remains constant at the last value that is estimated from each estimation exercise.

[29] The RMSE statistics assume that credibility over the forecast horizon remains constant at the last value that is estimated based on each data set that is assumed to be available when the forecasts are made.

[30] For comparison purposes these measures of fit from the two models are derived from OLS regressions that take the measures of the NAIRUs as given from the two approaches.

Out-of-sample forecasting performance: Individual country results

Figures 5a and 5b report country-RMSE estimates for the conventional model and Figures 6a and 6b report estimates for the general model. These figures are based on *k*-quarter-ahead forecasts, where *k* varies between 1 and 12. In addition, the figures also compare the estimates for each country to the overall average RMSE statistics to see which forecasts have been better and worse than the average over all of these countries. The panels that report the estimates for each country have also been ordered from best to worst based on the RMSE statistic at the 12^{th} quarter horizon.

To make the visual comparisons of the country results easier across the two models, Figure 7a and 7b report the values of the RMSE statistics derived from the conventional model as a proportion of their values from the general model. In these Figures, values of the RMSE ratios above one indicate that the conventional model has been performing worse than the general model while values below one indicate that the general model has been performing worse. These Figures show clearly that the general model not only has been outperforming the conventional model on average, but there are only a few cases where the conventional has outperformed the general model.

Figure 5a. Root-Mean-Square-Errors for Inflation from the Conventional Model
(bold line = average of all countries)

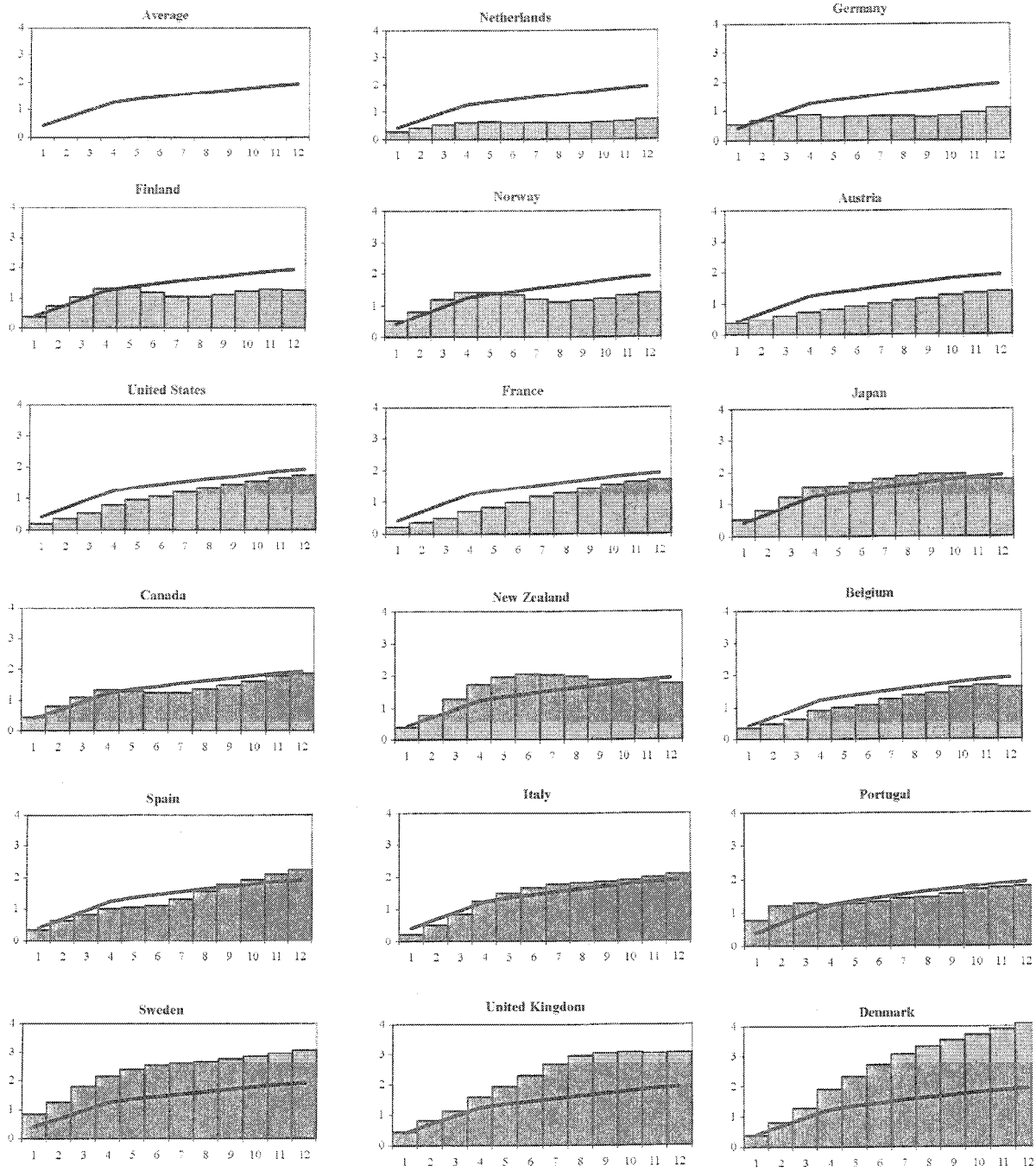


Figure 5b. Root-Mean-Square-Errors for Unemployment from the Conventional Model
(bold line = average of all countries)

