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Source: *Recherches Économiques de Louvain / Louvain Economic Review*, Vol. 57, No. 1 (1991), pp. 3-19
Published by: Department of Economics, Universite Catholique de Louvain
Stable URL: http://www.jstor.org/stable/40723941
Accessed: 09-12-2015 13:52 UTC

On the Role of Monetary Factors in Business Cycle Models

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1 Introduction

Serial correlation in output and comovements of nominal and real variables are widely regarded as the main stylized facts to be observed in western countries.

According to the new classical macroeconomics the correlation between financial and real variables can be explained within an equilibrium context where agents are not endowed with perfect information. Of course, the non fully revealing nature of currently available signals alone cannot account for persistent deviations from the natural level of activity. Serial correlation in output is then usually justified on the basis of adjustment costs, as in Sargent (1979), or inventory dynamics, as in Blinder and Fischer (1981). In other words, the original new classical story is superimposed on an economy where the evolution of real variables, after the impulse effect due to monetary factors, is driven by a real propagation mechanism, originated in the supply side of the system.

The early new classical approach seems now to have lost ground and given way to the so-called Real Business Cycle (RBC) theory[1]. In particular, the basic RBC model focuses on those properties of preferences and production possibilities that can endogenously generate real variable dynamics, abstracting completely, at least in its extreme form, from monetary factors and any kind of informational imperfections.

* We would like to thank, without implicating, Charlie Bean (LSE) and two anonymous referees for helpful comments and suggestions, and the C.N.R. (Consiglio Nazionale delle Ricerche) for financial support.

[1] See, for example, Kydland and Prescott (1982), Long and Plosser (1983), Prescott (1986) and the excellent reviews by McCallum (1986, 1989).

Although one should regard these models as worthwhile attempts to refine the theoretical foundations of a predominantly real explanation of economic fluctuations, it is clear that they can prove to be most fruitful if a special effort is made in explicitly considering a non trivial role for money, as, for example, in the work by King and Plosser (1984) and Eichenbaum and Singleton (1986)[2]. Their empirical results, however, are viewed as broadly consistent with the predictions of RBC theories. In particular, money is neutral and fails to "Granger-cause" output while output "Granger-causes" money. Moreover, according to the innovation accounting analysis carried out by Eichenbaum and Singleton (1986) there is no detectable correlation at all between monetary shocks and real variables.

The main aim of the present paper is to demonstrate that such empirical findings are reconcilable with "monetary" (as opposed to strictly RBC) models of the cycle, when policy regime switches are appropriately taken into account. The basic model employed is an extension of Lucas (1973) original work, modified to incorporate expected inflation and supply shocks. As recently demonstrated by Froyen and Waud (1988), a Lucas-type paradigm augmented with real factors exhibits an important interrelationship between real and monetary factors which is totally neglected by the RBC literature.

Our results show that the evidence so far presented in favour of RBC theories can be perfectly consistent with our theoretical apparatus where monetary factors are an important source of cyclical variability. The obvious implication is that the available empirical results are not capable of discriminating among alternative theories of the cycle. However, we also argue that it is, in principle, possible to carry out different, and hopefully more informative, tests on these issues.

The scheme of the paper is as follows. Section 2 describes the model. The implications of alternative monetary regimes are analyzed and discussed in section 3. Our main results are compared with previ-

[2] On the one hand, King and Plosser (1984), following an approach recently emphasized by Fama (1980) and Fischer (1983), view the provision of transactions and accounting services as the essential function performed by the financial (banking) system and model banks simply as producers of a particular kind of intermediate good. In their view, comovements of financial and real variables are due to a "reverse causation" effect: shocks originated in the real sector of the economy are transmitted to the financial sector mainly through the use of transaction services as an input in the production of final goods. On the other hand, also Eichenbaum and Singleton (1986) stress the role of money as a means of exchange but adopt the approach of Lucas (1980) and Lucas and Stokey (1983), introducing money in an equilibrium business cycle model by means of a cash-in-advance constraint.

ous literature in section 4, where some suggestions for further empirical research are presented. Section 5 concludes the paper.

2 A simple "monetary" model of the cycle

This section presents a modified version of Lucas's (1973) "island" model.

