THE NEW KEYNESIAN PHILLIPS CURVE: SOME COUNTERFACTUAL EVIDENCE

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ABSTRACT

New Keynesian Models of the business cycle have become the new paradigm of monetary economics, often used for policy analysis. This paper shows that this class of models fail in one crucial aspect: they imply a strong negative contemporaneous correlation between inflation and output. Furthermore, this result is robust to parameter values and specification of the inflation equation.

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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 arising from nominal rigidities in products and/or labour markets. Furthemore, 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 its empirical counterparts, current New Keynesian (NK) models tries to build models that yield impulse response functions that replicate those obtained fromVARs. When comparing these two schools of thought, one could of course argue that monetary policy (and its shocks) should be included in any business 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. In this paper I aim to present some counterfactual implications emanating from NK-New Neoclassical Synthesis (NNS) models that has not been noticed due to the methodological approach mentioned above. In particular, NK models imply a negative contemporaneous correlation between inflation and output, a result that is robust to calibrated values and to model specification, that is, to models that ignore capital (Jeanne, 1998, McCallum and

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

Nelson, 1997), models with capital and ajustment costs (Casares and McCallum, 2001) or with capital and predetermined investment (Páez-Farrell, 2003). . Furthermore, including lagged inflation into the specification to generate more persistence as in Fuhrer and Moore (1995) has no effect on the results. This result is in stark contrast to empirical correlations between inflation and output: for the US this author found that the correlation coefficient was equal to 0.26 (0.09 in the case of the UK) for the postwar era. This correlation coefficient is not very large, but it is nevertheless significant and positive, a fact that New Keynesian models are not able to replicate.

Current 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, with the latter derived through the minimisation of a loss function or simply introduced as a simple description of the behaviour of the monetary authorities. However, it is the second element, the NKPC, that has generally been problematic. At its core, it relates current inflation (or its deviation from trend) to expected future inflation, marginal cost (or the output gap) and sometimes an additional disturbance is added. Because it is derived from firms' profit maximisation and these are assumed to be forward looking, lagged inflation had no role to play in explaining current inflation. Many authors have focused on two aspects of the relationship: the coefficient relating the inflation rate to the output gap and the persistence of inflation. With respect to the former, Galí and Gertler (2000) have found the coefficient to be negative, resulting in a serious blow to the New Neoclassical Synthesis/ New Keynesian (NNS/NK) modelling framework. However, Galí (2001) has argued that the reason estimates on the aforementioned coefficient have yielded negative results lies in the measurement of the output gap, hence the problem lies in the detrending procedure and not in the theoretical relationship between inflation and output themselves. Moreover, by estimating inflation with respect to real marginal cost, which is what the model implies, Galí has found a much stronger relationship. Therefore, the debate concerning the econometric validity of the NKPC has been partially overcome. Secondly, there is also the issue relating to inflation persistence and the role that lagged inflation has to play in the NKPC. As Nelson (1998) has pointed out, optimising models have difficulty achieving the persistence found in actual inflation. In this respect, Fuhrer and Moore's (1995) specification has gained in popularity as it is able to improve the fit with actual inflation, at the cost of weaker theoretical foundations when compared to alternative formulations. Nevertheless, one of the criticisms related to the most commonly used derivations of the NKPC (the Calvo equation), that it violates the natural rate, only arises in the context of approximation around a zero inflation steady state. Otherwise, in a world of inflation and assuming that firms unable to reoptimise their prices simply follow a mechanic price-updating procedure (i.e., previous period prices are updated by either the steady state value of inflation or the previous period's value) yields a Phillips Curve with lagged inflation that not only satisfies the natural rate but also introduces lagged inflation (see, e.g. Christiano et al, 2001). Consequently, by approximating around a non-zero inflation rate, optimising models are able to provide a better description of inflation persistence.

Technology shocks enter the production function in a form that it has a direct impact on output. Monetary shocks (in the form of changes in 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) Given that this coefficient is normally in the range of 1 to 5, its impact is partly ameliorated. Nevertheless, the solution to NNS-type models yields to 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 depends on the relative incidence of each of these shocks. Where the flaw of the NKPC lies then, is in the fact that technology shocks are generally twice as volatile as monetary shocks so that under a variety of sticky price models: without capital (Jeanne, 1998, McCallum and Nelson ,1997), with capital and ajustment costs (Casares and McCallum, 2001) or with capital and predetermined investment (Páez-Farrell, 2003), the relationship between inflaton and output remains negative. Furthermore, including lagged inflation into the specification to generate more persistence, has no effect. There is one extension to the benchmark model that may overturn this result: when fiscal policy shocks are introduced. In this case government spending enters the IS in the same manner as technology shocks, offsetting each other[3]. Moreover, because fiscal policy, in the form of government expenditure, has been more volatile than technology (at least in the case of the UK), this is enough to result in a positive correlation coefficient between inflation and output. But if this is the source of the positive relationship between inflation and output, then there is an implicitly stronger implication: that monetary policy is a secondary source of output fluctuations.

