Cardiff Economics Working Papers

Working Paper No. E2006/17

Assessing Sticky Price Models Using the Burns and Mitchell Approach

Juan Páez-Farrell

March 2006

Cardiff Business School
Aberconway Building
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
business.cardiff.ac.uk

ASSESSING STICKY PRICE MODELS USING THE BURNS AND MITCHELL APPROACH

Juan Páez-Farrell[1]

Cardiff Business School

ABSTRACT

This paper evaluates sticky-price models using the methods proposed by Burns and Mitchell, focusing on the monetary aspects of the business cycle. Recent research has emphasised the responses of models to shocks at the expense its systematic component. Whereas sticky-price models have been successful at replicating impulse response functions from VARs, this paper highlights that they are unable to mimic the data for nominal variables. Moreover, the results are robust to the specification of the Phillips curve, including its backward-looking variant; calibrated values and the inclusion of fiscal policy shocks. Since being able to mimic the data is the lowest hurdle a model must pass, these results pose a challenge for New Keynesian-type models.

JEL Classification: E32, E52, E58

Key Words: New Keynesian Models, Business Cycles, Correlations, Burns and Mitchell.

Mailing address: Economics Section, Cardiff Business School, Colum Road, CF10 3EU, tel: +44 20875558, fax: +44 20874419, paez-farrellj@cf.ac.uk. I am grateful to Max Gillman, Patrick Minford, Laurence Copeland and seminar participants at Cardiff Business School, the Bank of

1. Introduction.

Beginning with Kydland and Prescott (1982) real business cycle (RBC) macroeconomics has led to sweeping changes in the way macroeconomics is conducted. There is greater emphasis on building models with strong microeconomic foundations, with the aim of overcoming the Lucas critique; the supply side was considered the economy's driving force and traditional econometric techniques were eschewed in favour of a more a-theoretical approach that attempted to construct models which were able to replicate their empirical counterpart's second moments.

The current paradigm in macroeconomics, New Keynesian macroeconomics[2], builds on many elements from RBC theory, but has placed greater emphasis on nominal rigidities and the nominal causes of output fluctuations – so that consequently, less importance has been attached to technology shocks – and models are often evaluated by their ability to replicate the impulse responses obtained from vector autoregressions (VARs). But this focus on the effects of shocks, to the neglect of a model's systematic components, could potentially lead researchers to incorrectly conclude that their model performs well, as only one aspect of the model's characteristics is observed. The traditional assessment procedure used to evaluate RBC models proposed by Kydland and Prescott, which built on the work of Burns and Mitchell (1946), focused on the co movement of variables as the defining features of the business cycle. Nevertheless, this approach has been increasingly discarded due to identification problems. The purpose of this paper is to argue that

England and the Money, Macro and Finance Conference for many helpful comments. All errors are my own.

the RBC model-evaluation methodology can still provide useful insights and that this is an area that should not be neglected. Evaluating a model solely on the basis of the cross correlations it yields and the standard deviations of the variables has its limitations; simply because a model is able to mimic the data does not mean that it can explain it. As Summers (1986) argued, “Many theories can approximately mimic any given set of facts; that one theory can does not mean that it is even close to right”. Indeed, in the context of RBCs, one of the biggest limitations was the ability of many models to mimic the data and the Burns-Mitchell methodology was unable to discriminate alternative models. As King and Plosser (1994) found, one cannot distinguish between a Keynesian (Klein-Goldberger) and an RBC model when using the methods of Burns and Mitchell. As a result, to this author’s knowledge, there has been no general attempt to assess sticky price models using the Burns-Mitchell methodology. To the extent that alternative models are able to mimic the data, this exercise will yield few insights. However, if different model specifications result in clearly distinguishable co-movements in the variables, then it is possible to gain additional information on the models that satisfy this minimum of benchmarks. In effect, if matching the data’s co-movements is a necessary but not sufficient condition for explaining the data, then sticky price models that are unable to do so can be rejected on the grounds that they do not satisfy this minimum of criteria.

To this author’s knowledge, little work has been carried out that applies a general assessment of New Keynesian (NK) and other sticky price models using RBC methods, with particular focus on inflation and nominal interest rates. The purpose

[2] Also called New Neoclassical Synthesis (see Goodfriend and King, 1997).

of this paper is twofold: to determine whether different sticky price models lead to clearly distinguishable co-movement in the model's variables, and if so, which models are able to replicate the data.

