Long-Run Monetary Neutrality and Contemporary Policy Analysis

Keynote Speech by Bennett T. McCallum

Arguments are developed concerning a number of topics including long-run monetary neutrality, superneutrality, the natural-rate hypothesis, the quantity theory of money, the equation of exchange, the Fisher equation, and purchasing power parity. These are basic, fundamental topics that all students of monetary economics refer to frequently, but there is evidently considerable disagreement concerning their exact nature. Some of the disagreement has likely been generated by the recent practice by monetary economists of conducting monetary policy analysis in models that include no mention of any monetary variable such as M1 or the monetary base—thereby reflecting the actual policy practice of most central banks. It is argued that these models are consistent in most important ways with highly traditional monetary analysis. More generally, relationships among the various topics are developed and the validity of empirical tests (e.g., cointegration tests) relating to several of the topics are reconsidered.

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Carnegie Mellon University (E-mail: bmccallum@cmu.edu)

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I. Introduction

At a conference on "sustained economic growth" held by a central bank, it seems appropriate for me, a monetary economist, to discuss the long-run relationship between monetary policy and real economic growth. One could make this a very short talk without being entirely wrong by just saying that there is *no* long-run relationship and stopping with that, but presumably it would be better for me to go on a bit longer by adding some elaborations and qualifications to that basic proposition.

Accordingly, I would like to discuss a number of interrelated topics including long-run monetary neutrality, superneutrality, the natural-rate hypothesis, the quantity theory of money, the Fisher equation, purchasing power parity (PPP), and empirical tests relating to some of the above. These are basic, fundamental topics that all students of monetary economics refer to frequently, but there is evidently considerable disagreement concerning their exact nature, a matter that is certainly worthy of discussion. Some of this disagreement, moreover, has perhaps been generated by the recent tendency by leading monetary economists to conduct monetary policy analysis in models that include no mention of any monetary variable such as M1 or the monetary base. This tendency by analysts reflects, of course, the actual policy practice of most central banks in industrial nations, so several of the issues that come up could be of practical importance.

II. What Is the Quantity Theory of Money?

There is hardly a more basic topic in monetary economics than the quantity theory of money (QTM), yet there exists substantial disagreement over the meaning of the term. Some writers identify the QTM with the equation of exchange, $MV = PY$, where M, Y, and P are measures of money, real transactions, and the price level with V the implied "velocity." Such an identification is highly undesirable, however, because the equation of exchange is an identity—I think of it as the definition of velocity. Accordingly, the equation of exchange is consistent with any proposition concerning monetary economics and therefore cannot play any essential role in distinguishing different views. To identify the QTM with the equation of exchange would, therefore, rob it of any empirical or theoretical content.

That somewhat different meanings are assigned to the QTM can be seen by consulting the writings of Hume (1752), Wicksell (1906/1935), Fisher (1911), Keynes (1936), Friedman (1956), Patinkin (1956), Friedman and Schwartz (1963), Samuelson (1968), and Lucas (1980). Nevertheless, there is one basic proposition characterizing the QTM, one common thread that unites various definitions and applications. This proposition is that *if* a change in the quantity of money were exogenously engineered by the monetary authority, then the long-run effect would be a change in the price level (and other nominal variables) of the same proportion as the money stock, with no change resulting in the value of any real variable.[1]

1. The statement is *ceteris paribus* in the sense that it concerns effects of the single postulated change.

This proposition pertains to "long-run" effects, i.e., effects that would occur hypothetically after all adjustments are completed. In real time, there will always be changes occurring in tastes or technology before full adjustment can be effected, so no experiment of this kind can literally be carried out in actual economies. Furthermore, in most actual economies the monetary authority does not conduct monetary policy so as to generate exogenous changes in the stock of money, so nothing even approximating the hypothetical experiment is ever attempted in reality.

