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Output and Inflation in Models of the Business Cycle with Nominal Rigidities: Some Counterfactual Evidence

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OUPUT AND INFLATION IN MODELS OF THE BUSINESS CYCLE WITH NOMINAL RIGIDITIES: SOME COUNTERFACTUAL EVIDENCE

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This paper examines the relationship between cyclical output and inflation in models commonly used for monetary policy analysis. This includes models that incorporate the New Keynesian, Fuhrer-Moore and backward-looking Phillips curves. The main finding is that these models imply a strong negative relationship between inflation and output, a result that is at odds with the data. The fact that New Keynesian models yield counterfactual implications is not new; the novelty of the paper lies in the fact that the finding extends to the other variants, such as the backward-looking Phillips Curve, which has been put forward as displaying superior dynamics.

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Key words: nominal rigidities, monetary policy, Phillips Curve, Output, Inflation, Correlation.

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OUPUT AND INFLATION IN MODELS OF THE BUSINESS CYCLE WITH NOMINAL RIGIDITIES: SOME COUNTERFACTUAL EVIDENCE

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1. Introduction.

The late 1990s have seen the emergence of a new consensus in monetary theory. Current models of the business cycle now emphasise the role of monetary policy shocks[2] at the expense of technology (or real) shocks in generating output fluctuations[3] arising from nominal rigidities in products and/or labour markets. Furthermore, because the monetary policy instrument is taken to be a short-term nominal interest rate the quantity of money is endogenous and therefore its study is superfluous. Another break with the Real Business Cycle (RBC) approach has been the methodology used to evaluate models. Whereas RBCs focused on the dynamic cross-correlations provided by the model and their relationship with their empirical counterparts the current New Keynesian (NK) methodology tries to build models that yield impulse response functions that replicate those obtained from VARs. When comparing these two schools of thought, one could of course argue that monetary policy (and its shocks) should be included in any business

[2] Although it is also true that technology shocks have been retained.

[3] A recent defence of RBC models can be found in King and Rebelo (2000).

cycle model, but to devote one's sole attention to impulse response functions at the expense of other characteristics of the data is likely to lead to serious modelling flaws. This paper aims to present a key counterfactual implication emanating from NK-New Neoclassical Synthesis (NNS)[4] models that is not obvious when one focuses on impulse responses. Post-war data indicates that the correlation between cyclical output and inflation is positive and significant, but New Keynesian (NK) models of the business cycle commonly used for monetary policy analysis are unable to replicate this feature. The shortcomings of the basic NK model are well known, as clearly exposited by Mankiw (2001) and Ball (1994). Most relevant for the purposes of the present paper, Mankiw (2001) showed how assuming an impulse response function for inflation as a result of a monetary policy shock, the implied response of unemployment would yield dynamics that are "inconsistent with conventional views about the effects of monetary policy".[5] This implies that the contemporaneous correlation between inflation and output is negative. He therefore concludes that the data can be characterised by a model with adaptive expectations. However, this result is not a necessary implication of NK models. Firstly, Mankiw's result follows by positing an assumed path for unemployment as part of the conventional wisdom, but is not an inherent feature of sticky price models. Indeed, in a simple NK model where the behaviour of cyclical output is endogenous a monetary policy shock will reduce inflation and output contemporaneously, producing a positive relationship between the two variables. Secondly, the implied negative relationship

[4] A good presentation of the NNS framework is provided by Goodfriend and King (1997).

[5] Mankiw (2001).

between output and inflation that Mankiw obtains only applies as the result of monetary policy shocks; this will not necessarily be the case for a model embodying other shocks.

The awareness of the shortcomings present in the NKPC has led to greater use of the Fuhrer-Moore Phillips curve specification embodies inflation stickiness[6] so as to overcome many of the problems described above.

This paper presents a standard model embodying nominal rigidities that shows that the relationship between cyclical output and inflation depends not only on the volatilities of the different shocks, but also on the model's structure. The main finding is that these types of models ─ from forward to backward-looking Phillips curves ─ imply a negative correlation between cyclical output and inflation, a fact that is at odds with the data.

Furthermore, this result is robust to calibrated values and to model specification, for example, to models that ignore capital (Jeanne, 1998; McCallum and Nelson, 1997), models with capital and adjustment costs (Casares and McCallum, 2001) or with capital and predetermined investment (Páez-Farrell, 2003).