The paper proceeds as follows. Section 2 will present the cyclical characteristics of a small subset of key macroeconomic variables for the US economy that are at the core of most small models used for monetary policy analysis, so that the theoretical models can be evaluated using RBC methods. Section 3 will then present a small NK macro model representative of the literature for analysing monetary policy. Section 4 discusses the calibrated values used and section 5 then evaluates this benchmark model, as well as also assessing alternative variants commonly found in the literature. Section 6 will then consider the role of technology shocks in sticky-price business cycle models and section 7 concludes.

2. Some Business Cycle Facts.

The study of the stylised facts of economic fluctuations has already been well documented[3]. Therefore this section will provide a brief description of the variables of interest, focusing on a limited number of real and nominal variables that feature prominently in modern monetary policy analysis. These are output, the inflation rate and the nominal interest rate. Since the relationship between real and nominal variables is likely to be unstable with changes in monetary policy regime - and hence the term "stylised fact" would be inappropriate - this paper will focus on the period

[3] See among others, van Els (1995), Fiorito and Kollintzas (1994) and Millard, Scott and Sensier (1999).

1987:3-2002:2, which covers Greenspan as chairman of the Fed[4]. The data have been de-trended using the HP filter[5] on the grounds that this paper is focusing on fluctuations of 32 quarters or less, which is exactly what the HP filter yields, as argued by King and Rebelo (2000); furthermore, using a band pass filter that discards high frequency fluctuations does not change the main conclusions of this paper.

TABLE I

US BUSINESS CYCLE FACTS (1987:3-2002:2)

Variable	σ_x	σ_x/σ_y	ρ_1	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Y	0.99	1	.88	.29	.49	.73	.88	1	.88	.73	.49	.29
PI	1.02	1.03	.48	-.14	-.07	.01	.19	.24	.37	.35	.38	.35
FF	1.87	1.89	.96	.10	.21	.35	.47	.58	.63	.61	.54	.43

Note: Y denotes real GDP, PI denotes the GDP deflator inflation rate and FF is the federal funds rate (both annualised).

The second column presents the standard deviation for each variable, while in the third column these are stated as a proportion of the volatility of output. ρ_1 denotes the first order autocorrelation coefficient and the remaining columns present the correlation coefficient between each variable (at time $t+i$) with output at date t. A large number in (absolute terms) appearing in column t + i (t - i) indicates that the series lags (leads) the cycle by i quarters. If the absolute value of the cross-correlation is highest at i = 0, then the variable will be defined to move

[4] As in Judd and Rudebusch (1998) and Clarida, Galí and Gertler (2000), there are reasons to believe that the Fed's reaction function may be stable across different Fed Chairmen.

contemporaneously with the cycle. Additionally, for the whole sample period the critical value for the correlation coefficients[6] is 0.13. The results from Table I indicate that all variables are procyclical, with inflation and the nominal interest rate lagging the cycle.

These results are not new and well known in the RBC literature, but what has not been determined is how well sticky price models can fit these facts.

3. A Standard New Keynesian Model.

Most current models used for monetary policy analysis[7] are derived from optimising behaviour that can be simplified into three equations. An expectational IS that relates consumption (or output) to its expected future value and depends negatively on the real rate of interest; a Phillips curve that arises from the presence of nominal rigidities, typically in goods prices á la Calvo and a monetary policy rule that describes the setting of the monetary instrument (the interest rate) either exogenously or as a result of maximising some welfare criterion. The model to be presented in this section embodies all these features. This benchmark model is almost identical to that in Walsh (2003, Ch. 5); the structure is presented in Appendix A and the reader is asked to refer to it for details. It comprises a representative household with endogenous labour choice and monopolistic competition. Prices are set as in Calvo (1983) and because there is no investment

---

[5] With a value of λ=1600.

[6] See McCandless and Weber (1995) or Hoel (1954). The standard deviation of the correlation coefficient can be computed as: $(n-3)^{-\frac{1}{2}}$, where *n* is the sample size.

[7] Representative among these are Walsh (2003, Ch. 5), Galí (2003) and McCallum and Nelson (1997).