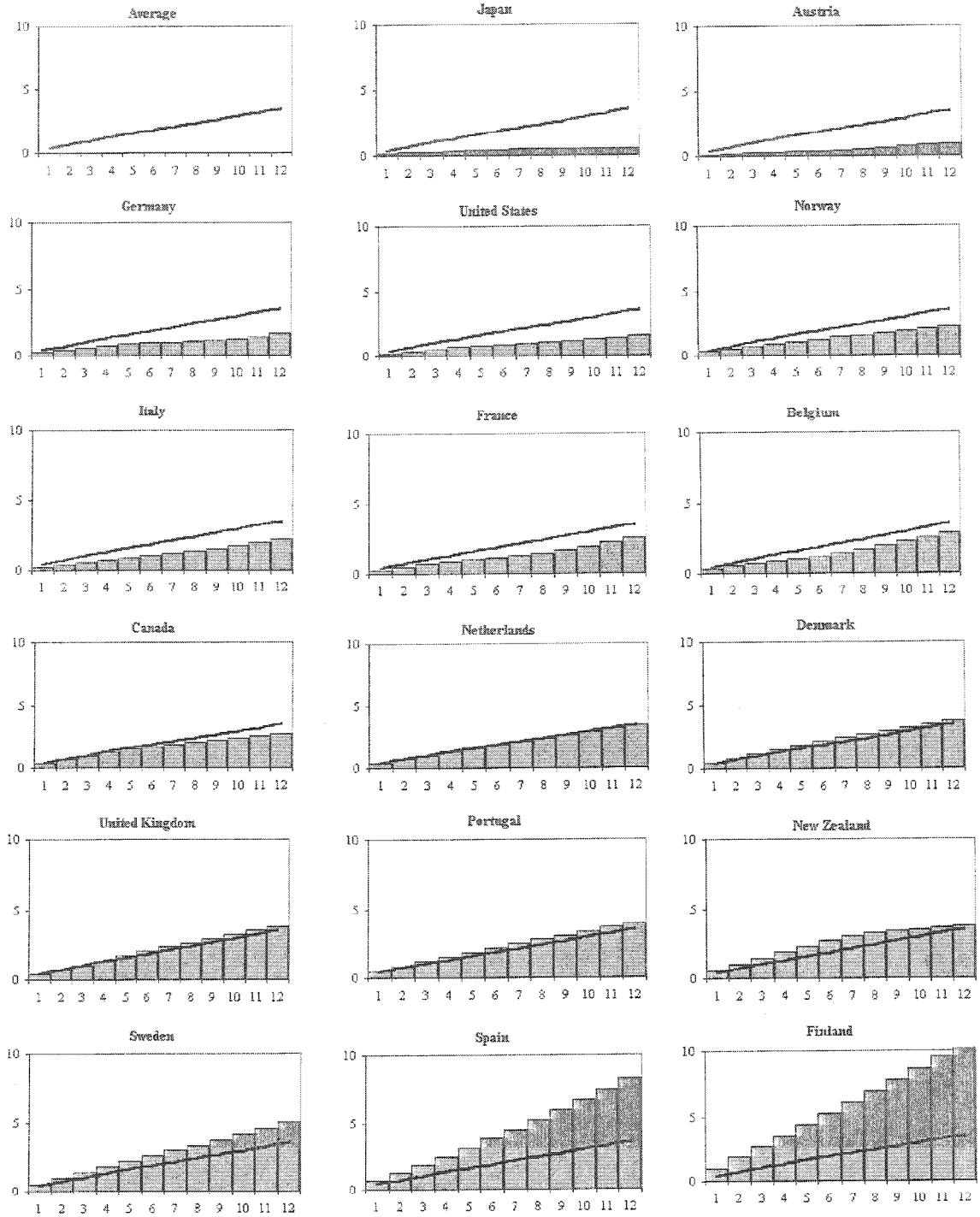


Figure 6a. Root-Mean-Square-Errors for Inflation from the General Model
(bold line = average of all countries)