Does that imply that we cannot say anything with empirical content about the QTM? Of course not; it is the ultimate task of economics to make predictions about hypothetical policy experiments, on the basis of models designed to reflect the properties of actual economies, so that knowledge about the models' behavior under alternative policies can be obtained without having to undertake massive real-world social experiments. In the case of the QTM, the essential point is that the basic QTM proposition mentioned above will hold in an economy if and only if it possesses the property known as long-run "neutrality of money." Indeed, the latter concept is defined so as to satisfy the stated proposition. Accordingly, I would argue that the QTM is a claim that actual economies possess the properties that imply long-run monetary neutrality.[2] What are these properties? Basically, they are that private agents' objective functions and technology constraints are formulated entirely in terms of real variables—there is no concern for nominal magnitudes *per se*.[3] Then implied supply and demand equations will also include only real variables—will be homogenous of degree zero in nominal variables.[4] Since supply and demand relations can be estimated econometrically, the QTM has empirical content—it requires that all supply and demand equations have the stated homogeneity property. These equations, if properly formulated, are structural relations that do not depend upon the policy rule in effect.[5] Their validity or invalidity therefore has nothing to do with the operating procedures of the monetary authority. The QTM does not, consequently, have anything to do with "the exogeneity of money" in actual practice. In particular, it does not matter whether the central bank is using an interest rate or a monetary aggregate (or, say, the price of foreign exchange) as its instrument variable.[6]

One of the relations in any complete macro/monetary model is a demand function for real money balances.[7] For long-run neutrality to hold, this function must relate the demand for real balances only to real variables (usually including a real rate of return differential that is the opportunity cost of holding money[8] and a real transactions quantity). This equation implies then that the steady-state inflation rate will equal

2. This position is closer to that of Patinkin (1972) than that of Friedman (1972), in their famous dispute.
3. It is possible that tax rules imposed by the government might be such that budget constraints are, nevertheless, not entirely in real terms. For simplicity, I am ignoring this case.
4. Note that in this (standard) case the monetary authority must conduct policy in a manner that depends upon some nominal variable; otherwise, nominal indeterminacy will prevail—i.e., the model will fail to determine the value of any nominal variable. This is very different from the type of "indeterminacy" featured in recent writings by, e.g., Woodford (2003).
5. Here I have in mind behavioral relations—e.g., Euler equations—rather than supply and demand functions under some terminologies.
6. For insightful discussion of related issues, see Nelson (2003).
7. It does not have to be known by the central bank in order for it to conduct monetary policy, of course.
8. This differential is the difference between the real (and nominal!) rates of return on money and interest-bearing assets. Here, for simplicity we assume that money is, like actual currency, non-interest-bearing.

the steady-state rate of growth of the money stock minus a term pertaining to the rate of growth of real transactions. An exogenous change (if it somehow occurred) in the rate of growth of the money stock would, therefore, induce a change of the same magnitude in the inflation rate unless it induced a change in the *rate of growth* of real transactions or the real interest differential. Neither of these possibilities seems at all plausible, so the QTM essentially implies that steady-state inflation rates move one-for-one with steady-state money growth rates.

III. Cointegration Tests

Various empirical procedures have been utilized to test variants of the QTM hypothesis. One that was popular a few years ago concerns possible *cointegration* of the (log of the) price level, p_t, with other variables including m_t, the (log of the) money stock. In particular, a frequently expressed contention is that if two or more difference stationary (DS) variables are not cointegrated, then there exists no long-run relationship between (or among) them.[9] Cuthbertson and Taylor (1990, p. 295) have, for instance, stated the notion as follows: "If the concept of a stable, long-run money demand function is to have any empirical content whatsoever, then m_t must be cointegrated" with p_t, y_t (the log of real income), and R_t (the relevant nominal interest rate). Cointegration requires that all linear distributed-lag relationships among these variables have residual disturbance terms that are covariance stationary.

But is it true that this cointegration concept accurately expresses the relevant notion of a long-run relationship? There is a definitional sense in which it does, in which the suggestions are correct: if z_t and x_t are both DS but not cointegrated, then the disturbance term in any linear relationship between them must by definition be nonstationary, implying that z_t and x_t can drift apart as time passes. I wish to argue, however, that it would be wrong to conclude that in practical terms long-run relationships are therefore nonexistent—or that long-run monetary neutrality (i.e., the QTM) does not hold.

To develop the argument, consider the example of an economy that includes a traditional money demand function of the form

$$m_t - p_t = \gamma_0 + \gamma_1 y_t + \gamma_2 R_t + \eta_t. \tag{1}$$

Suppose for the purpose of the present argument that m_t, p_t, y_t, and R_t are all DS(1) variables that have been processed by the removal of deterministic trends.[10] Then the cointegration status of the four variables depends upon the properties of the disturbance η_t; if its process is of the DS type, the variables in (1) will not be cointegrated.