(nor, initially, government expenditure) consumption equals output. Finally, monetary follows a Taylor rule with persistence, as estimated by McCallum and Nelson (1999). Writing the equations in percentage deviation from steady state:

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

$$\pi_t = \beta E_t \pi_{t+1} + \phi_1 x_t + \xi_t \tag{2}$$

$$R_t = (1 - \mu_3)[\mu_1 \pi_t + \mu_2 x_t] + \mu_3 R_{t-1} + v_t \tag{3}$$

$$y_t^f = \left[\frac{\sigma((1+\eta))}{\sigma(1-\alpha+\eta)+\alpha} \right] z_t \tag{4}$$

$$x_t = y_t - y_t^f \tag{5}$$

Equation (1) represents the expectational IS, with σ^{-1} denoting the coefficient of relative risk aversion[8]. Equation (2) is the NK Phillips Curve commonly used in the literature, where ϕ_1, the parameter relating the sensitivity of inflation to the output gap investment equation that arises as a result of the presence of investment adjustment costs, where γ is a function of the adjustment cost and θ is the firm's elasticity of demand. Equations (3) and (4) simply represent the marginal product of

[8] Or alternatively in this model, the inverse of the intertemporal elasticity of substitution in consumption.

capital and the transition equation for capital, respectively. Equation (5) is the aggregate resource constraint and equation (6) is a Phillips curve á la Fuhrer and Moore (1995). For robustness analysis this paper will analyse the consequences of varying the parameter ϕ_0, so that the standard New Keynesian Phillips Curve (NKPC) that arises from Calvo pricing will be nested within this framework. Finally, the underlying model structure is one where money enters the utility function in separable form, so that they can be ignored in the present model.

3.2 Monetary Policy

There is a considerable amount of literature on estimating monetary policy reaction functions for the US. Monetary policy in the US can be well characterised by a Taylor-type rule, that is, the monetary policy instrument is a short-term interest rate that reacts to both deviations of inflation from some target value and the output gap, $\tilde{y}_t$ [9], with most rules including the lagged interest rate as a source of persistence. Although the actual weights on inflation, the output gap and the lagged interest rate are not stable over time[10], however, but there is reason to believe that they may be stable during the tenure of the same Fed chairman; in our case the Greenspan period will be considered and the particular monetary policy rule will be that of McCallum and Nelson (1999), as shown in equation (7).

It is important to note that the monetary authority reacts to the gap between sticky-price output and its flexible-price counterpart, rather than cyclical output itself. The

---

[9] Defined as the deviation of current ouput from its flexible price level, $\hat{y}_t$.

[10] See Clarida, Galí and Gertler (2000).

fact that central banks are aware of this distinction is evident in their publications and speeches where high productivity growth is not regarded as inflationary[11]. One should also note that there are three shocks in this model. Technology shocks, z_t, affect potential output and therefore have a direct effect on the Phillips Curve and the monetary policy rule. Additionally, there are monetary policy shocks, v_t, and cost-push shocks (ξ_t). The latter are important in that they provide a theoretical rationale for the existence of a short term trade-off between inflation and output stabilisation, even if it is not clear how this shock originates in the model.

4. Calibration.

The calibrated values are shown in Table II and these are standard in the NK literature, where ρ_z is the autocorrelation of the technology shock (similarly for fiscal policy). δ is the depreciation rate, set at 10% per annum, σ is set at 5 as in McCallum and Nelson (1999) and justifiable on the grounds that this model includes both consumption and investment. θ (the elasticity of demand) has been set to 6[12] and the volatility of the cost-push shock is the same as in McCallum (2001a).

Table II: Calibration

Parameter	Value
ϕ_0	0.5

[11] For a discussion on this issue from a central bank perspective see ECB (2000).
[12] Using the alternative value of 11 (implying a markup of 1.1) does not affect the main results in this paper.

ϕ_1	0.05
β	0.995
α	0.3
σ	5
δ	0.025
γ	2.5
θ	6
ρ_z	0.95
σ_z	0.007
σ_ξ	0.002
σ_v	0.0017
μ_1	1.5
μ_2	0.1
μ_3	0.8

The paper will also present results for different values of ϕ_0 [13], given the considerable disagreement over the specific formulation of the Phillips curve.

5. Model Variants.

[13] Values of ϕ_1 =[0.05,0.1], often used in the literature were considered, but these do not alter the main conclusions of the paper. These results are available from the author on request.