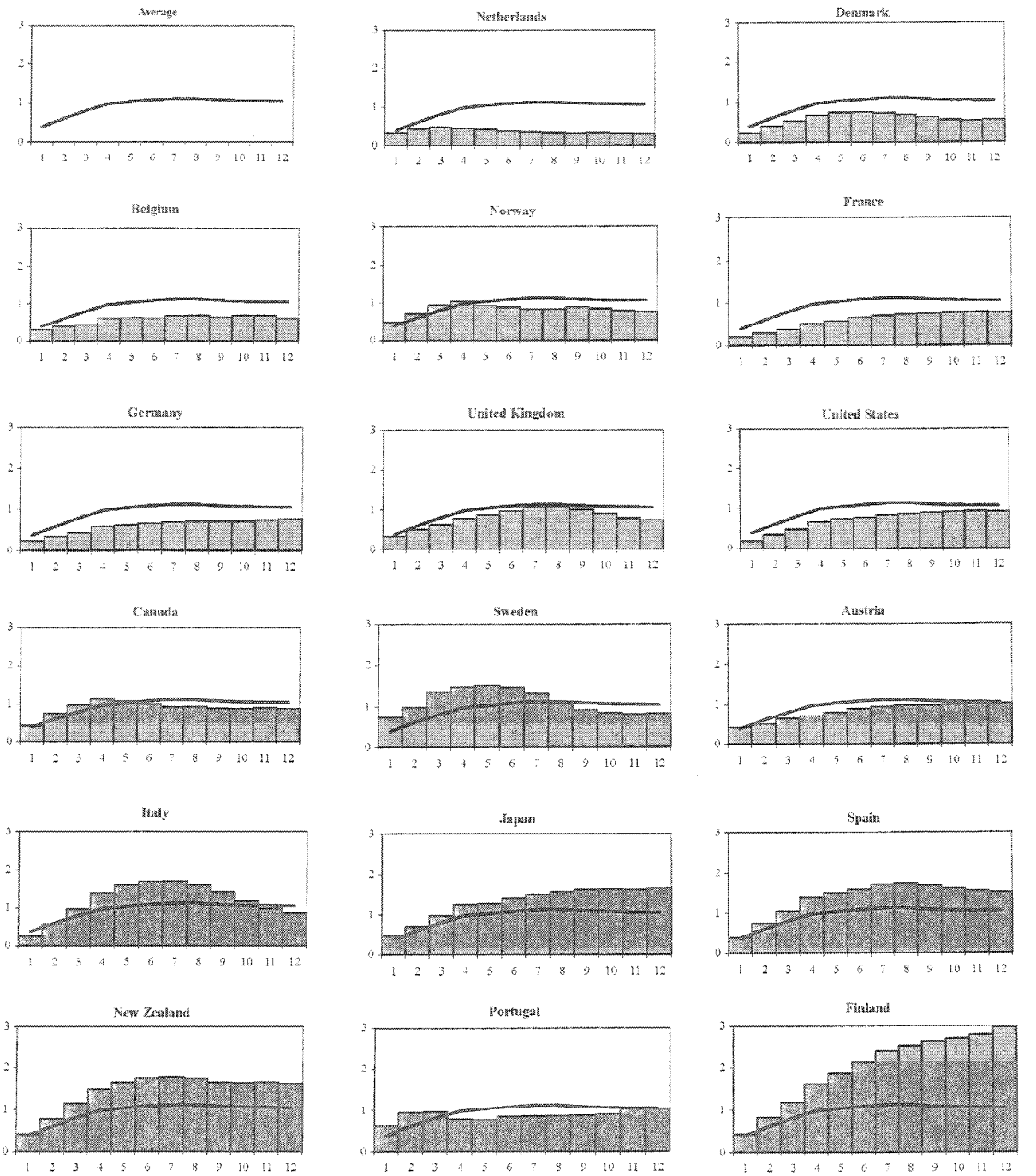


Figure 6b. Root-Mean-Square-Errors for Unemployment from the General Model
(bold line = average of all countries)