The consequences of this result extend beyond capturing the key characteristics of the monetary transmission mechanism, as it questions the robustness of studies that aim to calculate optimal policies[7] using these Phillips curves.

2. The Correlation between Inflation and Output.

Studies concerning the short-term relationship between output and inflation are not new. Nevertheless, these are generally consistent in finding a positive correlation coefficient

[6] Fuhrer and Moore (1995).

[7] See, e.g. Ravenna and Walsh (2003) or Woodford (2003).

between the two variables. Representative among these are the results of Lansing and Thalhammer (1999) who found that "the correlation between short-term movements in output and inflation is positive for the whole sample period[8] (correlation coefficient of 0.18), the post-WWII sample period (correlation coefficient of 0.20), and the 1917-1946 sample period, which includes two world wars and the Great Depression (correlation coefficient of 0.34)." Additional evidence is also provided by Galí and Gertler (1999, p. 202), who show a graph displaying this positive relationship.

Nevertheless, one clear issue that must be taken into consideration is the de-trending procedure used to obtain the short-term component of output, and on this there is no general consensus. Furthermore, there is also the distinction between the cyclical component of output and its gap, with the latter measured as the deviation of output from its flexible price level. In that sense, some of the cyclical fluctuations in output are caused by real factors which would not enter the NKPC or the monetary authority's reaction function, so three different methods will be used. The Hodrick-Prescott filter[9] will be used, partly because it makes results comparable with those from the RBC literature but also because its validity can be defended on the grounds that if the business cycle is defined as fluctuations in economic activity with a periodicity of eight years or less, this is then entirely consistent with HP detrended output.[10] The second detrending procedure, the Band Pass filter[11], characterises the business cycle as the component of output with

[8] 1890-1998.

[9] Important papers concerning the debate surrounding the HP filter are among others, Canova (1998a,b), Burnside (1998) and Cogley and Nason (1995).

[10] See King and Rebelo (2000) and Prescott (1986).

[11] See Christiano and Fitzgerald (1999) for details.

cyclicality between 6 and 32 quarters. Finally, results from quadratic de-trending, as in Galí and Gertler (1999) and Nelson (2000), will also be presented. In all of these cases the cyclical component of output obtained does not distinguish between fluctuations that arise from real or nominal shocks.

Table I presents the correlation coefficients between inflation (measured by the GDP deflator) and output for the US economy with each of the three de-trending procedures, where the sample period is 1949Q1-2001Q3.

Table 1

Correlation between detrended output and inflation

	Correlation Coefficient
HPF	0.17
Bpass	0.18
Quadratic Trend	0.23

As Table 1 clearly shows, in all cases the correlation coefficient is positive and significantly so.[12]

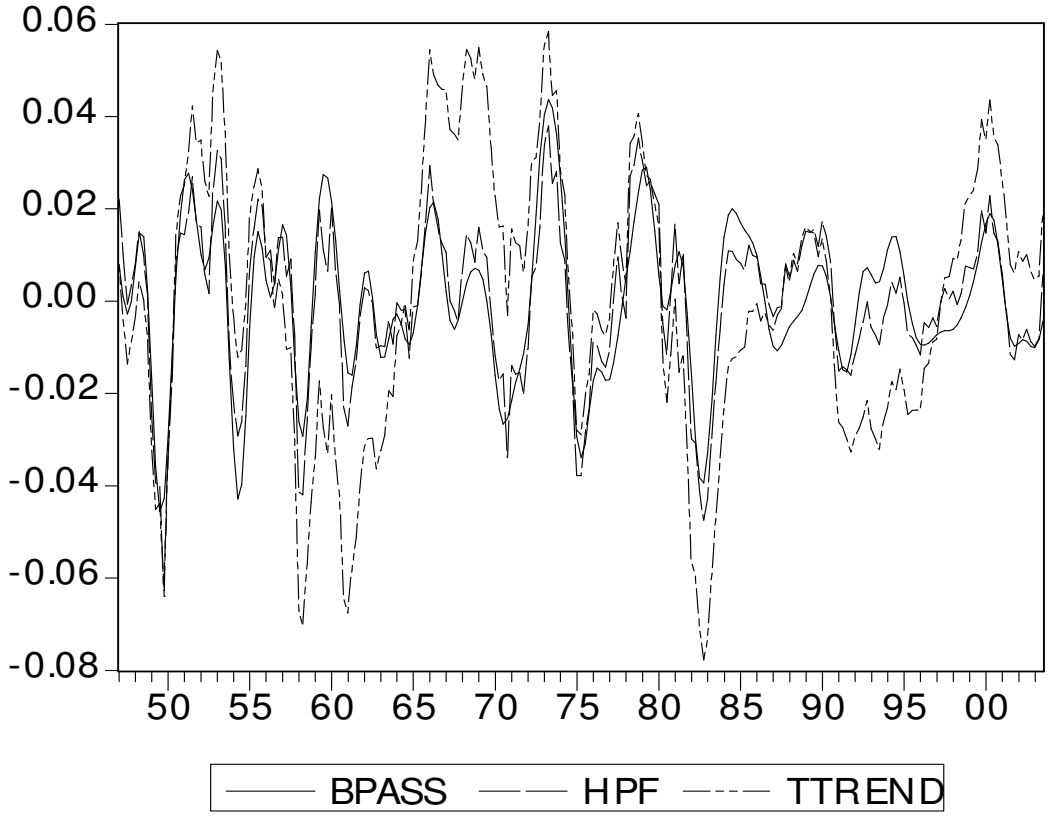
To illustrate what each de-trending procedure implies for the cyclical component of output, Fig.1 plots these four different measures of the output gap. Each measure is able to capture the major movements in output, such as those that occurred during the oil crises and the Volcker disinflation, with the BP and HP filters providing a very similar

[12] The standard deviation is 0.069, using the calculation presented in McCandless and Weber (1995).

description of the data.[13] However, not all measures are that highly correlated, as shown on Table 2, especially for the quadratic trend, which yields the most volatile series.

Figure 1

Detrended Ouput



Thus it is fair to conclude that the evidence suggests, as is generally believed, that the relationship between inflation and output is a positive one, when the latter is taken to imply its cyclical component. Given the results to be shown below, models of the business cycle embodying nominal rigidities are strongly at odds with this stylised fact.

[13] It should be noted that two years of data have been dropped from the beginning and end of the sample.

Table 2

Correlation Coefficient of Detrended Output Components

	HPF	Bpass	Quadratic Trend
HPF	1		
Bpass	0.88	1	
Quadratic Trend	0.72	0.49	1

3. Business Cycles and New Keynesian Models.

Most modern models of the business cycle used for policy analysis are built around three key equations: an IS equation relating output to the real interest rate; a New Keynesian Phillips Curve (NKPC) and a monetary policy rule. However, most of the research, and criticisms of NK models are related to the NKPC,[14] on which four main issues have been raised and some of the answers provided have repercussions for the analysis to be conducted below. The first criticism concerns the fact that the NKPC, which is commonly obtained as a result of the assumption of the Calvo (1983) pricing structure, does not satisfy the natural rate hypothesis. Secondly, as shown by Galí and Gertler (1999) among others, the estimated coefficient on the output gap in the NKPC is negative.[15] Thirdly, output gap stabilisation immediately implies inflation stabilisation, so that there is no trade-off, even in the short-run, between inflation and output. Finally, as shown by Nelson (1998), optimising models of the business cycle have difficulty

[14] An excellent review can be found in Walsh (2003, Ch. 5).

[15] See equation (8) in their paper.

matching the observed persistence of inflation. Several answers have been provided to overcome these problems. Explicitly incorporating the fact that the steady state level of inflation is not zero, which is what the standard Calvo specification does, raises the issue of what firms unable to re-optimise do with their prices. Allowing them to simply update their prices by the steady state level of inflation (or the previous period's level, as in Christiano et al, 2001) generates greater persistence in the inflation process and a trade-off between inflation and output,[16] while also satisfying the natural rate hypothesis. Moreover, even when the NKPC is approximated around a zero-inflation steady state, the coefficient inflation to the output gap has been positive if one takes into consideration the fact that empirical measures of the output gap (cyclical output) provide a poor measure of its theoretical counterpart (the sticky price output gap). By estimating the equation using real marginal costs Galí and Gertler (1999), show that the forward-looking component of inflation is the dominant factor driving the inflationary process, partly overcoming criticisms surrounding the econometric validity of the Phillips Curve. An additional response to the third criticism, apart from some of the elements mentioned above, has been the introduction of an error term in the NKPC, as in Clarida, Galí and Gertler (1999) for which Ravenna and Walsh (2004) have found a theoretical rationale. Finally, one partial answer to the issue of inflation persistence has been provided by the use of the inflation equation put forward by Fuhrer and Moore (1995) which is able to generate greater persistence of inflation, albeit at the cost of weaker theoretical foundations. In this context it is important to note that many of the modifications

[16] However, this is not necessarily the case, as shown by Minford and Peel (2004).

proposed to the NKPC do not change the main conclusions of the analysis to be conducted below; if anything, in some cases they strengthen it.

4. The Role of Shocks.

Being derived from optimising behaviour, standard NK models of the business cycle contain only a small number of exogenous error processes: technology, monetary policy and cost (or inflation) shocks. Technology shocks enter the production function in a form that has a direct impact on output. Monetary shocks (in the form of unexpected changes to the nominal interest rate) however, have an effect on output through the IS equation, where it is multiplied by the negative inverse of the coefficient of relative risk aversion (CRRA).[17] Given that this coefficient is normally in the range of 1 to 5, the impact of the monetary policy shock is therefore partly reduced. Nevertheless, the solution to NNS-type models yields two key conclusions: technology shocks lead to a negative relationship between output and inflation; interest rate shocks lead to a positive relationship between the two variables. As noted by Bénassy (1995), the correlation between inflation and output will then depend on the relative incidence of each of these shocks, and given that technology shocks are typically twice as volatile as interest rate shocks, the monetary transmission mechanism embodied in these models is unable to characterise the empirical relationship between inflation and output. Most importantly, including lagged inflation into the Phillips curve to generate more persistence does not overcome this problem and the introduction of a cost-push shock, which has become

[17] Or its counterpart if the model embodies habit formation in consumption.

increasing popular as a means of generating a trade-off between inflation and output exacerbates the problem.

5. A Simple New Keynesian Model

This section presents a simple model representative of the literature and often presented as usable for monetary policy analysis, which implies that it captures the most important elements in the monetary transmission mechanism. Similar variants can be found in McCallum and Nelson (1997), Walsh (2003, ch. 5), Galí (2003) and elsewhere.[18] It consists of a sticky-price representative agent-monopolistic competition model without capital, the production function is Cobb-Douglas where the elasticity of output with respect to labour is denoted by α. The utility function is given by $u(C_t, N_t) = \frac{C_t^{1-1/\sigma}}{1-1/\sigma} - \chi \frac{N_t^{1+\eta}}{1+\eta}$ and price rigidity is modelled as in Calvo (1983). The resulting linearised model can be written as (where all variables are percentage deviations from steady state):

$$y_t = E_t y_{t+1} - \sigma\left(R_t - E_t \pi_{t+1}\right) \tag{1}$$

$$x_t = y_t - y_t^f \tag{2}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + \xi_t \tag{3}$$

[18] The reader is asked to consult Walsh (2003, Ch. 5) for details.

$$R_t = \delta_1 \pi_t + \delta_2 x_t + v_t \tag{4}$$

$$y_t^f = bz_t \qquad b = \left[\frac{\sigma(1+\eta)}{\sigma(1-\alpha+\eta)+\alpha} \right] \tag{5}$$

$$z_t = \rho_z z_{t-1} + \varepsilon_{zt} \qquad v_t = \rho_v v_{t-1} + \varepsilon_{vt} \qquad \xi_t \text{ is white noise.} \tag{6}$$

Equation (1) represents the IS curve, which relates current output, y_t, to expected future output and the real interest rate, where $E_t \pi_{t+1}$ is the rational expectation of inflation using all available information up to period *t*. Equation (2) defines the output gap, x_t, as the difference between actual output and flexible-price output.[19] Equation (3) is the standard NK Phillips curve with β denoting the rate of time preference and ξ_t representing a cost-push shock. Equation (4) is a simple formulation of the monetary policy rule (via nominal interest rates) where it is assumed that the Taylor principle ($\delta > 1$) holds[20] and (5) defines the flexible level of output for this economy.[21] v_t, ξ_t and z_t represent the monetary, cost-push and technology shocks, respectively.

Using the Minimum State Variable (MSV) criterion,[22] the solution takes the form:

[19] Writing the Phillips curve in terms of real marginal costs does not affect the results in the present model.

[20] Issues related to interest rate smoothing have been ignored, as they do not alter the results.

[21] b depends on the coefficient of relative risk aversion and the elasticity of output with respect to employment, see Walsh (2003, ch. 5).

[22] As in McCallum (1983, 1998).

$$\pi_t = +\eta_{12} z_t + \eta_{13} v_t + \eta_{14} \xi_t \tag{7}$$

$$y_t = \eta_{22} z_t + \eta_{23} v_t + \eta_{24} \xi_t \tag{8}$$

and the sign of the correlation coefficient between inflation and output will depend on the sign of the covariance. In this context, it is informative that it could be written as:

$$E(\pi_t, y_t) = \lambda_1 \text{ var}(z_t) + \lambda_2 \text{ var}(v_t) + \lambda_3 \text{ var}(\xi_t) \tag{9}$$

Consequently, given the different sources of shocks in the model, the relationship between output and inflation will be dependent on which shocks predominate at a particular point in time, as emphasised by Bénassy (1995) and also on the manner in which each shock enters the model. For standard calibrated values, which will be presented below, the values are $\lambda_1 = -0.16$; $\lambda_2 = 0.0036$; $\lambda_3 = -0.28$. Given that most of the movements in the monetary policy are systematic, so that only a small portion are attributable to the error term, it becomes apparent that this model is going to yield a strongly negative correlation between inflation and output. However, at this stage it could be argued that the model presented above is too simple, as it does not include fiscal policy shocks (or alternatively, IS shocks), which would raise the value of the correlation coefficient and that a simple Taylor rule is not an accurate description of central bank behaviour. Furthermore, given the disagreement concerning the specification of the Phillips curve one should consider the consequences that arise from alternative

formulations. The next section therefore analyses the consequences of incorporating these three elements.

6. A Model for Monetary Policy Analysis.

The model to be presented in this section is more general than the one described above. As before the model is comprised of an expectational IS curve that includes fiscal policy,[23] a Phillips curve that overcomes the well known problems inherent in its NK variant and a monetary policy rule as in McCallum and Nelson (1999), which embodies interest rate smoothing. The full model is now:

$$y_t = E_t y_{t+1} - \sigma(R_t - E_t\pi_{t+1}) + (1-\rho_g)g_t \tag{10}$$

$$\pi_t = \phi_0 E_t\pi_{t+1} + \phi_1\pi_{t-1} + \kappa x_t + \xi_t \tag{11}$$

$$R_t = (1-\mu_3)[\mu_1\pi_t + \mu_2 x_t] + \mu_3 R_{t-1} + v_t \tag{12}$$

$$x_t = y_t - y_t^f \tag{13}$$

$$y_t^f = \left[\frac{\sigma\omega(1+\eta)}{\sigma\varpi(\eta+1-\alpha)+\alpha}\right]z_t + \left[\frac{\alpha(1-\varpi)}{\sigma\omega(\eta+1-\alpha)+\alpha}\right]g_t \tag{14}$$

[23] The model presented here assumes that the government consumes a fraction of the output of each good.

where ϖ represents consumption's share in output and government purchases follow an AR(1) process with coefficient ρ_g.

7. Quantitative Results.

This section discusses some of the calibrated values used and then reports on the resulting correlation coefficients between output and inflation.

7.1 Calibrated Values.

Some common parameter values will now be used as benchmarks to determine the correlation coefficient between output and inflation in this model. The CRRA coefficient (σ) will be set to 1, implying logarithmic utility in consumption, although there is considerable debate concerning the value for this parameter, ranging from 0.2 (McCallum and Nelson, 1999) to 6 (Rotemberg and Woodford, 1999).[24] α represents the coefficient on labour in a Cobb-Douglas production function, set at 0.64; $\eta = 1$ as in Galí (2003) and for β the value of 0.995 will be used. For the monetary policy rule, we follow McCallum and Nelson (1999) with the values of 1.5, 0.5 0.8 for μ_1, μ_2 and μ_3 respectively. Finally, for κ, which is affected by the degree of nominal rigidity and the effect of marginal cost on the output gap, the range $[0.0032, 0.1]$ will be used, with the lower value being the minimum proposed by McCallum (1999) and the higher value by Jensen (2002). For the Fuhrer-Moore Phillips curve, $\phi_0 = 0.5, \phi_1 = 0.5$ will initially be

[24] The main result of this paper is not altered by using either of these two values. The corresponding correlation coefficients are available from the author upon request.

used as benchmark values, but results for a backward-looking PC will also be analysed, as this has been proposed by Mankiw (2001), Roberts (1995, 2001) and others.

Concerning the innovations' standard deviations, the following will be used: $\sigma_v = 0.0017$ as estimated by McCallum and Nelson (1998) and $\sigma_\xi = 0.0025$ as in Isard, Laxton and Eliasson (1999). For postwar data one obtains $\sigma_g = 0.018$; $\rho_g = 0.61$; $\rho_z = 0.95$; $\sigma_z = 0.007$ and the government's share of output is equal to 0.28.

It is worth pointing out that this framework and the values used are standard in sticky-price models. Moreover, given the range of calibrated values used in the present paper, if the correlation between output and inflation remains negative it is hard to see how this result can be reconciled with the data unless the model is subjected to substantial modifications.

7.2 Numerical Results

Table 3 presents some correlation coefficients arising from different assumptions about the model. As argued by Clarida et al (1999), optimal monetary policy under discretion and perfect information implies that the central bank fully offsets demand shocks, leading to a negative correlation between inflation and the output gap, and this is the only trade-off faced by the monetary authorities.

However, under an operational monetary policy rule this is no longer necessarily the case, since demand shocks will no longer be fully offset by monetary policy, so that both inflation and output will be affected. For the model presented here the negative

correlation is robust. Changing the value of κ or eliminating ς_t has no effect on the sign of the correlation coefficient, even if one posits the FM specification.[25]

Table 3

Correlation coefficient (output, inflation) $\kappa = 0.1$

	$\sigma_\zeta = 0.0025$	$\sigma_\zeta = 0$
NKPC	-0.40	-0.51
FM	-0.44	-0.49
$\phi_0 = 0.5$ $\phi_1 = 0.5$		
Backward-looking	-0.57	-0.58
$\phi_0 = 0.1$ $\phi_1 = 0.9$		

What about the specific formulation of the Phillips Curve? Tables 3 and 4 show that making inflation stickier ─ that is, attaching a larger weight to past inflation in the Phillips curve ─ does not overturn the results. On the contrary, if anything, they worsen the more backward-looking the process on inflation. This result is noteworthy, because the flaws in the NKPC have led some researchers to use more backward-looking models. The results in this paper suggest that this may not necessarily solve the joint dynamics of output and inflation.

[25] Under the NKPC specification $\phi_0 = \beta,\ \phi_1 = 0$.

Table 4

Correlation coefficient (output, inflation) $\kappa = 0.0032$

	$\sigma_\zeta = 0.0025$	$\sigma_\zeta = 0$
NKPC	-0.21	-0.68
FM	-0.75	-0.70
$\phi_0 = 0.5$ $\phi_1 = 0.5$		
Backward-looking	-0.75	-0.70
$\phi_0 = 0.1$ $\phi_1 = 0.9$		

Calculating the correlation coefficient by modifying other parameter values not described above,[26] such as labour's share of income, coefficients in the Taylor rule or even by extending the model to include endogenous capital, as in Casares and McCallum (2000) and Páez-Farrell (2003) has no noticeable effect on the correlation coefficient, so that the results are robust to model formulation.

8. The Relative Size of Shocks.

Given the results above one could consider how large monetary policy shocks have to be to achieve a correlation coefficient between output and inflation consistent with the empirical evidence. Table 5 presents this result for the different model variants. The first

[26] These results are available from the author upon request.

column presents the necessary volatilities in the absence of cost-push shocks, and the second column uses its benchmark value.

In all cases monetary policy shocks need to be at least 2.5 times larger than standard estimates, making this result hard to reconcile with the data. Indeed, the last row shows that for the backward looking PC the correlation coefficient reaches a limit (0.06 in both cases) regardless of the volatility of the monetary policy shock. In order to reconcile these results with their empirical counterparts the New Keynesian Phillips curve seems to hold more promise.

Nevertheless, one could also argue that this puzzle arises because technology shocks have been overestimated, as argued by Galí (1999). As a counterpart to the previous exercise, Table 6 presents the necessary magnitude of the technology shocks given $\sigma_v = 0.0017$.

Those where a particular value is not provided indicate that even in the absence of technology shocks, the correlation coefficient between inflation and output is still negative. Of crucial importance is the presence of the cost-push shock, which also pushes the two variables in opposite direction. However, its presence in the model is necessary if there is to be a trade-off between output and inflation stabilisation, so that the solution of one problem causes another to arise. Finally it is worth mentioning that the necessary volatility of the technology shocks required to achieve the desired correlation coefficient is substantially lower than that normally used in the literature.

Table 5

Model formulation	σ_v necessary to achieve $cor(y_t, \pi_t) = 0.17$ $\sigma_\zeta = 0.0025$	σ_v necessary to achieve $cor(y_t, \pi_t) = 0.17$ $\sigma_\xi = 0$
NKPC, $\kappa = 0.1$	0.0045	0.004
NKPC, $\kappa = 0.0032$	0.013	0.005
FM, $\kappa = 0.1$	0.006	0.005
FM, $\kappa = 0.0032$	0.0275	0.007
Backward-looking $\phi_0 = 0.1$ $\phi_1 = 0.9$ $\kappa = 0.1$	0.027	0.02
Backward-looking $\phi_0 = 0.1$ $\phi_1 = 0.9$ $\kappa = 0.0032$	∞	∞

Tables 5 and 6 have presented several modifications to the three models considered and the main result is clear: models embodying nominal rigidities, which lead to one of the Phillips curves considered, do not satisfactorily explain the relationship between output and inflation. Furthermore, the more backward-looking the Phillips curve the stronger the results.

Table 6

Model formulation	σ_z necessary to achieve $cor(y_t, \pi_t) = 0.17$ $\sigma_\xi \neq 0$	σ_z necessary to achieve $cor(y_t, \pi_t) = 0.17$ $\sigma_\xi = 0$
NKPC, $\kappa = 0.1$	0.0008	0.0029
NKPC, $\kappa = 0.0032$	—	0.0023
FM, $\kappa = 0.1$	—	0.0023
FM, $\kappa = 0.0032$	—	0.002
$\phi_0 = 0.1$ $\phi_1 = 0.9$ $\kappa = 0.1$	—	0.0003
$\phi_0 = 0.1$ $\phi_1 = 0.9$ $\kappa = 0.0032$	—	—

9. Conclusion.

This paper has shown that models embodying nominal rigidities, of the type commonly used for monetary policy analysis, perform very poorly when measured in terms of the contemporaneous correlation coefficient between inflation and output. Furthermore, this result is robust to the specification of the Phillips curve and alternative parameter values. The fact that even the backward-looking Phillips curve implies countercyclical inflation

is most striking, since it is this form that has been suggested to overcome the well known problems inherent in the New Keynesian Phillips curve.

By focusing on shocks (monetary surprises) to the neglect of the systematic component of monetary policy, the consensus view that these models are usable for policy analysis, because they mimic the impulse response obtained from VARs can be misleading. Consequently, sticky-price and sticky-inflation models are only able to capture a limited fraction of the overall dynamics of the data, a fact that should be taken seriously when using them for policy formulation. Moreover, when one considers the magnitude of the shocks for the model to match the data it requires either unrealistically large monetary policy shocks, or the absence of cost push shocks. The limitations highlighted in this paper complement those found in Atkeson and Ohanian (2001) regarding the general failure of Phillips curve to forecast inflation.

Two key results emanate from this paper. First, models embodying nominal rigidities, such as those that yield a New Keynesian Phillips curve (or its backward looking variant) have serious difficulties in explaining the data when technology and cost-push shocks are incorporated. Second, ignoring technology shocks, as argued by Galí (2003) is unlikely to solve the problem; eliminating the cost-push shocks raises alternative theoretical difficulties already discussed in the literature.

What implications do these results have? The various representations of the Phillips curve discussed in this paper all seem to fail to match the data. Adding to this the fact that the Phillips curve also suffers from weak theoretical foundations, this questions the robustness of research on optimal monetary policy based on either forward or backward-looking Phillips curves.

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