Although the model presented above is representative of the NK literature on monetary policy analysis there is considerable disagreement on the specifics[14], especially those regarding the Phillips Curve (Fuhrer, 1997, Galí and Gertler, 2000) and the importance of technology.

This section will assess New Neoclassical Synthesis (NNS)[15] models using three different variants, with each model being denoted by a different suffix. All the simulated data from the models is contained in the tables in the Appendix and the figures present the dynamic cross-correlations in graphic form. The first model is the benchmark NK model presented above with the calibrated values described in Table II; model 2 only differs from the previous one in that the Phillips curve, equation (2) is replaced by:

$$\pi_t = \phi_0 E_t \pi_{t+1} + (1-\phi_0)\pi_{t-1} + \phi_1 x_t + \xi_t \qquad (5)$$

as in Fuhrer and Moore (1995), with a coefficient of 0.5 for both the backward and forward looking inflation coefficients. To contrast with the first model, model 3 embodies a predominantly backward looking Phillips Curve[16], with $\phi_0 = 0.1$

5. 1 Output.

[14] See McCallum (2001) for a lucid discussion of some of the issues.
[15] In this paper the term NNS will be used to define all models embodying nominal rigidities, not just the New Keynesian Phillips curve.
[16] According to Mankiw (2001), this formulation is superior to its forward looking variant as it better represents the economy's response to monetary shocks.

Y denotes the autocorrelation coefficients for the data (GDP). Figure I clearly shows that all models exhibit greater persistence than that found in the data and in this respect all models are virtually indistinguishable.

These results are not surprising when one considers that RBC models possess similar features and that these sticky price models have the same underlying real structure. In this regard, the main contribution of NK models is their ability to provide an account of the real effects of nominal variables, which is the emphasis of this paper.

5.2 Inflation and Interest Rates.

Figure II presents the results for the cross correlations of output with inflation. A striking feature in all three models, including the backward looking Phillips Curve, is that they imply countercyclical inflation and moreover, it moves contemporaneously with the cycle, whereas in the data inflation is procyclical and lags the cycle. . This result is stronger than that reported in Galí and Gertler (1999)[17], since it is not only the basic NK model where inflation is forward looking, but also in model 3, with backward-looking inflation. The results for the nominal interest rate are even more pronounced and in all cases it is clear that the models are unable to capture the dynamics of the data, even qualitatively[18]. These results may seem counterintuitive, but their interpretation is straightforward. The model includes technology, cost push and monetary policy shocks. The first two result lead to

[17] Also, they treat de-trended output as the output gap, whereas in this paper that variable would be cyclical output and the gap would be the difference between this variable and its flexible price counterpart.

[18] It is worth pointing out that these results are robust to changes in parameter values, as often used in the literature.

countercyclical inflation; that is, both move output[19] and inflation in opposite directions. The monetary policy shock however, produces a procyclical relationship between the two variables.

There are two important features regarding the shocks. First, in terms of their volatility, monetary policy shocks only account for a very small proportion of total interest rate volatility[20], which is the reason McCallum (2001b) has argued in favour of emphasising the systematic component of monetary policy. In effect, the monetary policy shocks are small relative to the cost push and technology shocks. The second feature is the way the shocks affect the model, that is, the model's structure. The cost push shock enters the Phillips curve one-for-one; the technology shock, by having a direct effect on the output gap[21] has a direct effect on inflation and on the IS part of the model, whereas the monetary policy shock affects the IS only.

Thus for these two nominal variables, interest rates and inflation, NNS models seem unable to explain their comovement with output, in other words, the business cycle. This is surprising, given the considerable amount of research and improvements in estimating monetary policy rules and robust estimates of the Phillips Curve. So this begs the question: how should these models be modified?

6. Including Fiscal Policy.

[19] It is important to note that this refers to cyclical output and not the output gap, which is a different concept in the present model.
[20] See McCallum (2001).
[21] The coefficient relating the flexible price level of output to the technology shock is generally close to one for standard calibrated values.