[3] However, to the extent that output does not reach its potential instantaneously, technology shocks will also affect the NKPC.

2. A Simple New Keynesian Model

Similar variants can be found in McCallum and Nelson (1997), Walsh (2003), Galí (2001) and elsewhere. It consists of a monopolistic competition model model[4] with a representative agent and price rigidity.

The model is comprised of the following equations:

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

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

$$\pi_t = \phi_0 E_t \pi_{t+1} + \phi_1 \pi_{t-1} + \kappa x_t + \xi_t \tag{3}$$

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

$$y_t^f = b z_t \tag{5}$$

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

Equation (1) represents the IS curve[5], equation (2) uses the theoretical measure of the output gap, that is, the deviation of output from its flexible price level; equation (3) is the Fuhrer-Moore (1995) specification of the Phillips curve, included here for generality and

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[4] See Walsh (2003, ch.5) for details.

[5] C/Y represents consumption's share in output.

because it encompasses the traditional Calvo formulation; (4) is a simple formulation of the monetary policy rule where it is assumed that the Taylor principle (δ >1) holds[6] and (5) defines the flexible level of output for this economy[7].

Using the Minimum State Variable (MSV) criterion[8], the solution takes the form:

$$\pi_t = \eta_{11}\pi_{t-1} + \eta_{12} z_t + \eta_{13} v_t + \eta_{14}\xi_t \tag{7}$$

$$y_t = \eta_{21}\pi_{t-1} + \eta_{22} z_t + \eta_{23} v_t + \eta_{24}\xi_t \tag{8}$$

The value for η_{11} is obtained from the following equation:

$$\phi_0\eta_{11}^3 - \left(1 + \beta_0\phi_0 + \kappa\sigma\frac{C}{Y}\right)\eta_{11}^2 + \left(\beta_0 + \phi_1 + \kappa\sigma\frac{C}{Y}\delta_1\right)\eta_{11} - \beta_0\phi_1 = 0 \tag{10}$$

yielding:

$$\eta_{21} = \frac{(1-\phi_0\eta_{11})\eta_{11} - \phi_1}{\kappa} \tag{11}$$

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[6] Issues related to interest rate smoothing have been ignored, as they do not alter the results.
[7] b depends on the coefficient of relative risk aversion and the elasticity of output with respect to employment.
[8] As in McCallum (1983).

$$\eta_{12} = -\frac{[1-\rho_z]b}{\left(\frac{1-\phi_0\eta_{11}}{\kappa}\right)\left(1+\sigma\frac{C}{Y}\delta_2-\rho_z-\eta_{11}\right)+\frac{\phi_1-\phi_0\rho_z\left(1+\sigma\frac{C}{Y}\delta_2-\rho_z\right)}{\kappa}+\sigma\frac{C}{Y}(\delta_1-\eta_{11}-\rho_z)} \tag{12}$$

$$\eta_{22} = \left[\frac{1-\phi_0(\eta_{11}+\rho_z)}{\kappa}\right]\eta_{12}+b \tag{13}$$

$$\eta_{13} = \frac{\sigma\frac{C}{Y}}{\left(\frac{(1-\phi_0\eta_{11})\eta_{11}-\phi_1}{\kappa}\right)\left(\eta_{11}-1-\sigma\frac{C}{Y}\delta_2\right)-\frac{\phi_1}{\kappa}-\sigma\frac{C}{Y}(\delta_1-\eta_{11})} \tag{14}$$

$$\eta_{23} = \left[\frac{1-\phi_0\eta_{11}}{\kappa}\right]\frac{\sigma\frac{C}{Y}}{\left(\frac{(1-\phi_0\eta_{11})\eta_{11}-\phi_1}{\kappa}\right)\left(\eta_{11}-1-\sigma\frac{C}{Y}\delta_2\right)-\frac{\phi_1}{\kappa}-\sigma\frac{C}{Y}(\delta_1-\eta_{11})} \tag{15}$$

$$\eta_{14} = \frac{1+\sigma\frac{C}{Y}\delta_2}{\left(1+\delta\frac{C}{Y}\delta_2-\eta_{11}\right)(1-\phi_0\eta_{11})+\phi_1+\kappa\sigma\frac{C}{Y}(\delta_1-\eta_{11})} \tag{16}$$

$$\eta_{24} = \frac{(1-\phi_0\eta_{11})\left(\frac{1+\sigma\frac{C}{Y}\delta_2}{\left(1+\delta\frac{C}{Y}\delta_2-\eta_{11}\right)(1-\phi_0\eta_{11})+\phi_1+\kappa\sigma\frac{C}{Y}(\delta_1-\eta_{11})}\right)-1}{\kappa} \tag{17}$$

3. Calibration.

Some common parameter values will now be used to determine the correlation coefficient between output and inflation in this model. The CRRA will be set to 1, as in Walsh (2003), Galí (2001) and elsewhere; α, the output share of capital will be set to 0.36; for β, the rate of time preference (and the coefficient on expected future inflation in the Calvo inflation equation) the value of 0.995 will be used. With respect to the monetary policy rule, the common values of 1.5 and 0.5 for δ_1 and δ_2 respectively, will be assumed. Finally, for κ, which is affected by the degree of nominal rigidity and the effect of marginal cost on the output gap, the range $[0.01, 0.1]$ will be used, with the lower value being the minimum proposed by McCallum and Nelson (2000) and the higher value by Jensen (2001). For the NKPC, $\phi_0 = 0.5, \phi_1 = 0.5$ initially.

Concerning the innovations' standard deviations, the following will be used: $\sigma_z = 0.007$; $\sigma_v = 0.001$ (as in Nelson and Neiss, 2001) and $\sigma_\xi = 0.025$ (as in Isard, Laxton and Eliasson, 1999). The AR(1) coefficient for the technology shock the standard value will be assumed ($\rho_z = 0.95$); the cost shock will be assumed to be white noise.

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).

4. Results

Table 1 presents some correlation coefficients arising from different assumptions about the model. A striking result is that the error term often included in the NKPC[9] (see Clarida, Galí and Gertler, 2001) to create an output-inflation tradeoff has a negative effect on the correlation coefficient. Therefore, although the introduction of such an error term provides a justification of the tradeoffs involved in stabilisation policy, it leads to a stronger negative relationship between output and inflation. Moreover, changing the coefficient on the output gap in the NKPC has no observable effects on the correlation coefficient.

TABLE 1

Correlation coefficient (output,inflation)

	$\sigma_\zeta = 0.025$	$\sigma_\zeta = 0$
$\kappa = 0.1$	-0.95	-0.97
$\kappa = 0.01$	-0.99	-0.91

Table 2 present the results concerning the specification of the NKPC, by modifying the weight attached to lagged inflation[10], with the third row representing the standard Calvo inflation equation linearised around the zero-inflation steady state. It is notable that

[9] This error term is often justified as caused by pricing error or from rigidities in input markets (Erceg, Henderson and Levin, 2001).
[10] Here and throughout, the innovations to the NKPC will be ignored.

although in this case the correlation coefficient remains strongly negative, the greater the degree of forward-lookingness in the inflation equation reduces the negativity.

TABLE 2

Coefficient	$\kappa = 0.1$	$\kappa = 0.01$
$\phi_0 = 0.1$ $\phi_1 = 0.9$	-0.97	-0.98
$\phi_0 = 0.5$ $\phi_1 = 0.5$	-0.99	-0.9
$\phi_0 = \beta$ $\phi_1 = 0$	-0.87	-0.90

There is, however, one modification that would alter the sign of the correlation coefficient and this is when fiscal policy is considered. Introducing government spending into the above model alters the IS equation such that:

$$y_t = E_t y_{t+1} - \sigma\left(\frac{C}{Y}\right)(R_t - E_t \pi_{t+1}) - \left(\frac{G}{C}\right)(E_t g_{t+1} - g_t) \quad (18)$$

where g is assumed to be AR(1).

On the standard deviation of government purchases, Neiss and Pappa (2002) report a value of 0.0146, whereas McCallum (2001) uses the value of 0.02, which will used in the present paper. Concerning the degree of persistence in g, three values will be used: those of McCallum (2001), ρ_g =0.99, Neiss and Pappa (2002), ρ_g =0.956 and Larsen, Neiss and Shortall (2002), ρ_g =0.965, as reported in Table 3.

TABLE 3

Coefficient	$\kappa = 0.1$	$\kappa = 0.01$
$\rho_g = 0.99$	-0.66	-0.71
$\rho_g = 0.956$	-0.82	-0.82
$\rho_g = 0.65$	-0.97	-0.98

Given that government spending has been more volatile that technology shocks, the effect on the correlation coefficient has been to bring it much closer to its empirical counterpart.

Thus it seems that a stylised fact for most of the industrialised countries over the post-war, that inflation has been procyclical, seems to hinge on fiscal rather than monetary policy, leading to the conclusion that the understanding of the monetary transmission mechanism is of second order for the study of output fluctuations. It is hard to modify these models to reconcile them with the data and it seems to be a robust weakness of the NKPC, confirming McCallum's (1999) view that aggregate supply is the least well understood component of this class of models. However, one could also reach an alternative conclusion: that these models are unable to capture the most important features of the monetary transmission mechanism.

5. Conclusion.

This paper has shown that current New Keynesian Models of the business cycle perform very poorly when in terms of the contemporaneous correlation coefficient between inflation and output. Furthermore, this result is robust to the specification of the New Keynesian Phillips curve, including Fuhrer and Moore's (1995) inflation equation, and a large range of parameter values. 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 is very misleading. Consequently, New Keynesian 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.

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