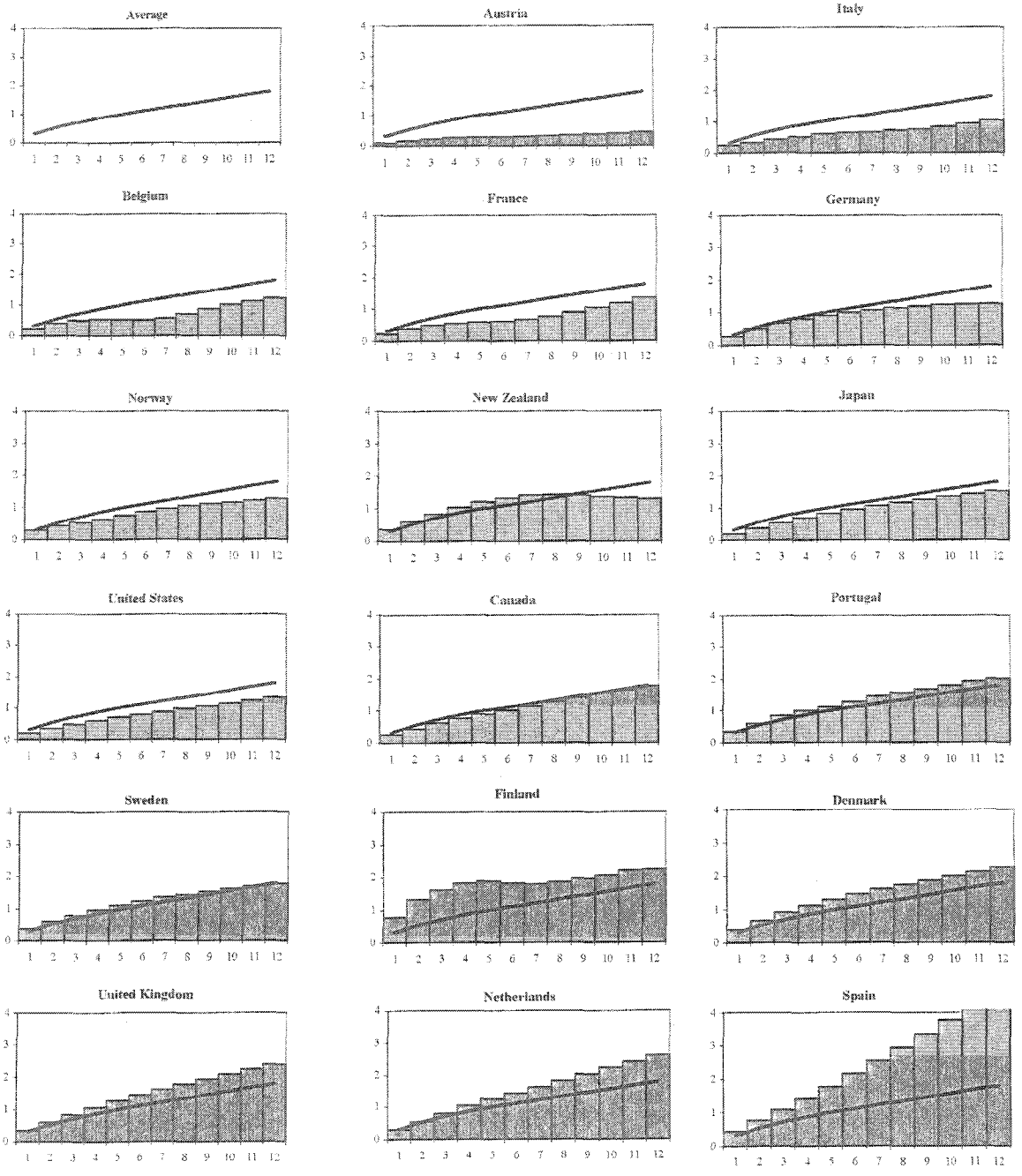


Figure 7a. Ratio of Root-Mean-Square-Errors for Inflation
(Errors from Conventional Approach Divided by Errors from General Model)