New Keynesian models tend to emphasise monetary policy issues and the role of nominal rigidities. Allowing for the inclusion of fiscal expenditure and assuming that government expenditures follow an AR(1) process[22], the effect would be to re-write equation (1) as:

$$y_t = E_t y_{t+1} - \sigma \frac{C}{Y}\left(R_t - E_t \pi_{t+1}\right) + (1-\rho_g)\frac{G}{Y} g_t \qquad (6)$$

where $\frac{G}{Y}$ represents the steady state government expenditure-output ratio, set to 0.17. The presence of government spending shocks in an NNS model is to raise output and, because the flexible price level of output is not affected, this will have the effect of increasing the output gap and consequently the inflation rate, potentially overcoming the effects of the previous shocks. The models with fiscal policy are shown in Figure III, with model 4 being the standard NK model, model 5 including the Fuhrer-Moore Phillips curve and model 6 embodying the backward looking PC. The results are consistent with the findings in Canzoneri *et al* (2004), whose impulse responses show that the impact of government spending shocks are negligible. This result holds despite the fact that fiscal policy shocks are as volatile as technology shocks, but the reason is clear: equation (6) shows that fiscal policy influences output but is scaled by the government spending-output ratio (which in the US is small) and the shock's persistence (which is very high). Consequently, the inclusion

[22] This follows Canzoneri *et al* (2004), except that, as with output, government purchases are detrended using the Hodrick-Prescott filter. The resulting AR(1) coefficient and standard deviation of the shocks are $\rho_g = 0.97$ and $\sigma_g = 0.007$ respectively.

of fiscal policy in the NNS models seems to provide very little additional insight[23], whether it is for inflation or interest rates.

However, it could be argued that the reason the results presented above are at odds with the data is not because IS shocks are too small, but because the role of technology shocks has been overstated.

7. The Role of Technology Shocks and Operational Monetary Policy.

Ever since the Kydland and Prescott (1982) argued that technology shocks were central to understanding fluctuations, many economists (e.g., Summers, 1986) have argued that the role of technology has been overstated. More recently, Galí (1999, 2003) has argued that technology shocks are much smaller than generally estimated. Could this provide an explanation for the puzzles above? Taking the approach to an extreme, one could explore the effects of eliminating technology shocks altogether and this forms our third variant. Again, the three alternative NNS model specifications are presented in Figure IV and the results, if anything, imply stronger counterfactual implications of NNS models, as both inflation and interest rates remain countercyclical. Part of the reason for this is that ignoring technology shocks results in a greater emphasis of the cost-push shocks.[24] Hence it seems that in order to capture the cyclical properties of the data, it is necessary to focus not only on the shocks and their magnitudes, but also the models' structure. In this sense, one element that has been ignored until now is the operationality of monetary policy, that is, in setting interest rates the monetary authorities do not have up to date

[23] Including investment as in Canzoneri *et al* (2004) does not change this result.

information on the current inflation rate and output gap. Consequently, it should be their expected values that should enter the policy rule. This is how McCallum and Nelson (1999) estimated equation (3):

$$R_t = (1-\mu_3)[\mu_1 E_{t-1}\pi_t + \mu_2 E_{t-1}x_t] + \mu_3 R_{t-1} + v_t \qquad (7)$$

This will result in monetary policy not being able to respond contemporaneously to events (and therefore, agents' expectations of changes in interest rates), and the models' cyclical behaviour is now markedly different to those presented earlier.

5.3 Operational Monetary Policy.

One issue that the simple models presented above ignored is that monetary policy, as described in equation (7) is not operational. That is, the monetary authorities do not have up to date information on inflation and the output gap[25]. Neglect of operationality in monetary policy is of substantial importance[26], especially when trying to determine optimal monetary policy. However, when the models described in this paper are simulated with the policy rule being operational –that is, using *t-1* information – the results remain robust[27].

6. The Role of Technology Shocks.

---

[24] It is important to emphasise that the inclusion of these shock is often essential for NNS models if these are to argue that there is a tradeoff between output and inflation stabilisation.
[25] Issues of uncertainty about the output gap is ignored in this paper.
[26] See, for example, the arguments put forward by McCallum (1997).

This model now possesses less output persistence than the data. As with RBC models, persistent technology shocks provide one of the main persistence mechanisms in sticky price models, and its removal results in the NK model embodying less persistence than in the data. For the purpose of this paper, it is worth noting that inflation now exhibits a phase shift, although it is still countercyclical and leading the cycle[28]. Nevertheless, the countercyclicality of inflation is now less pronounced, and this lends weight to the arguments put forward by Galí (2003), who questions the quantitative significance of technology shocks as a source of output fluctuations[29].