As recently emphasized by Froyen and Waud (1988), the Lucas paradigm can be generalized to include real effects, so that both monetary and real factors (specifically the variability of nominal demand and real supply-side shocks) interact in determining and shaping business cycle dynamics. In the model presented below this result is confirmed and will be briefly discussed[3]. We define a Lucas-type model as "monetary" given that the most popular RBC models (such as those of Kydland and Prescott, 1982; Long and Plosser, 1983 and King and Plosser, 1984) deny any role for monetary factors.

The basic structure of the model is as follows.

Output is produced in a large number of separated, competitive markets (indexed by $z = 1, \ldots, Z$), according to a local supply function of the form:

$$y_t^s(z) = \alpha[p_t(z) - E_z p_t] + u_t^s(z) + \varepsilon_t + \delta y_{t-1}(z) \tag{1}$$

where all variables (as in the following expressions) are in logarithms. Output supplied in each market $y^s(z)$ depends positively ($\alpha > 0$) on the discrepancy between the realized local price $p(z)$ and the expectation of the economy-wide price level p formed by agents in the market. $E_z p_t$ denotes the mathematical expectation of p based on information available to agents in local markets at time t, including the structure of the model, past realizations of all variables and the contemporaneous local price $p_t(z)$; ε is an economy-wide white noise supply shock with variance σ_ε^2 and $u^s(z)$ is a white noise market specific supply shock, independent of ε. It is also assumed that $\sum_z u^s(z) = 0$.

Local output supply depends positively ($0 < \delta < 1$) on lagged local output due to technological factors (adjustment costs, capital stock dynamics, etc.) of the kind emphasized by RBC theorists. This was the

[3] The second main result of Froyen and Waud's paper —that monetary factors can affect the long run behaviour of real output via the variability of inflation— is not considered in the present paper, since our focus is on the issue of stabilization policy in a Lucas-type model, and not on the long run determinants of real output.

admittedly *ad hoc* way of capturing persistence in output fluctuations adopted by Lucas (1973).

The supply function (1) can be given different interpretations. On the one hand, following Lucas (1973), workers and firms can be assumed to observe directly only the price of their product and infer from this signal whether a change in their price reflects a change in the aggregate price level or indicates a change in relative prices. In this latter case workers will alter their labour supply and firms will adjust current production.

On the other hand, developing the insight of Friedman (1968), one can assume competitive local labour markets, where the demand for labour from profit maximizing firms with loglinear production functions is determined by the observed local producer real wage (local nominal wage deflated by the local price $p(z)$). Labour supply is an increasing function of the consumer real wage, *i.e.* the local nominal wage deflated by a consumer price index, not directly observable but inferred from all available information: $E_z p$. These assumptions on the labour market yield exactly a supply function of the form in (1) [4].

Aggregate demand in each market is assumed to depend on the local real money supply $m(z)$ with unitary elasticity and on the locally expected inflation rate:

$$y_t^d(z) = m_t(z) - p_t(z) + \beta[E_z p_{t+1} - p_t(z)] \qquad \beta > 0 \tag{2}$$

Equation (2) can be interpreted as the reduced form of a standard IS-LM model where the real interest rate is a determinant of the IS curve whereas the nominal interest rate affects the LM curve and bond markets clear locally. It could also be interpreted as an inverted portfolio-balance equation à-la-Cagan.

The local nominal money supply is a stochastic fraction of the total money supply m:

$$m_t(z) = m_t + u_t^d(z) \tag{3}$$

$u^d(z)$ denotes a white noise market specific monetary shock with the property that $\sum_z u^d(z) = 0$.

Finally, the monetary authorities attempt to stabilize the economy in the face of the aggregate supply shock ε having as objective the minimization of the variance of aggregate output y (expressed as

[4] However, Bull and Frydman (1983) have pointed out some conceptual difficulties in integrating Friedman's discussion of the informational differences between employers and workers with an island paradigm, rational expectations model.

the geometric average of local outputs ($\frac{1}{Z}\sum_z y(z)$) about its full information level.