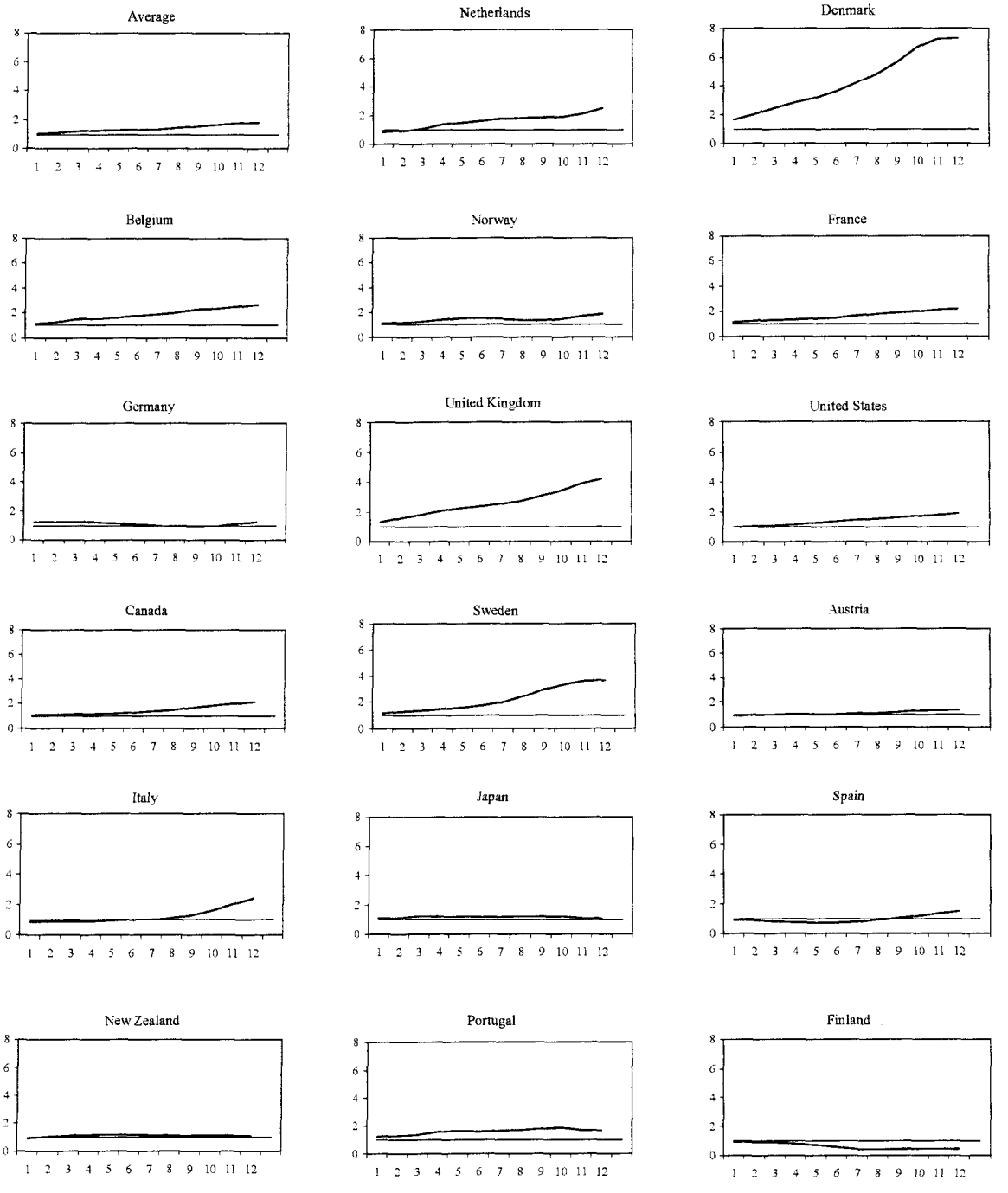
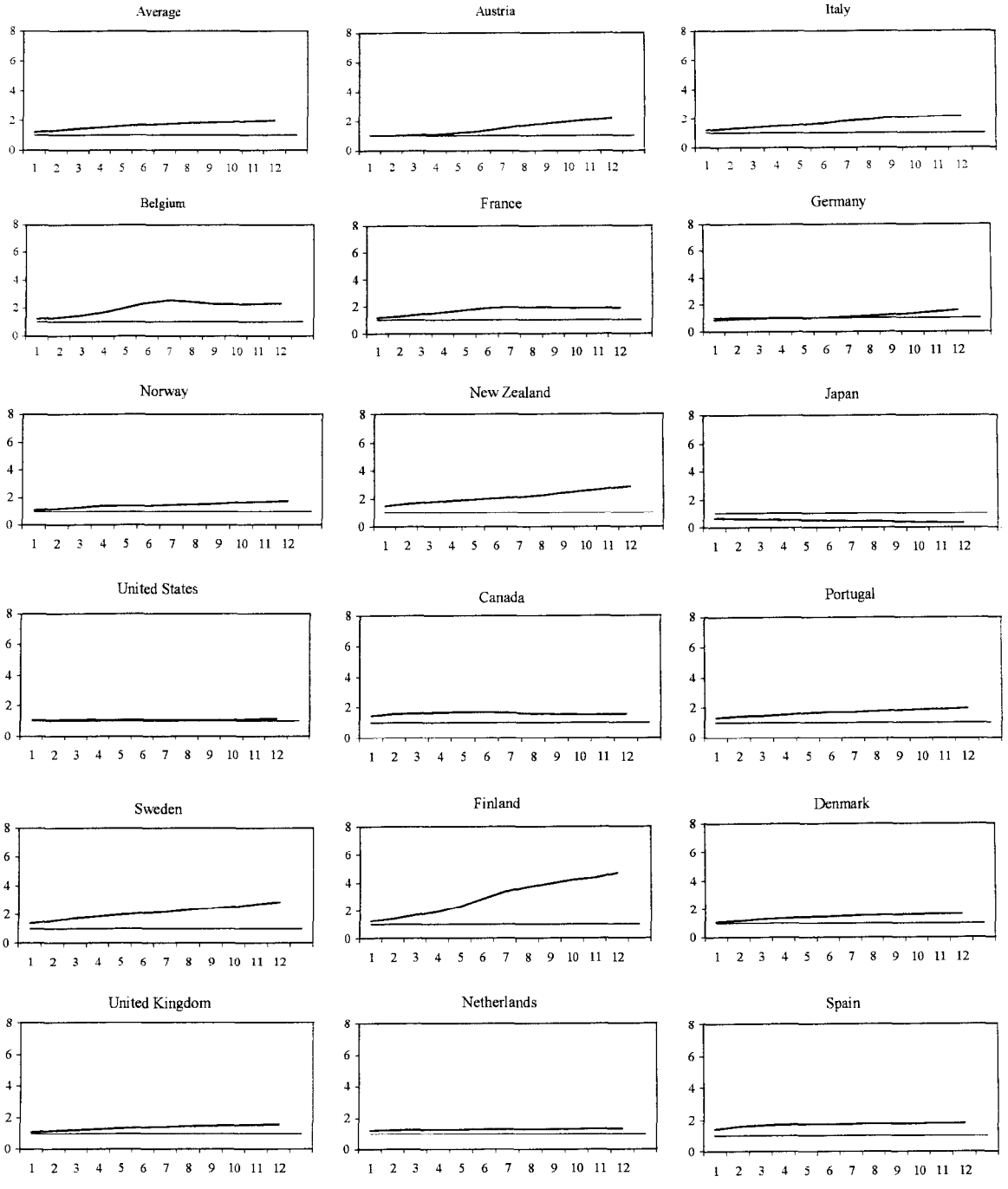


Figure 7b. Ratio of Root-Mean-Square-Errors for Unemployment
(Errors from Conventional Approach Divided by Errors from General Model)



Inflation-forecast confidence intervals: Recent estimates versus theory

The top left panel in Figure 6a plots the average RMSE statistics for inflation at forecast horizons that vary between 1 and 12 quarters. These average values of the RMSE statistics suggest that uncertainty in inflation forecasts rises initially as the forecast horizon increases but after about 4 quarters into the future the confidence intervals start to stabilize at a value just above 1 percentage point.[31] This basic pattern is consistent with a view about the role of monetary policy that suggests that monetary policy is perfectly capable of bounding uncertainty in inflation forecasts at some horizon. The fact that these estimates of the confidence intervals rise over the first year of a forecast is also consistent with conventional views about the monetary transmission mechanism, which suggest that because of lags in the monetary transmission mechanism and inertia in the inflation process, it is impossible (and not optimal) over the very near term for monetary policy to completely offset the effects of inflationary shocks.