9. A time-series variable is said to be DS of order $d \geq 1$ if it has to be differenced d times in order to be covariance stationary.
10. This step should not be at issue; the existence of technological change in the payments industry is generally accepted by monetary analysts.

It is my contention, however, that traditional money demand theory—as described by McCallum and Goodfriend (1987), for example—suggests that the variables in (1) are actually *unlikely* to be cointegrated. The reason is that the theoretical rationale for relationship (1) depends upon the transaction-facilitating function of money, but an economy's technology for conducting transactions is continually changing. Since technical progress cannot be well represented by measurable variables, furthermore, the effects of technical change that are not captured by the deterministic trend show up in the disturbance term, η_t. And the nature of technological progress is such that changes (shocks) are typically not reversed. Thus one would expect there to be a significant *permanent* (i.e., unit root) component to the η_t process, making it one of the DS type.

In such a case, however, the "long-run" messages of traditional monetary theory continue to apply. Most importantly, the zero-degree homogeneity of the money demand function is not altered, so long-run neutrality could continue to hold. Also, from an informal perspective, inflation rates Δp_t would continue to be dominated by Δm_t values, provided that the variability of the latter is large relative to the variability of the innovation component of η_t. In short, the failure of p_t to be cointegrated with m_t, y_t, and R_t does not necessarily imply any violation of the messages of traditional monetary theory.

Similar conclusions apply in the field of exchange rate analysis concerning the concept of PPP. In that context, various researchers have concluded, on the basis of cointegration tests, that PPP fails to hold even as a long-run tendency. These tests involve the relationship

$$s_t = p_t - p^*_t + q_t,$$

where s_t is the log of the price of foreign exchange while p_t and p^*_t are logs of the home-country and foreign-country price levels. Then, s_t will be cointegrated with $p_t - p^*_t$ if and only if q_t is trend-stationary.[11] Several studies have found q_t to be nonstationary, however, and have then concluded that PPP fails even as a long-run matter.

I would argue, nevertheless, that one should not be surprised to find a DS component in the process generating q_t, the real exchange rate, for the latter will be affected by preference and technology shocks that would be likely to include permanent components, implying that q_t is not covariance stationary. That situation would imply that s_t and $p_t - p^*_t$ are not cointegrated, but it would not necessarily invalidate the practical messages of the PPP doctrine.[12] Furthermore, if one expresses PPP as a long-run *neutrality* proposition, then it is clearly not invalidated by the presence of a permanent real component in the q_t process. It is my opinion that this is the way that PPP should be stated in the first place, i.e., as a long-run neutrality proposition.

11. Trend stationary means covariance stationary after removal of any deterministic trend.
12. I refer to long-run messages, of course. On a quarter-to-quarter or year-to-year basis, PPP fails in all respects.

IV. Superneutrality

The QTM proposition ending Section II, that steady-state inflation rates move one-for-one with steady-state money growth rates, does not imply that different maintained money growth (and inflation) rates do not have sustained effects on real variables. In particular, it does not rule out permanent effects on *levels* of output, consumption, real interest rates, etc. In fact, an increased (for example) inflation rate will normally imply an increased nominal interest rate and therefore an increased differential between the rates of interest on money and "bonds." This change amounts to an increased cost of holding real money balances so rational agents will choose to hold a smaller fraction of their assets in the form of money. Unless agents are holding so much money that they are satiated with its transaction-facilitating services, therefore, they will utilize smaller amounts of these services. In many cases, the implied type of portfolio readjustment will lead to changes in the steady-state levels of capital/labor and capital/output ratios, which are important real variables. If no such changes in real variables occur with altered steady-state inflation rates, the economy is said to possess the property of "superneutrality." The latter is thus another concept to consider in the context of long-run relationships between monetary and real variables. From what has been said, however, it should be clear that superneutrality should not be expected to hold in economies in which money provides transaction-facilitating services, as it does normally in most actual economies. Departures from superneutrality are likely to be small, however, for reasons discussed in McCallum (1990). Thus, for example, an increase in the steady-state inflation rate from zero percent (per annum) to 5 percent would perhaps result in a fall in the steady-state real rate of interest of only about 0.04 percent.[13]

One of the variables that is unaffected by alternative ongoing inflation rates when superneutrality holds is the (e.g., one-period) real rate of interest. The absence of superneutrality, on the other hand, implies that a change in the steady-state inflation rate may change the steady-state real rate of interest. It should be noted that this type of change does not imply any violation of the famous Fisher equation, $r_t = R_t - E_t\Delta p_{t+1}$. The latter should be thought of, I would suggest, as a definition of r_t.[14] There is arguably some confusion in the literature on this matter, with some writers incorrectly suggesting that the Fisher equation is incompatible with an altered inflation rate having a (steady-state) effect on the real interest rate. In the Sidrauski-Brock model, the steady-state real rate of interest is invariant to the steady-state rate of inflation, but such is not the case in a typical overlapping-generations model, even though the Fisher equation holds in both of them (McCallum [1990]).

13. For this calculation, involving specific assumptions about functional forms and quantitative magnitudes, see McCallum (2000, pp. 876–879).
14. Actually, the exact discrete-time expression is $(1 + R_t) = (1 + r_t)(1 + E_t\Delta p_{t+1})$. In these expressions, $E_t z_{t+j}$ reflects the expectation formed in period t of z_{t+j}.

V. The Natural-Rate Hypothesis

There is another concept involving long-run relationships, frequently mentioned in the literature, that differs from both neutrality and superneutrality—but is sometimes confused with the latter. This is the "natural-rate hypothesis," introduced by Friedman (1966, 1968) and refined by Lucas (1972). Friedman's version of this hypothesis is that differing steady-state inflation rates will not keep output (or employment) permanently high or low relative to the "natural-rate" levels that would prevail in the absence of nominal price stickiness in the relevant economies. Lucas's version is stronger; it is that there is no monetary policy that can permanently keep output (or employment) above its natural-rate value, not even an ever-increasing (or ever-decreasing) inflation rate. Note the distinction between these concepts and superneutrality: an economy could be one in which superneutrality does not obtain, in the sense that different permanent inflation rates lead to different steady-state levels of capital and thus the natural rate of output, without any implied failure of the natural-rate hypothesis (NRH).

The validity of the NRH, or Friedman's weaker version called the "accelerationist" hypothesis, was a matter of much analysis and debate in the late 1970s and early 1980s. Initial empirical tests were not supportive of the NRH, but the arguments of Lucas (1972) and Sargent (1971) that the utilized test procedures presumed expectational irrationality led to a reversal of typical findings and by 1980 even self-styled Keynesian economists were agreeing to the proposition that the NRH was basically valid. In recent years, however, this agreement has seemingly been implicitly overturned, not by argument but merely by example, via the widespread adoption of the famous Calvo (1983) model of nominal price stickiness. In its basic discrete-time form, the Calvo model posits that price adjustments can be made during any period by only a fraction of all sellers, with all others holding their nominal prices fixed at their previous-period values. This assumption leads to the following aggregate (average) relationship, in which π_t represents inflation, y_t is the log of output, and $\bar{y}_t$ is the natural rate (i.e., flexible price) level of output:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa(y_t - \bar{y}_t). \tag{2}$$

Here, β is a discount factor satisfying $0 < \beta < 1$ so, in a steady state, we have an implied relationship between inflation and the (constant) output gap, i.e., the constant value of $y_t - \bar{y}_t$. Therefore, the Calvo model does not satisfy even the accelerationist hypothesis, much less the stronger NRH. It is surprising to me that relationships similar to (2) would be used so frequently in today's analysis.[15] I would think that analysts would, at a minimum, replace (2) with something like the following:

$$\pi_t - \pi = \beta(E_t \pi_{t+1} - \pi) + \kappa(y_t - \bar{y}_t). \tag{2'}$$

15. I have used them several times myself, but mainly for illustrative purposes (as below).

Here, π represents the steady-state inflation rate under an existing policy rule, assumed to be one that permits a steady-state inflation rate.[16] Such a relationship would result if it is assumed that those sellers that do not have an opportunity (in a given period) to reset their prices optimally have their prices rise at the ongoing inflation rate (rather than held constant). From a steady-state perspective, (2′) would imply $y_t - \bar{y}_t = 0$, thereby satisfying the accelerationist hypothesis, Friedman's weaker version of the NRH. (Even so, specification (2′) does not imply the stronger Lucas version, which pertains to inflation paths more general than steady states.)

In what way would this change affect current reasoning regarding monetary policy? Basically, it would imply that different steady-state inflation rates would not induce different steady-state output gaps. In the influential analysis of Woodford (2003, chapter 6), the optimal steady-state inflation rate is zero, in the absence of traditional shoe-leather costs of inflation (due to transaction frictions that give money its medium-of-exchange role).[17] Thus, with these frictions included, as in Friedman (1969), the optimal rate will lie between zero and the negative value implied by Friedman's analysis. But with our suggested change to price adjustment specification (2′), the Friedman rate (which reduces the opportunity cost of holding money to zero) would seem to be implied from the steady-state perspective.

This last bit of reasoning does not, it should be added, take account of the zero lower bound on short-term interest rates—a complication that we have come to appreciate in recent years. That topic too is treated in detail by Woodford (2003). I hope that you will be relieved to hear that I have nothing to say about that subject today.

VI. Contemporary Monetary Policy Analysis

I have observed elsewhere (McCallum [2001]) that recent years have seen a notable convergence, among academic and central bank researchers, on a general approach for conducting analysis of monetary policy. While there are some aspects of this approach that I find slightly disquieting, by and large the convergence and the general approach both seem predominantly fruitful and encouraging. Let me briefly describe the approach and discuss a few issues that it raises. The method or approach on which there is substantial agreement can be outlined as follows: the researcher specifies a quantitative macro model that is intended to be structural (invariant to policy changes) and consistent with both theory and data. Then, by stochastic simulation or analytical means, he determines how crucial endogenous variables (such as inflation and the output gap) behave on average under various alternative policy rules. Usually, rational expectations (RE) is assumed to hold and frequently the model is based on optimizing analysis but with some form of nominal price or wage stickiness included. Evaluation of the different outcomes can be accomplished by means of an optimal control exercise, or by reference to an explicit objective function, or left to the judgment (i.e., objective function) of the implied policymaker. This approach is not entirely new,

16. Other reference values for inflation yield similar results.
17. Also see King and Wolman (1999).

of course, but major advances have been made in the last 10–12 years in terms of techniques, models, and extent of agreement.[18]

There is also considerable agreement about the general, broad structure—not details—of the macroeconomic model to be used.[19] It can be outlined in terms of a simplified three-sector representation in which R_t is a one-period interest rate while p_t and y_t are logs of the price level and output, with $\bar{y}_t$ the natural-rate value of y_t:

$$y_t = b_0 + b_1(R_t - E_t\Delta p_{t+1}) + E_t y_{t+1} + v_t \quad b_1 < 0 \tag{3}$$

$$\Delta p_t = \beta E_t \Delta p_{t+1} + \kappa(y_t - \bar{y}_t) + u_t \quad \kappa > 0 \tag{4}$$

$$\begin{aligned} R_t = (1-\mu_3)[&\mu_0 + \Delta p_t + \mu_1(\Delta p_t - \pi^*) + \mu_2(y_t - \bar{y}_t)] \\ &+ \mu_3 R_{t-1} + e_t. \end{aligned} \tag{5}$$

Here, (3) represents an optimizing IS-type relation or set of relations, (4) a price adjustment relation or set of relations such as (2) above, and (5) a Taylor-style monetary policy rule for period-by-period (e.g., quarters) setting of the policy instrument R_t. Also, $E_t z_{t+j}$ is the expectation of z_{t+j} conditional on information available in t, while v_t, u_t, and e_t are exogenous shocks, v_t reflecting tastes and fiscal policy. If capital and therefore $\bar{y}_t$ are treated as exogenous, as in the simplest versions, then (3)–(5) determine time paths for y_t, Δp_t, and R_t.[20] If investment is treated endogenously, then capital and $\bar{y}_t$ become endogenous and additional relations must be included in the sector here represented by (3). With no money stock terms in (3) or (4), it is not necessary to include a money demand equation even though one may be implied by the optimizing analysis.

The policy rule may or may not reflect optimizing behavior by the central bank, depending on the purpose of the analysis. If the object is to find the optimal policy for the particular model under consideration, then (5) will be replaced by the implied rule for R_t that results from optimization with respect to the central bank's objective function—which itself may or may not be explicitly based on the utility function of private agents.[21] But it seems to me untrue that all worthwhile analysis presumes optimization by the central bank; analysis of the differing effects of different hypothetical rules represents an alternative approach that may be useful for certain problems.

VII. Some Issues

One issue that has been raised by various economists concerns the absence of monetary variables from the system (3)–(5). Does this absence imply that the model represents

18. The development has been due to many researchers. Outstanding contributions include Taylor (1993), King and Wolman (1996), Clarida, Gali, and Gertler (1999), Rotemberg and Woodford (1997), and Woodford (1999a, 2003), among others.
19. See, e.g., Clarida, Gali, and Gertler (1999) and papers in the volume edited by Taylor (1999).
20. Also included are relevant transversality conditions.
21. No actual central bank has as yet publicly disclosed an explicit objective function, presumably because none has been adopted.

an economy in which money is not important, in which there is no medium of exchange that facilitates transactions and serves also as a medium of account? Is the implied economy one in which inflation is a non-monetary phenomenon? Is it one in which the QTM does not hold? Let us consider these questions.

The final question can be answered quickly. Inspection of the model's equations (3)–(5) indicates no departure from zero-degree homogeneity in nominal variables. Also, the optimizing analysis that leads to (3) would in addition lead to a money demand function of the form

$$m_t - p_t = \gamma_0 + \gamma_1 y_t + \gamma_2 R_t + \eta_t, \tag{6}$$

where m_t is the log of (base) money and η_t is a shock affecting the function that describes the transaction-facilitating properties of money. So it is evidently the case that the QTM pertains to the modelled economy.

To address the other questions, it is useful to consider the RE solution to the model at hand. On the basis of inspection, one can specify that the standard, bubble-free RE solution will be of the form

$$y_t = \phi_{10} + \phi_{11}\bar{y}_t + \phi_{12}R_{t-1} + \phi_{13}v_t + \phi_{14}u_t + \phi_{15}e_t, \tag{7a}$$

$$\Delta p_t = \phi_{20} + \phi_{21}\bar{y}_t + \phi_{22}R_{t-1} + \phi_{23}v_t + \phi_{24}u_t + \phi_{25}e_t, \tag{7b}$$

$$R_t = \phi_{30} + \phi_{31}\bar{y}_t + \phi_{32}R_{t-1} + \phi_{33}v_t + \phi_{34}u_t + \phi_{35}e_t. \tag{7c}$$

From (3), it can be seen that the average real rate of interest is $-b_0/b_1$, so we presume that the central bank sets its policy parameter μ_0 equal to that value. Let us also assume that the price adjustment relation (4) satisfies the accelerationist hypothesis, perhaps (but not necessarily) by being of form (2′). Then, in (7a), we know that $\phi_{11} = 1$ with $\phi_{10} = \phi_{12} = 0$. Next, apply the unconditional expectation operator E to (5). Then substitution into the latter of $\mu_0 = ER_t - E\Delta p_t$ yields the implication that $E\Delta p_t = \pi^*$. Therefore, we find that the system implies that the long-run average inflation rate is determined entirely by the central bank's target value, π^*. In this crucial sense, average inflation is—according to this model—determined entirely by monetary policy. It is the case, moreover, that the central bank has the power to set the one-period nominal interest rate, R_t, basically because of its ability to control the supply of base money.[22] If the central bank did not have that ability, it might not be able to implement its interest rate rule (5).

Accordingly, I would judge that an economy depicted by the system (3)–(6) is one that conforms in most important ways to traditional monetary analysis. While it may or may not be optimal for central banks to conduct policy by means of interest rate management, it is evidently the case that most of the leading central banks do so—and this conclusion does not have radical implications for monetary policy analysis.

22. For discussion of issues concerning the declining importance of base money, see McCallum (2004).

One of the healthy aspects of the contemporary style of monetary policy analysis, as described above, is that it leads analysts to emphasize the effects of the systematic component of monetary policy, as opposed to the effects of policy "shocks," featured in (for example) vector autoregression (VAR) analysis. This altered emphasis is healthy partly because most of the variation in interest rate instrument values, such as the federal funds rate in the United States, is evidently systematic (not random). Estimates of quarterly Taylor rules, for example, typically indicate that only about 2–5 percent of the variation in such rates is unexplained and therefore plausibly unsystematic.

Emphasis on the systematic rather than unsystematic portion of policy, moreover, leads naturally to the predominance of models that are designed to be structural, i.e., invariant to policy changes. Thus, analysis with VAR models has been de-emphasized in recent years. To me this seems a healthy trend, most importantly because VAR models—even "identified" or "structural" VAR models—are not structural in the sense of including equations that are designed to be invariant to alternative policy rule specifications. Such models are not, therefore, appropriately specified for use in the design of monetary policy (Lucas [1976]).