However, the countercyclical behaviour of the nominal interest rate has now become more pronounced compared to all the previous models, because of the effects of the monetary policy shocks.

Consequently, one could analyse the benchmark model where demand (monetary and fiscal policy) shocks are the only stochastic elements in the model. The result, not reported here[30], is that inflation lags the cycle and is procyclical, but excessively so. Moreover, the resulting volatility of output is lower than the data's. This

---

[27] These are available in the working paper version to this article.
[28] In this regard, a model that eliminates technology shocks and incorporates backward-looking inflation does not capture these features.
[29] It ought to be mentioned that the standard deviation of technology shocks for the sample period considered here is 0.0055, slightly smaller than the 0.007 traditionally used in RBC models.
[30] Available from the author upon request.

suggests re-introducing technology shocks, but with a standard deviation chosen so that the volatility of output matches the data's, as is common in RBC modelling and, more recently, in Walsh (2003).

The resulting model[31], shown in Figure VIII , captures the dynamic comovement between output and inflation over the cycle in a manner that none of the earlier models can, even if it does a poorer job at capturing the dynamics of output.

The relatively large influence of the monetary policy shocks leads to a strong negative correlation between the nominal interest rate and cyclical output, so that although this model with demand shocks and substantially smaller technology shocks is better able to replicate the cyclical behaviour of inflation, it does a dismal job at describing the behaviour of interest rates[32].

All of the models above have been modified in several ways in order to replicate some characteristics of the US business cycle. In the case of RBCs, part of the dissatisfaction of using the Burns-Mitchell methodology lied in the fact that different models could mimic the data and one could not discriminate in favour of the model that best fit the facts. For the models considered here this problem does not arise. Alternative models result in clearly different cyclical behaviour and modifying the model in order to capture the dynamics of inflation results in one favour specification. The limitation of the NK model is, however, that by being able to replicate the facts for inflation, its performance for the remaining variables, such as

[31] The resulting standard deviation of the technology shock is 0.0019.

output, consumption and the nominal interest rate, has worsened. To the extent that NK models have been designed to explain monetary phenomena the Burns-Mitchell methodology clearly shows some of the limitations of sticky-price business cycle models.

7. Conclusion.

Modern macroeconomics emphasises a model's response to shocks compared to that of a VAR when assessing its performance. Although this approach has yielded many useful insights, it has neglected to consider the implications pertaining to the systematic components of the models.

This paper has tried to determine to what extent sticky-price models of the business cycle are capable of capturing the sytematic component present in the data, especially with regards to nominal variables. It has done so by using the Burns-Mitchell methodology proposed by Kydland and Prescott (1982) to a variety of sticky-price models, and these are shown to have limited success at replicating the data. This is surprising for two reasons. Firstly, the Burns-Mitchell methodology has partly been neglected when analysing real business cycles because several different models could replicate the data, so one would expect a similar conclusion to be reached for a New Keynesian model. Secondly, New Keynesian models have been designed to explain monetary phenomena, so their inability to describe the behaviour of inflation and interest rates is surprising.

[32] The additional implication that since there are no cost-push shocks there is no trade-off between inflation and output stabilisation is a further limitation.

The model that best describes the data embodies a Fuhrer-Moore Phillips curve, monetary and fiscal policy shocks, and small technology shocks. However, although able to replicate the comovement between inflation and output, the results for the nominal interest rate and output are less satisfactory. Following Summers (1986), one should reject models that are unable to replicate the data, but being able to "mimic the facts" does not imply that a model can explain it; that is, it is a necessary but not sufficient criterion. Following this argument, since the sticky-price models considered above cannot replicate the data this poses a serious challenge to the New Keynesian paradigm.

An additional conclusion that emerges from the results in this paper is that by analysing both a model's systematic components and their response to shocks provides further insights and understanding of the model, whereas simply focusing on shocks can result in models that face serious shortcomings.

References

Burns, A. F. and W. C. Mitchell. 1946. *Measuring Business Cycles.* New York: NBER.

Canzoneri, M. B., R. E. Cumby and B. T. Diba. (2004) Price and wage inflation targeting: variations on a theme by Erceg, Henderson and Levin, *mimeo.*

Clarida, R. J. Galí and M. Gertler. 1999. "The Science of Monetary Policy: A New Keynesian Perspective". Journal of Economic Literature, Vol. XXXVII, December, pp. 1661-1707.