The feedback monetary rule adopted has the simple form:

$$m_t = \overline{m} + \mu\varepsilon_{t-1} + v_t \tag{4}$$

where $\overline{m}$ is a constant and v denotes a white noise innovation in the monetary rule, independent of the supply shock ε and with variance σ_v^2. The money supply also reacts to the previous period aggregate supply shock through the policy parameter μ, to be optimally chosen.

Equations (1)–(4) completely describe the structure of the economy. The classical Lucas paradigm has been modified in two main respects. Firstly, following Froyen and Waud (1988), real factors are introduced in an otherwise purely monetary model of cyclical fluctuations by means of the lagged output term in (1), capturing persistence of the effects of shocks on output behaviour, and the presence of both aggregate and local supply shocks.

Secondly, a positive effect of expected inflation on demand is introduced, creating the scope for a powerful stabilization effect of monetary policy, as discussed below[5]. The presence of economy-wide and local shocks on both the supply and the demand side[6], gives rise to a signal extraction problem, since agents have to infer whether movements in the observed local price are due to aggregate shocks or to local disturbances.

The model (1)-(4) can now be solved using standard techniques.

Substituting (3) and (4) into (2) and equating (1) and (2) we obtain the equilibrium local price level:

$$\begin{aligned} p_t(z) \;=\; & \frac{1}{k}\Big[\alpha E_z p_t + \beta E_z p_{t+1} + \overline{m} + \mu\varepsilon_{t-1} + v_t - \varepsilon_t \\ & + u_t(z) - \delta y_{t-1}(z)\Big] \end{aligned} \tag{5}$$

where $k = 1+\alpha+\beta$ and $u(z) = u^d(z) - u^s(z)$, the market specific excess demand shock, with variance σ_z^2.

In order to solve for the expectations of the aggregate price level in (5) we "guess" a solution for $p_t(z)$ of the following form (see, for

[5] For a more detailed analysis of this issue see Marini (1988).

[6] On the demand side, the only aggregate shock is the innovation in the money supply rule v and the local shock is represented by the term $u^d(z)$ in (3). The introduction of the usual aggregate and/or local disturbances in the demand equation (2) would merely complicate the algebra without altering our analysis and results.

example, McCallum, 1983):

$$\begin{aligned} p_t(z) &= \pi_0 + \pi_1 u_t(z) + \pi_2 v_t + \pi_3 \varepsilon_t + \pi_4 \varepsilon_{t-1} \\ &\quad + \pi_5 y_{t-1}(z) + \pi_6 y_{t-1} \end{aligned} \tag{6}$$

The local price level is assumed to depend on the whole set of aggregate and local contemporaneous shocks, on the lagged economy-wide supply shock (via the monetary feedback rule) and on both the local and the aggregate (average) lagged output.

The "signal extraction" problem is solved as:

$$E_z v_t = \frac{\theta_1}{\pi_2}(\pi_1 u_t(z) + \pi_2 v_t + \pi_3 \varepsilon_t) \tag{7a}$$

$$E_z \varepsilon_t = \frac{\theta_2}{\pi_3}(\pi_1 u_t(z) + \pi_2 v_t + \pi_3 \varepsilon_t) \tag{7b}$$

where

$$\theta_1 = \frac{\pi_2^2 \sigma_v^2}{\pi_1^2 \sigma_z^2 + \pi_2^2 \sigma_v^2 + \pi_3^2 \sigma_\varepsilon^2} \tag{8a}$$

$$\theta_2 = \frac{\pi_3^2 \sigma_\varepsilon^2}{\pi_1^2 \sigma_z^2 + \pi_2^2 \sigma_v^2 + \pi_3^2 \sigma_\varepsilon^2} \tag{8b}$$

Using (7) and (8), the final reduced form solution for the local price level is found to be (see the Appendix):

$$\begin{aligned} p_t(z) &= \overline{m} + \pi(\mu)(u_t(z) + v_t - \varepsilon_t) + \frac{\mu}{1+\beta}\varepsilon_{t-1} \\ &\quad - \frac{\delta}{k} y_{t-1}(z) - \frac{\delta(\alpha + \beta\delta)}{k[1 + \beta(1-\delta)]} y_{t-1} \end{aligned} \tag{9}$$

where $\pi(\mu)$ highlights the dependence of the coefficient on the contemporaneous composite shock $u_t(z) + v_t - \varepsilon_t$ on the policy parameter μ.

Aggregating (9) over all markets yields:

$$p_t = \overline{m} + \pi(\mu)(v_t - \varepsilon_t) + \frac{\mu}{1+\beta}\varepsilon_{t-1} - \frac{\delta}{1 + \beta(1-\delta)} y_{t-1} \tag{10}$$

and taking conditional expectations of (10), using (7), we obtain:

$$\begin{aligned} E_z p_t &= \overline{m} + \pi(\mu)(\theta_1 + \theta_2)(u_t(z) + v_t - \varepsilon_t) + \frac{\mu}{1+\beta}\varepsilon_{t-1} \\ &\quad - \frac{\delta}{1 + \beta(1-\delta)} y_{t-1}. \end{aligned} \tag{11}$$

Subtracting (11) from (9):

$$p_t(z) - E_z p_t = \pi(\mu)(1-\theta_1-\theta_2)(u_t(z)+v_t-\varepsilon_t) - \frac{\delta}{k}(y_{t-1}(z)-y_{t-1}). \quad (12)$$

Substituting (12) into (1) we obtain the equilibrium level of local output as:

$$\begin{aligned} y_t(z) &= \alpha\pi(\mu)(1-\theta_1-\theta_2)(u_t(z)+v_t-\varepsilon_t)+u_t^s(z)+\varepsilon_t \\ &\quad +\tfrac{\alpha\delta}{k}y_{t-1}+\tfrac{(1+\beta)\delta}{k}y_{t-1}(z). \end{aligned} \quad (13)$$

Finally, aggregation of (13) over all markets yields aggregate (average) output:

$$y_t = \alpha\pi(\mu)(1-\theta_1-\theta_2)(v_t-\varepsilon_t)+\delta y_{t-1}+\varepsilon_t \quad (14)$$

Aggregate output is determined by the monetary innovation v_t, the supply disturbance ε_t and lagged output. The impact effect of both monetary and real disturbances depends on the variances of local and aggregate monetary and real shocks, $\sigma_z^2,\sigma_v^2,\sigma_\varepsilon^2$, through $\pi(\mu)$ and θ_1,θ_2. The relevance of the variances of both real and monetary disturbances is due to the signal extraction problem faced by private agents.

This confirms the result of Froyen and Waud (1988), that in a generalized Lucas-type model the real output response to nominal as well as real shocks is determined by the interrelationship of monetary and real factors, in sharp contrast with the dichotomy between real and monetary factors present in RBC theories of fluctuations.

Our main focus is on the dependence of the impact coefficient in (14) on the policy parameter μ. The next section analyzes the role for stabilization policy in this extended Lucas framework and shows the implications of different policy regimes for the interpretation of some empirical evidence apparently in favour of RBC theories of the cycle.

3 The effects of monetary shocks on output under alternative policy regimes

As shown in (14), the choice of the policy parameter μ can alter the response of real output to both monetary and real disturbances. The assumed objective of monetary authorities is the minimization of fluctuations of actual output y about its full information level y^*.

In our model, full information output is only affected by supply shocks, altering production possibilities, and not by monetary innovations. Hence, full information output evolves according to:

$$y_t^* = \delta y_{t-1} + \varepsilon_t \tag{15}$$

The welfare function to be minimized is:

$$E_{t-1}[y_t - y_t^*]^2 = [\alpha\pi(\mu)(1-\theta_1-\theta_2)]^2(\sigma_v^2+\sigma_\varepsilon^2) \tag{16}$$

where E_{t-1} denotes the expectation formed on the basis of the information set available to the monetary authorities. From the expression for $\pi(\mu)$ given in the Appendix, we can derive the optimal value of the policy parameter as:

$$\mu^* = \frac{(1+\beta)\{1+\beta[1-\delta(1-\theta_2)]\}}{\beta\theta_2[1+\beta(1-\delta)]} > 0. \tag{17}$$

When $\mu = \mu^*$, actual output is perfectly stabilized around y^* and evolves according to:

$$y_t = \delta y_{t-1} + \varepsilon_t \tag{18}$$

exactly replicating the full information output path given in (15).

The reason for the effectiveness of feedback monetary rules in this model lies in the fact that the local price level in (5) can respond to current anticipations of future values of the aggregate price level via the effect of expected inflation on demand. In other words, the local price is a non-predetermined variable according to the definition proposed by Buiter (1982). Movements in the local price level, caused by monetary or real disturbances, will also alter inflation expectations and, in forming these revised expectations, the feedback money rule will be taken into account. An optimal response of the money supply to past shocks (μ^*) can thus alter inflation expectations in such a way as to offset completely the impact effect on demand of nominal shocks. The inability of agents to observe directly current shocks creates some uncertainty about next period's monetary response, enabling the monetary authorities to stabilize real output even when they react to only one aggregate past disturbance, ε_{t-1}, and not to the full set of shocks hitting the economy[7]. It is now possible to see how the recent empirical evidence summarized in the introduction and often cited in support

[7] The magnitude of the optimal response μ^* depends on the relative variances of the various shocks. In particular, $\delta\mu^*/\delta\sigma_\varepsilon^2 < 0$ since if the variance of ε is relatively high a substantial fraction of all movements in the price level will be interpreted as signalling aggregating supply shocks, to which the money supply will respond in the next period. Perfect stabilization can thus

of an RBC interpretation of U.S. post-war data, can be reproduced by the simple model presented, directly derived from Lucas's original island framework. In this respect, the explicit consideration of different policy regimes is crucial in order to understand how these results are sensitive to changes in the policymakers' efforts to stabilize the economy.

To this aim, we consider a bivariate system with real output y and money supply m under two alternative extreme policy regimes: the optimal feedback rule $(\mu = \mu^*)$ and a fixed money rule $(\mu = 0)$.

Examining the behaviour of the (y,m) system under perfect stabilization, we immediately derive two simple results on Granger-causality $(G - C)$ between money and output. First, adopting the concept of G-C "in mean" (see Buiter, 1984) and confronting the expectation of y_t conditional only on its own past values with that obtained when also past values of the money supply are added to the conditioning set, we obtain the following result:

$$E[y_t|y_{t-1},\ldots] = E(y_t|y_{t-1},\ldots,m_{t-1},\ldots) = \delta y_{t-1}. \tag{19}$$

Past values of money have no additional predictive power for future realizations of real output, that is money does not G-C output.

On the other hand, output appears to G-C money since

$$E[m_t|m_{t-1},\ldots] = \overline{m} \tag{20a}$$

but

$$E[m_t|m_{t-1},\ldots,y_{t-1},\ldots] = \overline{m} + \mu^* y_{t-1} - \mu^* \delta y_{t-2} = \overline{m} + \mu^* \varepsilon_{t-1}. \tag{20b}$$

Past values of y do improve the forecast of future money supply.

Under perfect stabilization, output follows its full information path given by (18) which, in our model, is independent of any monetary variable. The data would show that money has no influence on future output.

The relevance of past output in forecasting future realizations of the money supply is easily explained by the policy reaction of m to past real shocks.

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be achieved with a relatively small response to supply shocks. On the other hand, $\delta\mu^*/\delta\sigma_v^2 > 0$ and $\delta\mu^*/\delta\sigma_z^2 > 0$, since a larger response to ε_{t-1} is needed if movements in the price level are interpreted as signalling mainly either nominal aggregate shocks or local disturbances. The adoption of a more complex, and perhaps more realistic, feedback rule reacting also to past nominal aggregate shocks $(m_t = \overline{m} + v_t + \mu_1\varepsilon_{t-1} + \mu_2 v_{t-1})$ and/or including m_{t-1} in the money rule (4) would not alter any of the main results in the paper, only complicating the algebra.

Moreover, applying the variance decomposition techniques introduced by Sims (1980a, 1980b, 1982) to our bivariate (y,m) system under perfect stabilization, would yield the result that monetary innovations have no role in the explanation of the asymptotic variance of real output.

This result, together with those in (19) and (20), is usually interpreted as supporting RBC views of the cycle, denying any influence of monetary variables (both anticipated *and* unanticipated) on output dynamics. However, this set of results has been derived from a model where monetary factors do affect output under an optimally designed feedback money rule.

This becomes particularly evident if we modify our previous hypothesis on policy behaviour and assume that the monetary authorities stick to a fixed money rule of the form: $m_t = \overline{m} + v_t$. In this case, output follows (14) with $\pi(0) > 0$. Monetary innovations have now a detectable positive impact effect on real output and would be attributed some weight in the decomposition of the asymptotic variance of output.

The consideration of the behaviour of real variables under different policy regimes seems therefore a potentially fruitful way of discriminating among competing "monetary" and real theoretical models of fluctuations, since only the latter imply that shifts in the policy regime should not have any noticeable effect on real variables dynamics.

The policy change considered above, with the shift from the perfectly stabilizing feedback rule to a fixed money rule, is admittedly extreme but useful to illustrate the main points of our analysis. In practice, even less dramatic changes in the attitude towards stabilization -such as, for example, the shift from interest rate pegging to the adoption of monetary targeting by the Federal Reserve in October 1979- may be exploited for this purpose[8].

In summary, our analysis highlights one channel —the countercyclical role played by monetary policy— whereby innovations in policy may be empirically found not to have a substantial effect on output behaviour even if the underlying structure of the economy allows for such an effect.

This result calls for caution in interpreting the outcome of both innovation accounting analyses and of Granger-causality tests as supporting any specific view on the structural characteristics of the econ-

[8] For example, in their empirical investigation, Eichenbaum and Singleton (1986) note that the inclusion of the post-1979 period into the analysis determines a substantial increase of the fraction of output variance attributed to monetary innovations.

omy. In the next section we put our results in the context of the existing literature on the subject.

4 A reinterpretation of the empirical evidence on monetary innovations and output

Recent attempts to discriminate empirically between monetary and RBC theories of the cycle have brought about the resurgence of G-C tests as one of the main tools of analysis. The earlier debate on the power of such tests in evaluating the effectiveness of demand management had been settled by Buiter's (1984) demonstration that G-C from money to output is not necessary for policy effectiveness. This argument, together with the parallel proof of non-sufficiency already offered by Sargent (1976), implied that no inferences about policy effectiveness could be drawn from the results of such tests.

In the new context of the debate over real versus monetary theories of economic fluctuations, the use of G-C tests may appear, as noted by McCallum (1986, p.402), "potentially appropriate", since RBC theorists claim that not only anticipated movements in nominal variables but also the innovations in their processes are of no consequence for the behaviour of real activity. A finding of non G-C from nominal to real variables may thus appear to provide support for an RBC model of the economy. On the other hand, as pointed out by King (1986) and Eichenbaum and Singleton (1986), evidence of nominal-to-real G-C is spurious -and hence not sufficient for rejection of RBC theories- if relevant variables have been incorrectly omitted from the empirical analysis.

We have demonstrated, however, that the absence of G-C from nominal to real variables is also *not sufficient* for the validity of RBC theories. The extended Lucas-type framework can explain absence of G-C from money to output just as accurately as RBC models. Hence, the only possible conclusion to be drawn from our analysis is that G-C tests are uninformative in discriminating among alternatives theories of economic fluctuations.

More sophisticated analyses of the role of innovations in nominal variables in explaining the variance of real activity, within the context of the Vector Autoregression (VAR) models introduced by Sims (1980a, b; 1982), have seemingly provided empirical support for the RBC view.[9]

[9] Sims (1980a) contains theoretical justifications for the adoption of the VAR approach to macroeconometrics. For criticisms of Sims's work see Leamer (1985) and Cooley and LeRoy (1985) and for a recent assessment of alterna-

The question of what inferences on the underlying structure of the economy can be drawn from such exercises has also been addressed in the literature. In particular, King and Trehan (1984) highlighted the possibility that spurious rejections of the neutrality hypothesis may occur even if it is actually true if money is endogenous.

Following this insight, Siegel (1985) has provided a rationale for the compatibility of existing money-output correlation with RBC theories. The argument is simple: the money supply yields valuable information about the level of real economic activity and future real interest rates. Monetary innovations are viewed as signals, conveying some new information about real activity and hence correlation with output measures is the inevitable outcome of the conditional estimates of rational agents.

On the other hand, the empirical investigation by Eichenbaum and Singleton (1986) shows that innovations in the money supply are not capable of explaining a significant part of the variance of output. This result is regarded as clear evidence of the scarce empirical plausibility of the Lucas paradigm.

Such presumption is obviously flawed as well. Even absence of correlation between monetary innovations and output can be compatible with a traditional monetary model of the cycle as the one presented in the previous sections. We are thus able to conclude that not only Granger-causality tests but also innovation accounting techniques present rather serious problems when used to discriminate among competing macroeconomic theories.

In our view, a more appropriate framework for empirical testing should explicitly take into account changes in policy regimes. The procedure adopted by Neftci and Sargent (1978) and Bean (1984) in assessing the validity of the neutrality hypothesis can be extended to discriminate empirically between monetary and RBC theories. For example, according to the predictions of our monetary model, a switch from countercyclical to fixed monetary rules should be associated with a larger impact of monetary innovations on output. Such a switch would be, on the other hand, totally irrelevant if the true underlying theory were of the RBC variety[10].

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tive econometric methodologies, including Sims', see Pagan (1987).

[10] The finding by Eichenbaum and Singleton that U.S. data show a detectable impact of monetary innovations on output over the years 1979–1982 and not in the previous postwar period appears to be consistent only with our model and not with RBC views.

Cross-country studies could also serve similar purposes. It is, in principle, possible to verify whether or not the impact effect of monetary factors on real output is inversely related to the degree of countercyclicality of the monetary rules adopted in each country.

Research along these lines should improve our present understanding of economic fluctuations.

5 Conclusions

Neither Granger-causality tests nor innovation analyses can be used to discriminate among competing theoretical models of economic fluctuations. In particular, absence of correlation between monetary innovations and output could be the by-product of a successful stabilization policy in models preserving a central role for monetary shocks. The extended Lucas paradigm may outperform empirically Real Business Cycle models when changes in policy regimes are taken into account. Further empirical research, evaluating cross-regime and/or cross-country evidence may shed further light on these issues.

APPENDIX

From the guess solution for $p_t(z)$ given in (6), aggregating over all markets and recalling that $(1/Z)\Sigma_z u(z) = (1/Z)\Sigma_z y(z) = 0$, we obtain:

$$p_t = (1/Z)\Sigma_z p_t(z) = \pi_0 + \pi_2 v_t + \pi_3 \varepsilon_t + \pi_4 \varepsilon_{t-1} + (\pi_5 + \pi_6) y_{t-1}. \qquad (A1)$$

Taking conditional expectations of (A1):

$$E_z p_t = \pi_0 + \pi_2 E_z v_t + \pi_3 E_z \varepsilon_t + \pi_4 \varepsilon_{t-1} + (\pi_5 + \pi_6) y_{t-1}. \qquad (A2)$$

Making use of the "signal extraction" formulae in (7) and (8), the conditional expectation of the aggregate price level becomes:

$$E_z p_t = \pi_0 + (\theta_1 + \theta_2)(\pi_1 u_t(z) + \pi_2 v_t + \pi_3 \varepsilon_t) + \pi_4 \varepsilon_{t-1} + (\pi_5 + \pi_6) y_{t-1}. \quad (A3)$$

Leading $(A1)$ one period we obtain:

$$p_{t+1} = \pi_0 + \pi_2 v_{t+1} + \pi_3 \varepsilon_{t+1} + \pi_4 \varepsilon_t + (\pi_5 + \pi_6) y_t. \qquad (A4)$$

Given the assumed white noise properties of v and ε we have that $E_z v_{t+1} = E_z \varepsilon_{t+1} = 0$.

Aggregation of (1) over all markets yields:

$$y_t = \alpha[p_t - (1/Z)\Sigma_z E_z p_t] + \varepsilon_t + \delta y_{t-1}. \qquad (A5)$$

Using (A3) and averaging across markets we obtain:

$$(1/Z)\Sigma_z E_z p_t = \pi_0 + (\theta_1 + \theta_2)(\pi_2 v_t + \pi_3 \varepsilon_t) + \pi_4 \varepsilon_{t-1} + (\pi_5 + \pi_6) y_{t-1}. \quad (A6)$$

Subtracting (A6) from p_t in (A1) yields:

$$p_t - (1/Z)\Sigma_z E_z p_t = [1 - (\theta_1 + \theta_2)](\pi_2 v_t + \pi_3 \varepsilon_t). \qquad (A7)$$

Finally, substituting (A7) into (A5) we can derive the output equation as:

$$y_t = \alpha[1 - (\theta_1 + \theta_2)](\pi_2 v_t + \pi_3 \varepsilon_t) + \varepsilon_t + \delta y_{t-1}. \qquad (A8)$$

The conditional expectation $E_z y_t$ is, using (7) and (8):

$$\begin{aligned} E_z y_t &= \{\alpha\,[1 - (\theta_1 + \theta_2)]\,(\theta_1 + \theta_2) + (\theta_2/\pi_3)\} \\ &\quad (\pi_1 u_t(z) + \pi_2 v_t + \pi_3 \varepsilon_t) + \delta y_{t-1}. \end{aligned} \qquad (A9)$$

Using (A9) and (A4), the conditional expectation of p_{t+1} is found to be:

$$\begin{aligned} E_z p_{t+1} &= \pi_0 + \{(\pi_4/\pi_3)\theta_2 + (\pi_5 + \pi_6)[\alpha(1 - \theta_1 - \theta_2)(\theta_1 + \theta_2) \\ &\quad + (\frac{\theta_2}{\pi_3})]\}(\pi_1 u_t(z) + \pi_2 v_t + \pi_3 \varepsilon_t) + (\pi_5 + \pi_6)\delta y_{t-1}. \end{aligned} \qquad (A10)$$

Substituting the expressions for $E_z p_t$ and $E_z p_{t+1}$, (A3) and (A10), into (5) and collecting terms, gives:

$$\begin{aligned} p_t(z) &= \frac{(\alpha + \beta)\pi_0 + \overline{m}}{k} + \frac{1}{k}\left\{\alpha(\theta_1 + \theta_2) + \beta\left[\frac{\pi_4}{\pi_3}\theta_2 + (\pi_5 + \pi_6)\alpha\right.\right. \\ &\quad \left.\left.(1 - \theta_1 - \theta_2)(\theta_1 + \theta_2) + (\pi_5 + \pi_6)\frac{\theta_2}{\pi_3}\right]\right\} \\ &\quad (\pi_1 u_t(z) + \pi_2 v_t + \pi_3 \varepsilon_t) \\ &\quad + \frac{1}{k}(u_t(z) + v_t - \varepsilon_t) + \frac{\alpha\pi_4 + \mu}{k}\varepsilon_{t-1} - \frac{\delta}{k} y_{t-1}(z) \\ &\quad + \frac{1}{k}(\pi_5 + \pi_6)(\alpha + \beta\delta) y_{t-1}. \end{aligned} \qquad (A11)$$

Equating coefficients in (A11) and (6) yields the following solutions for the undetermined coefficients:

$$\pi_0 = \overline{m} \quad \text{(A12a)}$$

$$\pi_1 = \pi_2 = -\pi_3 \quad \text{(A12b)}$$

$$\pi_3 = \frac{\frac{\beta}{1+\beta}\theta_2\mu - \frac{\beta\delta\theta_2}{1+\beta(1-\delta)} - 1}{k - \alpha(\theta_1 + \theta_2)[1 - \frac{\beta\delta}{1+\beta(1-\delta)}(1 - \theta_1 - \theta_2)]} \quad (A12c)$$

$$\pi_4 = \frac{\mu}{1+\beta} \quad (A12d)$$

$$\pi_5 = -\frac{\delta}{k} \quad (A12e)$$

$$\pi_6 = -\frac{\delta(\alpha + \beta\delta)}{k[1 + \beta(\delta)]}. \quad (A12f)$$

Substituting the expressions for $\pi_0, \ldots, \pi_6$ into (6) and denoting $\pi_1 = \pi_2 = -\pi_3$ as $\pi(\mu)$ we can write the final reduced form solution for the local equilibrium price level as in (9).

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