In addition, it seems to me that there are a number of fallacies which can easily result from application of VAR methods to policy issues. Two of these can be illustrated by a system just slightly different from the one in equations (3)–(6) and (7) above. Specifically, I now assume that the relevant model of the economy is given by

$$y_t = b_0 + b_1(R_t - E_t\Delta p_{t+1}) + E_t y_{t+1} + v_t \quad b_1 < 0 \tag{8}$$

$$\Delta p_t = [\beta/(1+\beta)]E_t\Delta p_{t+1} + [1/(1+\beta)]\Delta p_{t-1} + \alpha(y_t - \bar{y}_t) + u_t \quad \alpha > 0 \tag{9}$$

$$R_t = (1-\mu_3)[\mu_0 + \Delta p_t + \mu_1(\Delta p_t - \pi^*) + \mu_2(y_t - \bar{y}_t)] + e_t, \tag{10}$$

and

$$\Delta m_t - \Delta p_t = \gamma_0 + \gamma_1\Delta y_t + \gamma_2\Delta R_t + \eta_t. \tag{11}$$

Here, I have eliminated interest rate smoothing from the policy rule (10) and have altered the price adjustment equation (9) so as to reflect "inertia" that seems to be present for some theoretically impure reason. In this system, (8), (9), and (10) determine y_t, Δp_t, and R_t, so the solution for those three variables is given by equations of the form

$$y_t = \phi_{10} + \phi_{11}\bar{y}_t + \phi_{12}\Delta p_{t-1} + \phi_{13}v_t + \phi_{14}u_t + \phi_{15}e_t, \tag{12a}$$

$$\Delta p_t = \phi_{20} + \phi_{21}\bar{y}_t + \phi_{22}\Delta p_{t-1} + \phi_{23}v_t + \phi_{24}u_t + \phi_{25}e_t, \tag{12b}$$

$$R_t = \phi_{30} + \phi_{31}\bar{y}_t + \phi_{32}\Delta p_{t-1} + \phi_{33}v_t + \phi_{34}u_t + \phi_{35}e_t. \tag{12c}$$

With $\bar{y}_t$ exogenous, then it is clear that there is no Granger causality from the money growth rate Δm_t to inflation. In fact, there is no Granger causality from the interest rate instrument, R_t, to inflation. And if the variance of the random component of monetary policy, e_t, is small—it could in principle equal zero!—then a variance decomposition analysis would find little effect on inflation of monetary policy conducted via R_t. In short, VAR-type analysis could easily lead to the idea that inflation is not due to monetary policy, in an economy of the depicted type, although the average inflation rate would be determined by the inflation target in the monetary policy rule, as in the example above.

A very interesting development, due primarily to Woodford (1999b), is that of the "timeless perspective" approach to policy rule formulation. The basic idea is that a central bank would commit itself not to a fixed algebraic rule for policy, but to a fixed *process* of decision-making. Then the same type of optimization calculation could be conducted each period without the internal dynamic inconsistency of standard "commitment" procedures, but with scope for updating the central bank's model of the economy whenever new results indicate that such a change is needed. This approach would not fully overcome the dynamic inconsistency "temptation" identified by Kydland and Prescott (1977), but would feature full continuation on its own terms, after a start-up period that avoids any attempt to exploit the conditions that happen to prevail at the date at which this approach is first adopted. It would accordingly stand a good chance of achieving credibility, and would in almost all circumstances perform better on average than discretionary period-by-period reoptimization (see, e.g., McCallum and Nelson [2004]).

VIII. Conclusion

The last time that I gave a paper at this conference was in 1995, and my topic was "inflation targeting." In that paper, I argued that a central bank's main duty with regard to monetary policy was to keep nominal aggregate demand growing smoothly at a rate consistent with its long-run inflation target, which should reflect a quite low inflation rate. My preferred scheme involved nominal income growth targeting, but I argued that this would in practice be very similar to inflation targeting, and that the latter should be viewed as a highly attractive policy strategy. In the years since then, we have heard a great deal more about inflation targeting, but I do not know of any development that would lead me to drastically change the basic contours of what I wrote in 1995. In particular, I still believe that the most important thing that a central bank can do, to encourage and support sustained economic growth, is to keep nominal aggregate demand growing smoothly at a pace consistent with a small but positive (and explicit) long-run inflation target.

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