Clarida, R. J. Galí and M. Gertler. 2000. “Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory.” The Quarterly Journal of Economics, February, pp. 147-180.

Els, P. J. A. van, 1995. “Real Business Cycle Models and Money: A Survey of Theories and Stylised Facts”. Weltwirtschaftliches Archiv, 131, pp. 223-263.

European Central Bank. 2000. “Monthly Bulletin”. October. Frankfurt.

Fiorito, R. and T. Kollintzas. 1994. “Stylised Facts of Business Cycles in the G7 from a Real Business Cycle Perspective”, European Economic Review, 38, pp. 235-269.

Fuhrer, J. F. 1997. “The (Un)Importance of Forward-Looking Behaviour in Price Specifications.” Journal of Money, Credit and Banking, Vol. 29, no. 3 (August), pp. 338-350.

Galí, J. 1999. “Technology, Employment and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?” American Economic Review, Vol. 89, No. 1, pp. 249-271.

———. 2003. “New Perspectives on Monetary Policy, Inflation and the Business Cycle.” In *Advances in Economic Theory*, M. Dewatripont, L. Hansen and S. Turnovsky (Eds.), Vol. III, pp. 151-197, Cambridge University Press.

———. and M. Gertler. 2000. “Inflation Dynamics: A Structural Econometric Analysis.” Journal of Monetary Economics, Vol. 44, no. 2, pp. 195-222.

Goodfriend, M. and R. G. King. 1997. “The New Neoclassical Synthesis and the Role of Monetary Policy”, National Bureau of Economic Research Macroeconomics Annual, pp. 231-95.

Hoel, P. G. 1954. “Introduction to Mathematical Statistics.” New York: Wiley.

Judd, J. P., and G. D. Rudebusch. 1998. “The Taylor Rule and the Fed: 1970-1997.” Federal Reserve Bank of San Francisco Economic Review 3, pp. 1-16.

King, R. G. and C. I. Plosser, 1994. “Real Business Cycles and theTest of the Adelmans,” Journal of Monetary Economics 33, 405-438.

King, R. G. and Rebelo, S., 2000. “Resuscitating Real Business Cycles”. NBER Working Paper No. 7534, (February).

Kydland, F. E. and E. C. Prescott, 1982. “Time to Build and Aggregate Fluctuations.” Econometrica, Vol. 50 (6), 1345-1370.

McCallum, B. T. 1997. “Issues in the Design of Monetary Policy Rules.” NBER Working Paper no. 6016, NBER.

———. 2001a. “Should Monetary Policy Respond Strongly to Output Gaps?” American Economic Review Papers and Proceedings, 91 (May), pp. 258-262.

———. (2001)b Analysis of the monetary transmission mechanism: methodological issues, in *The Monetary Transmission Process: Recent Developments and Lessons for Europe* (Ed.) Deutsche Bundesbank, Palgrave Publishers.

———, and E. Nelson, 1999. “An Optimising IS-LM Specification for Monetary Policy and Business Cycle Analysis,” Journal of Money, Credit and Banking, Vol. 31, August, pp. 296-316.

McCandless, G. T. and W. Weber, 1995. “Some Monetary Facts,” Federal Reserve Bank of Minneapolis Quarterly Review, Vol. 19, 3, 2-11.

Millard, S., A. Scott and M. Sensier. 1997. "The Labour Market Over the Business Cycle: Can Theory Fit the Facts?" Oxford Review of Economic Policy, Vol. 13, No. 3, pp. 70-92.

Summers, L. H., 1986. "Some Skeptical Observations on Real Business Cycle Theory." Federal Reserve Bank of Minneapolis Quarterly Review, 10 (4) Fall, 23-27.

Walsh, C. 2003. "Monetary Theory and Policy." Second Edition. Cambridge, MA: MIT Press.

———. 2003. "Labour Market Search, Sticky Prices and Interest Rate Policies." Mimeo.