What accounts for the superior forecasting accuracy?: The role of time-varying policy credibility

The third row of Table 4 reports results for the case where the NAIRU estimates continue to be derived from the HP filter but in this case c is not imposed to be equal to zero. In this case the RMSE statistics for inflation are almost identical to those obtained from the general model suggesting that it is this assumption that is accounting for its superior forecasting performance. As shown earlier the important difference between this model and the conventional model, which imposes c=0, is that it predicts that persistent unemployment gaps will have less cumulative inflationary consequences once the monetary authorities have developed a track record in controlling inflation. This variant produces exactly the same parameters and diagnostic statistics for unemployment as was the case with the conventional model (Row 1) because exactly the same gaps are being used.

What accounts for the superior forecasting accuracy?: The role of model-consistent NAIRU estimates

The fourth row in Table 4 reports the results where c is imposed to be zero but where the kalman-filtering procedure is used to construct model-consistent measures of the NAIRU. This model produces almost exactly the same measures of goodness of fit as the general model for both inflation and unemployment. However, it produces significantly larger out-of-sample forecast errors for inflation at longer forecast horizons which reinforces the conclusion that the assumption of time-varying policy credibility is the principal modeling assumption that is accounting for the superior inflation forecasting performance in the general model. This model also produces better forecasting performance for unemployment suggesting that this approach to

[31] This pattern for inflation confidence intervals is very similar to what has been derived with stochastic simulation techniques from the types of structural macro models used in central banks to forecast inflation. See Isard and Laxton (2000).

measuring the NAIRU should be expected to produce more efficient forecasting properties than approaches that involve pre-filtering the data with a univariate filter like the Hodrick-Prescott filter.

Comparison of parameter values and sacrifice ratios

The estimated average values of the parameters from the unemployment gap equations are much more similar across models than the parameters obtained from the alternative specifications for the inflation equations. Note that the degree of unemployment persistence [ϕ] only varies between 0.89 and 0.91 and the inflation-feedback parameter [ρ] varies from a number close to zero to 0.02. By contrast, in the inflation equations the average estimated coefficient on the unemployment gap [β] varies between 0.14 and 0.70 and the average estimated coefficient on the change in the unemployment gap [Ω] varies between 1.18 and 1.62.

The most interesting changes in parameter values occur between the models reported in rows 2 and 4 in Table 4. These are the cases that are based on model-consistent measures of the NAIRU, but in model 2 policy credibility is assumed to be time varying while in model 4 policy credibility [c] is imposed to be equal to zero. Note, that for the case where c = 0 the estimated coefficient on the unemployment gap declines from 0.54 to 0.14 and the estimated coefficient on the change in the unemployment gap rises from 1.18 to 1.62. The reduction in the estimated coefficient on the unemployment gap and increase in the coefficient on the change in the unemployment gap observed when c is imposed to zero reinforces the conclusion that credibility effects may have reduced the sensitivity of inflation to persistent unemployment gaps. Note that when c is imposed to be zero in the conventional model the coefficients on the unemployment gaps in the Phillips curve [β, Ω] will be forced to represent the average responses of inflation to unemployment gaps over the sample. In this case the coefficient on the level of the unemployment gap [β] will be biased downward if it includes periods where c is nonzero.[32]

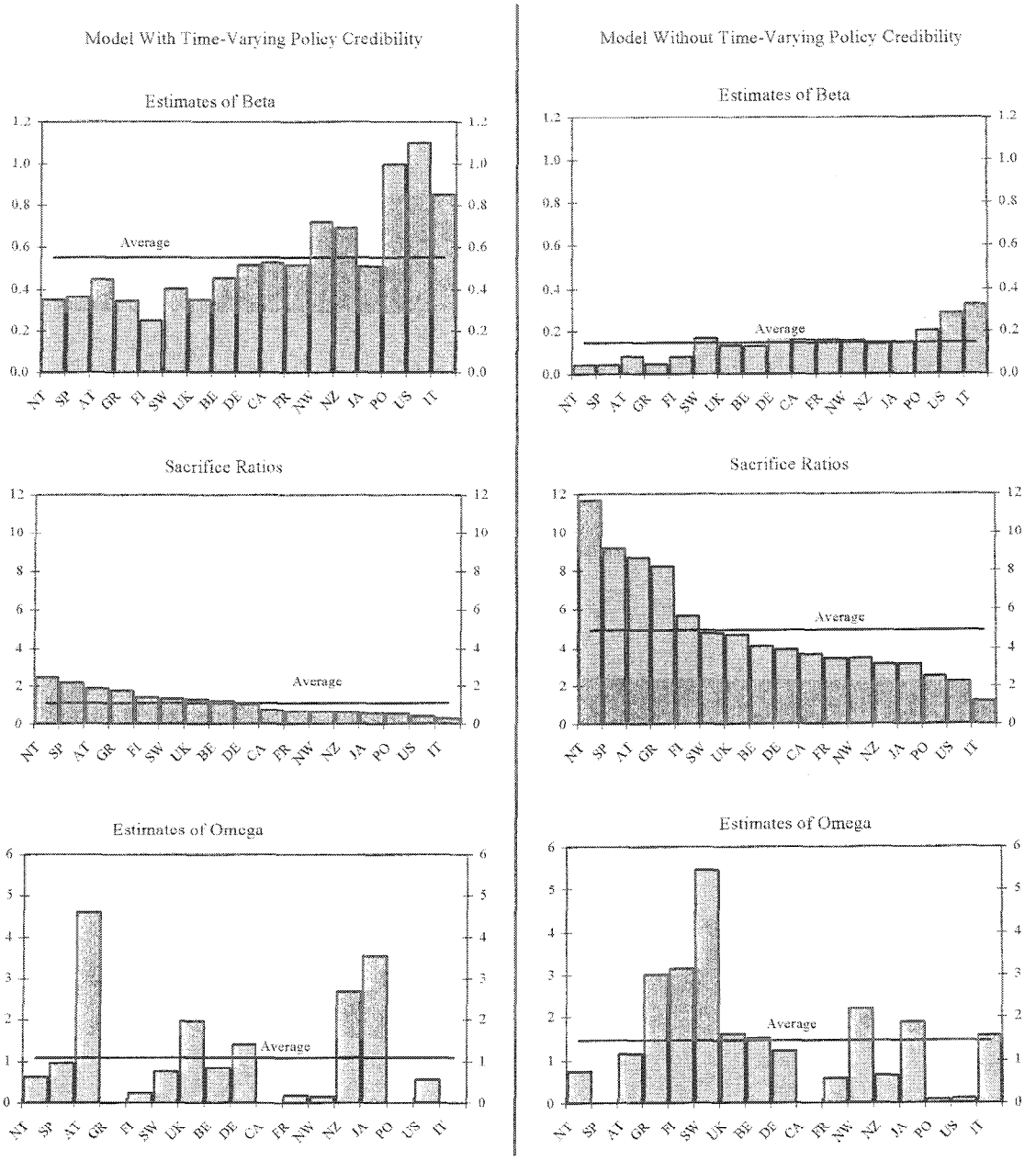
Figure 8 provides a comparison of country-specific and average estimates for β and Ω for both the conventional model and general model. In addition, Figure 8 also includes estimates of sacrifice ratios under the assumption that policy credibility is zero.[33] As can be seen

[32] If c is nonzero imposing c to be equal to zero will also bias the coefficients on the change in the unemployment gap [Ω] upwards. These directions of bias in both [β, Ω] have been confirmed using Monte Carlo simulations and can be obtained by contacting the authors.

[33] The sacrifice ratio is commonly defined to be the cumulative annual unemployment (or output) gap that is required to permanently lower inflation by one percentage point. Obviously, in the general model the sacrifice ratio will depend on the degree of policy credibility. Since c is assumed to be zero in the calculations reported in Figure 8 the estimates in the left panels might be considered as upper bounds for the sacrifice ratio in the general model.

in the right panels of Figure 8 the low parameter estimates on the level of the unemployment gap in the conventional model results in enormous and implausible estimates of the sacrifice ratio which average around 5 over this sample of countries. This in our view reflects downward bias in the estimates β when the model is estimated over a sample when c can be quite reasonably expected to be nonzero over some subsample of the estimation period. Note that in the case of the general model the implied estimates of β are significantly larger and this results in much more plausible estimates of the cost of disinflation in these countries.

Figure 8. Beta and Omega Estimates, and Sacrifice Ratios



IV. Sensitivity Analysis

The models estimated in this paper have relied upon a number of simplifying assumptions to make it tractable to evaluate the out-of-sample forecasting performance of the conventional model and the general model on a large set of countries in a manner that is as transparent as possible.[34] A natural common concern is that the models are too simple because they ignore the effects of import prices and oil prices in the inflation equations and make extremely specific assumptions about policy credibility and certain parameters that determine the underlying degree of variability in the NAIRU estimates. This section reports on some sensitivity analysis that was conducted to see if these simplifying assumptions matter or not.

Does adding oil prices and import prices change the conclusions?

No. While adding oil prices and import prices to the model helped improve the historical fits of many of the equations it does not alter the basic conclusion. The predictions of the general model are still substantially better than the out-of-sample forecasts of the conventional model that imposes a time-invariant link between past inflation and inflation expectations. In addition, while conditional forecasts and historical fits can be improved with models that include import prices they do not necessarily improve unconditional forecasts because of the difficulties associated with forecasting future movements in exchange rates.

How do the results change when alternative proxies for policy credibility are used?

As mentioned earlier the proxies that are used to measure policy credibility are based on an implicit assumption that most of the variation in long-term real interest rates between high and low regimes is a result of variation in inflation expectations rather than variation in the long-term real interest rates. This appears to be confirmed from data derived from indexed bonds at least over sample periods where the data exist. A number of tests were performed to see if the results were sensitive to some of the specific assumptions that were made to construct the proxies for policy credibility.

First, to allow for the possibility that the equilibrium real interest rate might be lower or higher than the implicit estimate that was embodied in imposing RL^{LOW} equal to 5 the model was re-estimated under the assumption that RL^{LOW} might be one percentage point higher or lower. The results, which are available from the authors, did not result in any significant change in average out-of-sample forecasting performance for these industrial countries. Second, in response to a suggestion we also considered an alternative specification for RL^{HIGH} that was based on the previous maximum value for RL rather than the sample average. While this altered the historical measures of policy credibility for some countries it did not results in any significant changes in out-of-sample forecasting performance. Thirdly, we also experimented with more sophisticated unobserved-components models where we attempted to derive

[34] As mentioned earlier the GAUSS code and data that were used to generate the results in this paper are available from the authors. See page 1 for their e-mail addresses.

measures of policy credibility under an assumption that the equilibrium real interest rate may be subjected to permanent shifts. Again, while in some cases this resulted in a different interpretation of the unemployment-inflation process in these countries it did not result in a significant change on average in the out-of-sample forecasting performance of the general model.

How do the results change when alternative values of the critical hyper-parameter are used?

Following Boone and others (2002) all of the variants of the general models discussed earlier were re-estimated using the extreme lower bound and upper bound priors that they suggest for the critical hyperparameter ($\Psi_{ugap,\Delta\bar{u}}$) that determines the degree of underlying variability in the NAIRU. When $\Psi_{ugap,\Delta\bar{u}}$ is raised from 7.5 to 10 the average standard deviation of the first difference of the NAIRU estimates declines from .08 to .06. On average, this results in slightly better forecasts for unemployment and slightly worse out-of-sample forecasts for inflation. By contrast when $\Psi_{ugap,\Delta\bar{u}}$ is lowered from 7.5 to 5.0 the average standard deviation of the first difference of the NAIRU estimates rises from .08 to .14 and on average, this results in slightly better forecasts for inflation and slightly worse out-of-sample forecasts for unemployment.

Is the poor out-of-sample forecasting performance of the conventional model a result of choosing poor values for the Hodrick-Prescott parameter that determines the degree of variability in the NAIRU estimates?

No. The poor out-of-sample forecasting performance of the conventional model is not a result of a poor choice for the HP smoothing parameter. The average out-of-sample forecasts of the conventional model are worse than the general model for any value of the HP smoothing parameter. While there may be other reasons that can rationalize why HP filter is still used so extensively in policymaking institutions to measure potential output and the NAIRU a concern over out-of-sample forecasting accuracy is not one of them.

Is the superior forecasting performance of the general model a result of inflation expectations being partially anchored to the target ($\lambda = .4$) or the result of adding additional lags to the inflation process?

To establish if the forecasting performance of the general model was attributable to the assumption that inflation expectations have become partially anchored to the long-run target, the general model with time-varying policy credibility was re-estimated with the restriction that $\lambda = 0$. This restriction resulted in a significant deterioration in the out-of-sample forecasting performance for inflation and suggests that the superior forecasting performance of the general model is a result of expectations becoming partially anchored to the target.

V. Conclusions

This paper does not claim to have found the perfect forecasting model for inflation and unemployment. But, it does show that even using crude measures of credibility derived from long-term bond yields can provide a much better statistical model of the unemployment-inflation process in many industrial countries than can be provided by conventional constant-parameter reduced form models that impose a stable link between past inflation and inflation expectations. The paper also illuminates the problem with fitting historical Phillips curves and shows the benefits of subjecting models to real-time out-of-sample forecasting. Finally, the paper shows that the short-run unemployment inflation trade-off has probably improved in the 1990s in many countries because monetary policy has been more successful in providing an anchor for inflation expectations.[36]

There are a number of interesting extensions that are worthwhile pursuing. First, it would be useful to expand the system to include measures of exchange rates and short-term interest rates. This would help elaborate the story and may further improve the out-of-sample forecasts. Second, it would be useful to allow for some time-variation in the process that has governed monetary policy. Third, the development of indexed bond markets in the United Kingdom, and other countries will make it possible to develop more refined measures of policy credibility and it may be possible to exploit this information for forecasting even though the samples are not long enough for estimation purposes. For countries where these data do not exist it may be possible to construct more reliable historical measures of policy credibility by allowing for some time variation in the equilibrium long-term real interest rate. Finally, it would be useful to extend the model of inflation to allow for other nonlinearities in the unemployment-inflation process that are related to more rigid capacity constraints.[37]

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[36] Using a similar modeling approach, Debelle and Wilkinson (2002) have recently reached the same conclusion for Australia.

[37] For example, despite its implications for monetary policy the idea of convexity in the Phillips curve has been completely ignored in this paper. For a discussion of the policy and econometric issues related to convexity in the Phillips curve see Schaling (1998). For a useful collection of papers on the policy implications of uncertainty for monetary policy, see Hunt and Orr (1999).

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