TABLE A1

Benchmark model

MODEL I

Variable	ρ1	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Y	0.93	0.76	.81	.87	.93	1	.93	.87	.81	.76
C	0.97	0.78	.82	.87	.91	.96	.92	.89	.85	.82
X	0.92	0.74	.79	.85	.91	.98	.90	.83	.77	.71
PI	0.69	-.43	-.47	-.50	-.50	-.46	-.37	-.32	-.29	-.28
R	0.87	-.52	-.58	-.65	-.73	-.82	-.76	-.70	-.64	-.60

TABLE AII

Benchmark with $\phi_1 = 0.1$ Model 2.

Variable	ρ_1	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Y	0.93	.77	.82	.87	.93	1	.93	.87	.82	.77
C	0.97	.78	.82	.87	.92	.96	.92	.89	.86	.83
X	0.92	.75	.80	.85	.91	.97	.90	.83	.77	.72
PI	0.68	-.42	-.45	-.47	-.46	-.41	-.33	-.30	-.29	-.29
R	0.81	-.55	-.59	-.66	-.74	-.83	-.77	-.71	-.66	-.62

TABLE AIII

MODEL 3 (NKPC)

Variable	ρ_1	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Y	0.93	.78	.82	.87	.93	1	.93	.87	.82	.78
C	0.96	.77	.82	.86	.91	.96	.92	.89	.86	.83
X	0.92	.76	.81	.86	.91	.98	.90	.84	.78	.83
PI	0.43	-.48	-.50	-.51	-.52	-.51	-.48	-.48	-.48	-.47
R	0.82	-.57	-.61	-.67	-.74	-.83	-.76	-.71	-.67	-.64

TABLE AIV

Backward looking model. Model 4

Variable	ρ_1	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Y	0.94	.76	.82	.88	.94	1	.94	.88	.82	.76
C	0.97	.77	.81	.86	.90	.94	.91	.87	.84	.81
X	0.93	.74	.80	.86	.92	.98	.91	.84	.77	.71
PI	0.87	-.56	-.59	-.61	-.61	-.58	-.50	-.43	-.38	-.33
R	0.88	-.52	-.58	-.66	-.73	-.81	-.77	-.72	-.66	-.61

TABLE AV

Benchmark without technology shocks, model 5.

Variable	ρ_1	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Y	0.70	.15	.27	.45	.70	1	.70	.45	.27	.15
C	0.84	.18	.29	.44	.62	.81	.64	.49	.38	.30
X	0.72	.16	.28	.46	.67	.91	.63	.39	.21	.09
PI	0.61	-.25	-.32	-.36	-.33	-.16	.10	.21	.22	.19
R	0.71	-.15	-.27	-.44	-.66	-.92	-.64	-.40	-.21	-.08

Appendix B: Model descriptions.

Model 1: Basic New Keynesian Model described in the text, with $\kappa = 0.05$.
Model 2: Basic NK model with $\kappa = 0.1$
Model 3: Model with Fuhrer-Moore Phillips Curve and $\kappa = 0.05$.
Model 4: Model with Fuhrer-Moore Phillips Curve and $\kappa = 0.1$.
Model 5: Backward looking PC and $\kappa = 0.05$.
Model 6: Backward looking PC and $\kappa = 0.1$.

Models with government expenditure
Model 7: Basic NK model, with government expenditure and $\kappa = 0.05$.
Model 8: Basic NK model, with government expenditure and $\kappa = 0.1$.

Model 9: Model with Fuhrer-Moore Phillips Curve, government expenditure and $\kappa = 0.05$.

Model 10: Model with Fuhrer-Moore Phillips Curve, government expenditure and $\kappa = 0.1$.

Model 11: Backward looking PC, government expenditure and $\kappa = 0.05$.

Model 12: Backward looking PC, government expenditure and $\kappa = 0.1$.

Models without technology shocks.

Model 13: Basic NK model with government expenditure $\kappa = 0.05$ and no technology shocks.

Model 14: Basic NK model with government expenditure $\kappa = 0.1$ and no technology shocks.

Model 15: Model with Fuhrer-Moore Phillips Curve, government expenditure and $\kappa = 0.05$ and no technology shocks.

Model 16: Model with Fuhrer-Moore Phillips Curve, government expenditure and $\kappa = 0.1$ and no technology shocks.

Model 17: Backward looking PC, government expenditure and $\kappa = 0.05$.and no technology shocks.

Model 18: Backward looking PC, government expenditure and $\kappa = 0.1$.and no technology shocks.

Models with operational monetary policy.

Model 19: