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ABSTRACT

I consider some of the leading arguments for assigning an important role to tracking the growth of monetary aggregates when making decisions about monetary policy. First, I consider whether ignoring money means returning to the conceptual framework that allowed the high inflation of the 1970s. Second, I consider whether models of inflation determination with no role for money are incomplete, or inconsistent with elementary economic principles. Third, I consider the implications for monetary policy strategy of the empirical evidence for a long-run relationship between money growth and inflation. And fourth, I consider reasons why a monetary policy strategy based solely on short-run inflation forecasts derived from a Phillips curve may not be a reliable way of controlling inflation. I argue that none of these considerations provides a compelling reason to assign a prominent role to monetary aggregates in the conduct of monetary policy.

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It might be thought obvious that a policy aimed at controlling inflation should concern itself with ensuring a modest rate of growth of the money supply. After all, every beginning student of economics is familiar with Milton Friedman's dictum that "inflation is always and everywhere a monetary phenomenon" (*e.g.*, Friedman, 1992), and with the quantity theory of money as a standard account of what determines the inflation rate. Yet nowadays monetary aggregates play little role in monetary policy deliberations at most central banks. King (2002, p. 162) quotes then-Fed Governor Larry Meyer as stating that "money plays no explicit role in today's consensus macro model, and it plays virtually no role in the conduct of monetary policy."

Not all agree that this de-emphasis of money growth as a criterion for judging the soundness of policy has been a good thing. Notably, the European Central Bank continues to assign a prominent role to money in its monetary policy strategy. In what the ECB calls its "two-pillar strategy," one pillar is "economic analysis," which "assesses the short-to-medium-term determinants of price developments." According to the ECB, this analysis "takes account of the fact that price developments over those horizons are influenced largely by the interplay of supply and demand in the goods, services and factor markets." But in addition, a second pillar, "monetary analysis", assesses the medium-to-long-term outlook for inflation, "exploiting the long-run link between money and prices." The two alternative frameworks for assessing risks to price stability are intended to provide "cross-checks" for one another (ECB, 2004, p. 55).

But what exactly is the nature of the additional information that can be obtained by tracking trends in the growth of monetary aggregates, and why should it be of such crucial importance for the control of inflation as to constitute a separate "pillar" (not infrequently characterized as the "first pillar") of the ECB's policy strategy? And does "monetary analysis" genuinely represent a distinct and complementary perspective on the determinants of inflation, that cannot be subsumed into an "economic analysis" of the inflationary pressures resulting from the balance of supply and demand in product and factor markets, and that can be used to guide policy decisions?

I here review several of the most important arguments that have been made for paying attention to money, considering both the purported omissions made by "economic analysis" alone and the asserted advantages of the information revealed by monetary trends. Of course, it is impossible to review the voluminous literature on this topic in its entirety, so I shall have to stick to a few of the most prominent themes in recent discussions.

First, I consider whether ignoring money means returning to the conceptual framework that allowed the high inflation of the 1970s. The architects of the ECB's monetary policy strategy were undoubtedly concerned not to repeat past mistakes that have often been attributed to a failure to appreciate the role of money in inflation determination. Have those central banks that assign little importance to money, like the current Federal Reserve, forgotten the lessons of the crucial debates of a quarter century ago? Second, I consider the theoretical status of models of inflation determination with no role for money. Are such models incomplete, and hence unable to explain inflation without adding the additional information provided by a specification of the money supply? Or, even if complete, are they inconsistent with elementary economic principles, such as the neutrality of money? Third, I consider the implications for monetary policy strategy of the empirical evidence for a long-run relationship between money growth and inflation. And finally, I consider reasons why a monetary policy strategy based solely on short-run inflation forecasts derived from a Phillips curve may not be a reliable way of controlling inflation, and ask whether "monetary analysis" is an appropriate way to increase the robustness of the conclusions reached regarding the conduct of policy.

1 The Historical Significance of Monetarism

One of the more obvious reasons for the ECB's continuing emphasis on the prominent role of money in its deliberations is a concern not to ignore the lessons of the monetarist controversies of the 1960s and 1970s. Monetarists faced substantial opposition to their theses at the time, but they largely won the argument with their Keynesian critics, especially in the minds of central bankers. Moreover, those central banks, such as the Bundesbank, that took on board monetarist teachings to the greatest extent had the best performance with regard to inflation control in the 1970s and 1980s. Hence it may be feared that abandoning an emphasis on monetary aggregates in the conduct of monetary policy would mean returning to the intellectual framework of 1960s-vintage Keynesianism, with the consequent risk of allowing a return of the runaway inflation experienced in many countries in the 1970s.[1]

[1]For example, Lucas (2006) admits that "central banks that do not make explicit use of money supply data have recent histories of inflation control that are quite as good as the record of the ECB," but then warns: "I am concerned that this encouraging but brief period of success will foster

But is this fear well-founded? Monetarism did surely represent an important advance over prior conventional wisdom, and it would indeed be a grave mistake to forget the lessons learned from the monetarist controversy. Yet I would argue that the most important of these lessons, and the ones that are of greatest continuing relevance to the conduct of policy today, are not dependent on the thesis of the importance of monetary aggregates.[2]

First, monetarism established that monetary policy can do something about inflation, and that the central bank can reasonably be *held accountable* for controlling inflation. This was not always accepted — in the 1950s and 1960s, many Keynesian models treated the general price level as given, independent of policy, or only affected by policy under relatively extreme circumstances (when capacity constraints were reached), but not in the most common situation. Even in the 1970s, when inflation could no longer be considered a minor detail in macroeconomic modeling, it was often argued to be due to the market power of monopolists or labor unions rather than to monetary policy.

Monetarists contested these skeptical theses about the possibility of controlling inflation through monetary policy, and the quantity theory of money provided them with an important argument. Given that central banks obviously could affect — and even to a certain extent control — the quantity of money, the quantity-theoretic view of inflation made it clear that central banks *could* affect inflation, and indeed could contain it, at least over the medium-to-long run, if they had the will to do so.

But it is not true that monitoring monetary aggregates is the *only* way that a central bank can control inflation. Present-day central banks that pay little attention to money do *not,* as a consequence, deny their responsibility for inflation control. To the contrary, many have public inflation targets, and accept that keeping inflation near that target is their primary responsibility. And while the Fed has no explicit target of this kind, Federal Reserve officials speak often and forcefully about their

the opinion, already widely held, that the monetary pillar is superfluous, and lead monetary policy analysis back to the muddled eclecticism that brought us the 1970s inflation" (p. 137).

[2] I do not pretend, of course, in the brief discussion that follows, to provide an exhaustive account of the desirable elements in monetarist thought. Many other ideas originated or championed by monetarists, such as the importance of the distinction between real and nominal interest rates and the concept of the natural rate of output, have had a profound effect on contemporary monetary economics and policy analysis — but these are even more obviously independent of any thesis about the importance of monetary aggregates.

determination to ensure price stability, and the record of the past decade makes such statements highly credible. Nor do the models used for policy analysis within such banks, even when these do not involve money at all, imply that monetary policy cannot affect inflation, as is discussed further in the next section.

Second, monetarism emphasized the importance of a *verifiable commitment* by the central bank to a non-inflationary policy. Monetarists were the first to emphasize the importance of containing inflation *expectations,* and to stress the role that commitment to a policy rule could play in creating the kind of expectations needed for macroeconomic stability. Research over the past several decades has only added further support for these views.[3]

The prescription of a money growth target provided a simple example of a kind of commitment on the part of a central bank that should guarantee low inflation, at least over the long run, and moreover of a type that would be relatively straightforward for the public to monitor.[4] But, once again, this is not the *only* kind of commitment that would serve, and a central bank can fully accept the importance of commitment, and of making its commitments clear to the public, without having a money growth target. Indeed, inflation targeting central banks do clearly bind themselves to a specific, quantitative commitment regarding what their policy will aim at, and they have given great attention to the issue of how to show the public that their policy decisions are justified by their official target, notably through the publication of *Inflation Reports* like those of the Bank of England or the Swedish Riksbank.

Thus in neither case does preservation of the important insights obtained from the monetarist controversy depend on continuing to emphasize monetary aggregates in policy deliberations. And the fact that inflation targeting central banks dispense with monetary targets and analyze their policy options using models with no role for money does not imply any return to the policy framework that led to (or at any rate allowed) the inflation of the 1970s.[5] Indeed, not even Milton Friedman continued, in

[3]For example, both the importance of expectations in the monetary transmission mechanism and the advantages of suitably designed policy rules are central themes of Woodford (2003).

[4]Neumann (2006), in a review of monetary targeting by the Bundesbank, stresses the desire to influence public expectations of inflation as a central motivation for the strategy and a key element in its success.

[5]In section 4 I consider some specific errors in policy analysis that may have contributed to the "Great Inflation" of the 1970s, and discuss whether the avoidance of such errors requires a central bank to monitor the supply of money.

his later years, to view monetary targets as a prerequisite for controlling inflation.[6]

Are there nonetheless reasons to assign a greater importance to money than central banks other than the ECB generally do at present? To consider this, it is useful to begin with a discussion of the theoretical framework behind optimization-based dynamic general-equilibrium models such as that of Smets and Wouters (2003, 2007), now widely used for quantitative policy analysis in central banks, and the role of money in such models.

2 Can One Understand Inflation without Money?

A first question about the role of monetary aggregates in a sound strategy for monetary policy is whether one can reasonably base policy decisions on models of the transmission mechanism for monetary policy that make no reference to monetary aggregates. Many of the quantitative models now used in central banks are of this kind, and this is surely one of the reasons for the minor role now played by monetary statistics in policy deliberations at many central banks, as the quotation above from Larry Meyer indicates. But is there perhaps something inherently problematic about relying upon models with this feature, especially in a central bank which takes the maintenance of price stability as its primary objective? At the ECB, for example, the fact that "economic analysis" of inflation risks is expected to mean analysis in the context of models that include no role for money is one of the primary justifications given for the inclusion of a second "pillar" of the policy strategy, the cross-check provided by monetary analysis.[7]

[6] Simon London (2003) reports an interview in which Friedman stated that "the use of quantity of money as a target has not been a success," and that "I'm not sure I would as of today push it as hard as I once did." In a more recent interview, Robert Kuttner (2006) quotes Friedman as having said,"I believe [that] economists in general have ... overestimate[d] how hard it is to maintain a stable price level. We've all worked on getting rules, my money rule and others, [on the ground that] it's such a hard job to keep prices stable. Then along comes the 1980s, and central banks all over the world target price stability; and lo and behold, all of them basically succeed.... So it must be that that [it] is easier to do than we thought it was.... Once [central banks] really understood that avoiding inflation, keeping prices stable, was their real objective, their first order objective, and put that above everything else, they all turned out to be able to do it."

[7] According to the ECB, an important limitation of "economic analysis" is the fact that "important information, such as that contained in monetary aggregates, is not easily integrated into the framework used to produce the [staff macroeconomic] projections" (ECB, 2004, p. 61).

There are a variety of misgivings that one might have about the soundness of "cashless" models as a basis for policy analysis. One sort of doubt may concern their theoretical coherence, or at least their consistency with a fundamental principle of economic theory, the *neutrality of money*. One might suppose that a model that makes no reference to must either be inconsistent with monetary neutrality, or leave the general level of prices indeterminate — so that such a model could not be used to predict the consequences for inflation of alternative policies. Alternatively, one might suppose that the models are coherent as far as they go, but that they are incomplete. For example, Nelson (2003) argues that standard "new Keynesian" models that make no reference to money only model the (temporary) departures of the inflation rate from an assumed long-run steady-state inflation rate, and that this steady-state inflation rate can only be understood by taking account of the long-run growth rate of money. And finally, even if one grants that cashless models provide a theoretically coherent account of inflation determination, it may be argued that they fly in the face of well-established empirical regularities. For example, Alvarez, Lucas and Weber (2001, p. 219) assert that current consensus models involve "a rejection of the quantity theory," and argue as a consequence that some quite different theory of the monetary transmission mechanism needs to be developed.

2.1 A Model without Money

In order to address these questions about the general structure of "cashless" models of inflation determination, it is useful to give an explicit example of a model of this kind. The most basic "new Keynesian" model[8] consists of three equations. The first is an aggregate supply relation,[9]

$$\pi_t - \bar{\pi}_t = \kappa \log(Y_t/Y_t^n) + \beta E_t[\pi_{t+1} - \bar{\pi}_{t+1}] + u_t, \tag{2.1}$$

[8]In Woodford (2003) I call models of this kind "neo-Wicksellian," in order to draw attention to the fundamental role in such models of a transmission mechanism in which interest rates affect intertemporal spending decisions, so that monetary policy need not be specified in terms of an implied path for the money supply; but the terminology "new Keynesian" for such models has become commonplace, following Clarida *et al.* (1999) among others.

[9]See Woodford (2003, chaps. 3-5) for discussion of the microeconomic foundations underlying equations (2.1) and (2.2), as well as more complicated versions of the model, including some small empirical models that are close cousins of the model presented here.

where π_t represents the rate of inflation between periods t and $t+1$, $\bar{\pi}_t$ is the perceived rate of "trend inflation" at date t, Y_t is aggregate output, Y_t^n is the "natural rate of output" (a function of exogenous real factors, including both technology and household preferences), u_t is a possible additional exogenous "cost-push" disturbance, and the coefficients satisfy $\kappa > 0, 0 < \beta < 1$. This equation represents a log-linear approximation to the dynamics of aggregate inflation in a model of staggered price-setting of the kind first proposed by Calvo (1983) and incorporated into a complete monetary DSGE model by Yun (1996). In the variant of the model presented here, in periods when firms do not re-optimize their prices, they automatically increase their prices at the trend inflation rate $\bar{\pi}_t$; departures of aggregate output from the natural rate and/or cost-push shocks give firms that re-optimize their prices an incentive to choose a price increase different from the trend rate, and so create a gap between π_t and $\bar{\pi}_t$. This assumption of automatic indexation was first used in the empirical model of Smets and Wouters (2003), who assume indexation to the current inflation target of the central bank,[10] as discussed further below.

The second equation is a log-linear approximation to an Euler equation for the timing of aggregate expenditure,

$$\log(Y_t/Y_t^n) = E_t[\log(Y_{t+1}/Y_{t+1}^n] - \sigma[i_t - E_t\pi_{t+1} - r_t^n], \qquad (2.2)$$

sometimes called an "intertemporal IS relation," by analogy to the role of the IS curve in Hicks' exposition of the basic Keynesian model. Here i_t is a short-term nominal interest rate (a riskless "one-period rate" in the theoretical model, earned on money-market instruments held between periods t and $t+1$) and r_t^n is the Wicksellian "natural rate of interest" (a function of exogenous real factors, like the natural rate of output). This equation is the one that indicates how monetary policy affects aggregate expenditure: the expected short-term real rate of return determines the incentive for intertemporal substitution between expenditure in periods t and $t+1$. The equation is here written in terms of the output gap $\log(Y_t/Y_t^n)$ rather than the level of aggregate real expenditure Y_t in order to facilitate solution of the model.

The remaining equation required to close the system is a specification of monetary policy. We might, for example, specify policy by a rule of the kind proposed by Taylor

[10] Actually, their empirical model assumes indexation to an average of the current inflation target and a recent past inflation rate. The assumption here of simple indexation to the inflation trend or inflation target simplifies the algebra of the discussion below of equilibrium determination, while still conveying the essential flavor of the Smets-Wouters model of price adjustment.

(1993) for the central bank's operating target for the short-term nominal interest rate,

$$i_t = r^*_t + \bar{\pi}_t + \phi_\pi(\pi_t - \bar{\pi}_t) + \phi_y \log(Y_t/Y^n_t). \tag{2.3}$$

Here $\bar{\pi}_t$ is the central bank's inflation target at any point in time, and r^*_t represents the central bank's view of the economy's equilibrium (or natural) real rate of interest, and hence its estimate of where the intercept needs to be in order for this policy rule to be consistent with the inflation target; ϕ_π and ϕ_y are positive coefficients indicating the degree to which the central bank responds to observed departures of inflation from the target rate or of output from the natural rate respectively. I shall assume that both $\bar{\pi}_t$ and r^*_t are exogenous processes, the evolution of which represent shifts in attitudes within the central taken to be independent of what is happening to the evolution of inflation or real activity. This is a simplified version (because the relation is purely contemporaneous) of the empirical central-bank reaction function used to specify monetary policy in the empirical model of Smets and Wouters (2003). Note that while (2.3) includes two distinct types of "monetary policy shocks," corresponding to innovations in r^*_t and $\bar{\pi}_t$ respectively, there is no economic significance to anything but the sum $r^*_t + (1 - \phi_\pi)\bar{\pi}_t$; the two components are empirically identified only insofar as their fluctuations are assumed to exhibit different degrees of persistence. Like Smets and Wouters, I shall assume that the inflation target follows a random walk,

$$\bar{\pi}_t = \bar{\pi}_{t-1} + \nu^\pi_t, \tag{2.4}$$

where ν^π_t is an i.i.d. shock with mean zero, while r^*_t is stationary (or, if the natural rate of interest has a unit root, $r^*_t - r^n_t$ is stationary).

It might be thought unrealistic to assume that the output gap to which the central bank responds is identical to the theoretical conception of the output gap that appears in the aggregate-supply relation (2.1). However, if the central bank responds to a different measure (for example, to $\log Y_t$ minus a deterministic trend), the discrepancy between the central bank's conception of the output gap and the theoretically relevant one can be taken to be included in the intercept term r^*_t. (As long as the discrepancy is a function of purely exogenous variables, as in the example just proposed, this changes nothing in my analysis.)

It might also be thought extraordinary to suppose that the inflation target of the central bank, denoted $\bar{\pi}_t$ in (2.3), should coincide with the rate of inflation, denoted $\bar{\pi}_t$ in (2.1), to which price-setters index their prices when not re-optimizing them.

One interpretation of this, proposed by Smets and Wouters, is that the private sector observes the central bank's inflation target and indexes prices to it. If one does not wish to postulate a behavioral relation for the private sector that depends on an assumption of a particular type of monetary policy (namely, the existence of a well-defined inflation target at each point in time), one can interpret the indexation rate $\bar{\pi}_t$ in (2.1) as the Beveridge-Nelson (stochastic) trend of the inflation process,[11]

$$\bar{\pi}_t \equiv \lim_{T\to\infty} E_t \pi_T. \tag{2.5}$$

As we shall see, in the equilibrium of the present model, the inflation rate π_t fluctuates around a stochastic trend given by the central bank's inflation target, and since (2.4) implies that $E_t\bar{\pi}_T = \bar{\pi}_t$ for any future date T, under definition (2.5) the indexation rate will in fact equal the central bank's inflation target at each point in time, assuming that this is part of the information set of price-setters.

2.2 Can Such a Model Explain the Rate of Inflation?

A first question about this model is whether such a model — which has thus far made no reference to the economy's supply of money — has any implication for the general level of prices and for the rate of inflation. It is easily shown that it does. Using (2.3) to substitute for i_t in (2.2), the pair of equations (2.1) – (2.2) can be written in the form

$$z_t = A\ E_t z_{t+1} + a\ (r_t^n - r_t^*), \tag{2.6}$$

where

$$z_t \equiv \begin{bmatrix} \pi_t - \bar{\pi}_t \\ \log(Y_t/Y_t^n) \end{bmatrix}$$

A is a 2×2 matrix of coefficients and a is a 2-vector of coefficients. The system (2.6) has a unique non-explosive solution (a solution in which both elements of z_t are stationary processes, under the maintained assumption that the exogenous process

[11] This is well-defined as long as monetary policy implies that the inflation rate is difference-stationary, and that the first difference of inflation has an unconditional mean of zero, *i.e.*, there is no long-run inflation trend. Atheoretical characterizations of inflation dynamics in countries like the US, that lack an official inflation target, often have this property (*e.g.*, Stock and Watson, 2006). And the model sketched here implies that equilibrium inflation should have this property as well.

$r_t^n - r_t^*$ is stationary) as long as both eigenvalues of A are inside the unit circle;[12] this condition holds if[13]

$$\phi_\pi + \frac{1-\beta}{\kappa}\phi_y > 1. \tag{2.7}$$

If this condition holds (as it does for many empirical Taylor rules), the unique non-explosive solution is given by

$$z_t = \sum_{j=0}^{\infty} A^j a \; E_t[r_{t+j}^n - r_{t+j}^*]. \tag{2.8}$$

This implies, in particular, a solution for equilibrium inflation of the form

$$\pi_t = \bar{\pi}_t + \sum_{j=0}^{\infty} \psi_j E_t[r_{t+j}^n - r_{t+j}^*], \tag{2.9}$$

where

$$\psi_j \equiv [1\,0] \; A^j \; a$$

for each j.[14] This shows how inflation is determined by the inflation target of the central bank, and by current and expected future discrepancies between the natural rate of interest and the intercept adjustment made to central bank's reaction function. (If the intercept r_t^* is adjusted so as to perfectly track r_t^n, the central bank should perfectly achieve its inflation target.) So the model does imply a determinate inflation rate. Moreover, given an initial price level (a historical fact at the time that one begins to implement the policy represented by equation (2.3)), the model correspondingly implies a determinate path for the price level.[15]

[12] The analysis here treats the inflation trend to which price-setters index in (2.1) as being given by the central bank's inflation target in (2.3); thus the $\bar{\pi}_t$ appearing in both equations represents the same quantity, and this is exogenously specified by (2.4). If, instead, one supposes that the $\bar{\pi}_t$ appearing in (2.1) is defined by (2.5), one must consider the possibility of an equilibrium in which the inflation trend differs from the central bank's target rate. But one can show that under the condition (2.7) stated in the text, there cannot exist an equilibrium of that kind.

[13] See Woodford (2003, Prop. 4.3). Note that in equation (2.7) there, a factor of 4 appears, because the Taylor-rule coefficients are quoted for the case in which the interest rate and inflation rate are annualized, while the "period" of the discrete-time model is assumed to be a quarter. Here instead (2.3) is written in terms of "one-period" rates for simplicity.

[14] For plots of these coefficients in some numerical examples, see Woodford (2003, Figs. 4.5, 4.6). The coefficients are denoted ψ_j^π in the figures.

[15] It is not true, as sometimes supposed, that the initial price level fails to be determined by the

Does the fact that this model determines the equilibrium price level without any reference to the money supply imply a violation of the long-established economic principle of the *neutrality of money*? It does not. The most important aspect of monetary neutrality, and the one that represents a genuinely deep principle of economic theory, is the proposition that decisions about the supply and demand of goods and services should (if decisionmakers are rational) depend only on the *relative prices* of different goods, and not on the *absolute* price (price in terms of money) of anything. This has an important implication for the theory of inflation, which is that one cannot expect there to be a theory of the general price level (at least, not one founded on rationality and intertemporal general equilibrium) for a world *without government* — in the way that one can, for example, speak of what the relative price of oil would be in a hypothetical world in which there were no government petroleum reserves or other government interventions in the market for oil. The equilibrium price level, or alternatively the real purchasing power of the monetary unit, depends crucially on government policy, and more specifically on monetary policy: it is only the fact that the central bank's actions are *not* independent of the absolute price level that gives a nation's currency unit any specific economic significance.[16]

Thus one should not expect a well-formulated model to explain the general level of prices *except* as a result of the way in which monetary policy is specified. But this does not mean that the model must involve any reference to the supply of money. For example, the monetary policy rule might specify that the national currency is convertible into some real commodity (gold being the most popular choice, historically). The parity at which the central bank is committed to maintain convertibility

model. If t_0 is the first period in which the policy begins to be implemented, a higher price level P_{t_0} will correspond to a higher inflation rate π_{t_0} and so will provoke a higher interest-rate target from the central bank. Given the value of P_{t_0-1}, which is at that point a historical fact — and not one that is irrelevant for the central bank's policy rule — there is a uniquely determined equilibrium value for P_{t_0}, and similarly for P_t in any period $t \geq t_0$.

[16] In theory, it is possible to have a regime under which the equilibrium price level is determined by *fiscal* policy, even though the central bank behaves in a way that is independent of the absolute level of prices; this is illustrated by the theory of the functioning of a wartime bond price-support regime proposed in Woodford (2001). I shall leave aside this possibility, however, for purposes of the present discussion. Even if one accepts this type of regime as a theoretical possibility, there is no reason to think of it as a practical alternative to the assignment to the central bank of responsibility for maintaining price stability; the adoption of such schemes during wartime represents a temporary sacrifice of the goal of inflation control to increased flexibility of government finance.

is then the crucial determinant of the real purchasing power of the currency unit; the nominal stock of money that ends up being held in such an economy is neither a policy decision by the central bank nor an essential element of an account of equilibrium determination under such a regime. The kind of policy represented by (2.3) is another example of a way that a central-bank policy that does not involve a target for the quantity of money, and that can be implemented without even measuring any monetary aggregates, can determine the general level of prices.

The model is in fact fully consistent with monetary neutrality, as I have defined this principle above. Each of the two private-sector behavioral relations, (2.1) and (2.2), relates real variables only to *relative* prices. Indeed, not only is the absolute level of prices irrelevant in these equations, but the absolute rate of inflation is irrelevant as well (a property sometimes referred to as "superneutrality"): in (2.1) only the inflation rate relative to the inflation trend matters, and in (2.2) only the inflation rate relative to the nominal interest rate matters. Thus a permanent increase in the inflation rate (shifting the perceived inflation trend by the same amount), if accompanied by a corresponding increase in the level of nominal interest rates (so as to keep the short-run real rate of interest unchanged), would make the same pattern of real economic activity over time consistent with these equations. The equilibrium inflation rate is only determinate because the policy rule (2.3) does *not* have this property.

It is sometimes asserted that models like the one sketched above do not actually explain the rate of inflation without reference to money growth, but only departures of inflation from its trend rate, with the trend needing to be determined somewhere else — specifically, by the long-run rate of money growth. For example, Nelson (2003, sec. 2.2) attributes to McCallum (2001) the argument that in such models "inflation ... can still be regarded as pinned down in the long run by the economy's steady-state nominal money growth rate."[17] In particular, Nelson argues that because equations like (2.1) – (2.3) have been log-linearized, analyses using these equations

[17]This is not an obvious reading of what McCallum (2001) actually says. McCallum is concerned with whether *the aggregate-supply relation alone* can be viewed as determining the equilibrium inflation rate, independently of *monetary policy*; and his answer is that, in the new Keynesian model that he discusses, "the long-run average rate of inflation ... is controlled entirely by the central bank – the monetary authority" (p. 146). Similarly, I have shown that in the model sketched here, the inflation trend is determined purely by the central bank's policy rule. But this does not mean that the complete model, *including* equation (2.3), is incomplete; nor does McCallum suggest otherwise.

"take as given" the long-run average inflation rate rather than determining it within the model; the economic relation through which money growth determines the long-run inflation rate "is buried in the constant terms" and "suppressed altogether in the dynamic equations that are expressed in terms of deviations from the steady state."[18]

But this is a misunderstanding. While (2.8) represents a solution for the evolution of the "inflation gap" (*i.e.*, the deviation of the inflation rate from the trend $\bar{\pi}_t$), the trend inflation rate $\bar{\pi}_t$ is *also* determined within the system: it corresponds to the central bank's target rate, incorporated into the policy rule (2.3). Of course one could determine it in other ways as well; if, for example, one were to close the model by specifying a loss function for the central bank, rather than a Taylor rule, then one could derive the trend rate of inflation from this model of central-bank behavior as well. (Again it would depend on the central bank's inflation target, specified in the loss function.) The fact that the equations are log-linearized does not mean that one simply *assumes* an average inflation rate; the equations allow one to derive the average inflation rate corresponding to a given policy, though one only expects the log-linearized equations to be accurate if the solution obtained in this way is one in which endogenous variables such as the "inflation gap" turn out not to be very different from the steady-state values around which the equations have been log-linearized.[19] So while it is true that a model like this does not determine the inflation rate independently of *monetary policy*, it *does* determine the inflation rate without any reference to money growth and without any need to specify additional relations beyond those listed above.

[18] Reynard (2006) criticizes mainstream monetary policy analysis on similar grounds, arguing that linearized models "focus on relative instead of general price level fluctuations," while the issue of importance for policy is the control of the inflation trend (pp. 2-3). Lucas (2006) echoes this view, stating that a unified treatment of the inflation trend and fluctuations around the trend "remains an unsolved problem on the frontier of macroeconomic theory. Until it is resolved, the use of monetary information should continue to be used as a kind of add-on or cross-check, just as it is in ECB policy formulation today" (p. 137).

[19] The restriction of attention above to the non-explosive solution of (2.6) does not mean assuming that the variables z_t must have zero means, though that is true in the example discussed above if one supposes that r_t^* is equal to r_t^n on average. And if one were *not* to restrict attention to non-explosive solutions, there would be a multiplicity of solutions to equation system (2.6), but this problem would *not* be eliminated by adjoining a quantity equation to the system. Indeed, it would not be solved even if the policy rule (2.3) were to be replaced by an exogenously specified path for the money supply.

Some may object that an assumption that the central bank can *implement* the policy represented by equation (2.3) over the long run is unwarranted, unless it does so by paying attention to money growth and not solely to the variables appearing in the equation. Milton Friedman's (1968) celebrated critique of attempts to peg nominal interest rates might be cited as illustration of the proposition that pursuit of an interest-rate rule without reference to the resulting growth in the money supply can easily lead to eventual infeasibility of the policy. But the set of interest-rate rules that lead to unstable dynamics of the kind described by Friedman can be characterized simply in terms of the degree to which the nominal interest-rate operating target responds to variations in inflation (or the price level), output, and inflation expectations; thus one can identify rules that it *should* be possible to implement indefinitely, and others that one should *not* be able to implement.[20] In the case of a rule like (2.3), that leads to stable dynamics under plausible assumptions about expectation formation, there is no problem with the assumption that the rule determines monetary policy indefinitely. Following the rule may *imply* a stable long-run rate of growth of the money supply,[21] but there is no need to monitor money growth in order to implement the rule; and the predicted consequences of following the rule for inflation and output are the same whether money demand remains stable or not.

2.3 How Gross is the Abstraction from Reality in Ignoring Money?

Thus far I have argued that there is nothing conceptually incoherent about a model of inflation determination that involves no role whatsoever for measures of the money supply. But is such a model, while internally consistent, nonetheless patently unrealistic, so that it would be foolish to base practical analyses of monetary policy options

[20]Bullard and Mitra (2002) and Preston (2005) provide examples of analyses of this kind, in the context of a New Keynesian model similar to the one sketched in the previous section, supplemented by a model of adaptive expectation formation in the spirit of Friedman's (1968) analysis of expectational dynamics. These formal analyses confirm Friedman's assertion that an interest-rate peg should lead to explosive dynamics (and hence be eventually unsustainable), but find that a Taylor rule satisfying (2.7) is instead associated with stable expectational dynamics, and eventual convergence to a determinate rational-expectations equilibrium like that characterized in (2.9).

[21]This will be true if there exists a money-demand relation, such as (2.10) below, that remains stable over the long run.

on a model of this kind? One answer to this question would be to point out that more complicated versions of the model just sketched, such as the model of Smets and Wouters (2003, 2007), are able to account fairly well for the historically observed dynamics of inflation and other key macroeconomic variables in both the U.S. and the euro area. For example, Smets and Wouters (2007) show that their model compares favorably with atheoretical VAR or BVAR models in terms of out-of-sample forecasting performance, especially over horizons from one to three years.

Are such models nonetheless obviously unrealistic on dimensions other than those with which Smets and Wouters are concerned, so that one might nonetheless suspect that this apparent empirical success is accidental — and that the estimated "structural" relations might not prove to be structural at all, if one were to choose policies substantially different from those followed over the sample period? Of course these models, like all models, abstract from a vast number of complications of actual economies; the practical question is not whether a model is literally correct, but whether the simplifications that it involves are fatal to a realistic analysis of the types of questions for which it is intended to be used. Here I wish to focus on whether the omission of money is likely to distort key relationships that matter for an analysis of the effects of alternative monetary policy decisions.

It is especially important to address a common misunderstanding about the implications of a moneyless model like the one presented above. Such a model does not require one to believe that efforts by the central bank to control the money supply will have no effect on the economy, owing to the completely elastic character of the velocity of money, as held by some extreme Keynesians in the 1950s (the U.K. "Radcliffe Report" being the best-known expression of such views[22]). It is true that the model presented above includes no description of a demand for money; derivation of the relations (2.1) and (2.2) does not require one to take any particular view of whether money is or is not perfectly substitutable for other financial assets in private portfolio decisions. In fact, the equations as written are *compatible* with a world in which there is no special role for money in facilitating transactions, and hence no reason for money not to be perfectly substitutable with any other similarly riskless nominal asset; and deriving the model in this "frictionless" case is one way to clarify that the key relationships in the model have no intrinsic connection with the evolution of the money supply. But despite the pedagogical value of considering that case,

[22]See *e.g.,* Radcliffe Committee (1959, para. 391).

the use of such a model to understand inflation determination in an actual economy does not require one to suppose that open-market operations are in fact irrelevant, or that there is not a uniquely defined path for the money supply associated with the policy described by rule (2.3).

For the model equations presented above are also *consistent* with the existence of a well-defined money-demand curve of a conventional sort, giving rise to an additional equilibrium relation of the form

$$\log(M_t/P_t) = \eta_y \log Y_t - \eta_i i_t + \epsilon_t^m, \tag{2.10}$$

in which M_t is the (nominal) money supply in period t, the positive coefficients η_y and η_i are the income elasticity and interest-rate semielasticity of money demand respectively, and ϵ_t^m is an exogenous disturbance to money demand. This standard "quantity equation" does not contradict any of the equations written earlier; in the case of a monetary policy of the kind described by (2.3), equation (2.10) simply indicates the way in which the money supply will have to vary as the central bank implements the interest-rate target specified by (2.3). Adjoining the quantity equation to the previous system provides additional detail about what happens in the equilibrium previously described, and about what is involved in policy implementation. The additional equation is not needed, however, in order for the model to predict the evolution of inflation, output and interest rates under a given interest-rate rule; and it is accordingly not needed in order to judge whether one interest-rate rule or another would have more desirable features, as long as the objectives of policy relate only to the evolution of these variables. One's conclusions about these matters would be the same regardless of the coefficients of the money-demand specification, or indeed whether a stable money-demand relation even exists.

The model is thus not one that requires the existence of a money-demand relation such as (2.10), but not one that is incompatible with the existence of such a relation either. It is thus incorrect to claim, as Alvarez, Lucas and Weber (2001) do, that models like the one set out above "reject" the quantity theory of money, and can accordingly be dismissed in light of the empirical support for that theory. No matter how strong one might believe the evidence to be in favor of a stable money-demand relation, this would not *contradict* any of the equations of the "new Keynesian" model, and would thus provide no ground for supposing that an alternative model is needed in order to reach sound conclusions about monetary policy.[23]

Still less is the model inconsistent with such elementary observations as the fact that non-interest-earning currency continues to be held even in financially developed economies like that of the U.S. It is true that a fully "frictionless" model would not allow currency to be held if it pays an interest rate lower than the interest rate on other riskless nominal assets. And it would certainly be a mistake for a central bank to take literally the prediction of such a model that it should be impossible to raise short-term nominal interest rates above zero as long as there are no plans to retire the entire stock of currency from circulation. But one can adjoin to the model a money demand equation that solves the "paradox" of the existence of different interest rates on currency and on T-bills (or in the federal funds market), without requiring any material change in the relations relied upon above to predict equilibrium inflation.

It may be objected that while an equation of the form (2.10) is not *mathematically* inconsistent with the structural relations derived earlier, it is nonetheless not economically plausible that the transactions frictions that account for the existence of a "liquidity premium" should not also change the correct specification of relations such as (2.1) and (2.2). In fact, it is theoretically plausible that transactions frictions do have *some* effect on the correct specification of these structural relations. For example, if one motivates the existence of a liquidity premium by supposing that households obtain a service flow from cash balances, and accordingly write the period flow of utility of the representative household not as $U(C_t)$, where C_t is real consumption expenditure, but as $U(C_t, M_t/P_t)$, then except in the special case of additive separability in the two arguments — a familiar case in textbook expositions, but one that is hard to defend as realistic — the marginal utility of real income each period depends on the level of real money balances in addition to the level of consumption. This in turn means that the equilibrium real rate of interest should depend not only on current and expected future real activity (which determines equilibrium consumption), as in equation (2.2), but also on current and expected future real money balances, as discussed in Woodford (2003, chap. 2, sec. 3). This change in the relation between real activity and the marginal utility of income also implies that real money balances should generally enter the aggregate-supply relation (2.1) as well (Woodford, 2003, chap. 4, sec. 3).[24]

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[23] See, *e.g.*, McCallum (2001) and Svensson (2003) for previous discussions of this point.

[24] Other, more explicit, models of the way in which cash balances facilitate transactions often have

The question is how large this correction is likely to be in practice. McCallum (2001), Woodford (2003, pp. 117-121 and 304-311), and Ireland (2004) all examine this issue in the context of new Keynesian models that include transactions frictions of a kind that give rise to a money demand relation of the form (2.10). McCallum and Woodford each calibrate their model specifications so that the implied money-demand relation agrees with estimated relations for the U.S., while Ireland presents maximum-likelihood estimates of a complete structural model using U.S. data on money growth, inflation, output and interest rates. All find that under an empirically realistic specification, the real-balance corrections are nonzero, but quite small, and that they make little difference for the quantitative predictions of the model with regard to a variety of monetary policy experiments.

And even granting that one wishes to take corrections of this kind into account, for the sake of greater accuracy, it is not obvious that this implies that money balances should become an important state variable. While in the non-separable case, the marginal utility of income is no longer a function solely of consumption and exogenous preference parameters, the missing variable can as well be described as the *interest-rate differential* between non-monetary and monetary assets (which represents the opportunity cost of holding wealth in the form that yields transactions services), as some measure of the *quantity* of liquid wealth. At least in some cases, expressing the relationship in terms of the interest-rate differential is clearly superior. Suppose, for example, that the utility in period t is given by a (non-separable) function of the form

$$U(C_t, M_t/(P_t\bar{m}_t)),$$

where $\bar{m}_t$ is an exogenous disturbance representing changes in the transactions technology. In this case, the marginal utility of (real) income λ_t will depend on C_t and $M_t/(P_t\bar{m}_t)$, and the equilibrium interest-rate differential Δ_t will *also* be a function of those two quantities, so that there exists a functional relationship

$$\lambda_t = \lambda(C_t, \Delta_t)$$

that is invariant to changes in the transaction technology. (The relationship between λ_t, C_t and M_t/P_t will instead also involve the disturbance $\bar{m}_t$.) Using this relation, one can express the generalized versions of the structural relations (2.1) and (2.2) in

a similar implication; see, *e.g.*, Woodford (2003, appendix, sec. A.16).

terms of inflation, output, and *two* short-term nominal interest rates (the interest rate on non-monetary assets and the interest rate paid on money, if any), as discussed in Woodford (2003, chap. 4). Since the payment of interest on money is not commonly used as an independent instrument of policy, this does not introduce any additional state variables, though the dynamics of the effects of interest rates on inflation and output are now somewhat more complex than in the baseline model presented above. Writing the model in terms of inflation, output, the nominal interest rate (on non-monetary assets) and money balances would not only introduce an additional state variable, but would introduce dependence of all three structural equations on an additional structural disturbance ($\bar{m}_t$), that could be eliminated by writing the model in terms of the *cost* of liquidity rather than the *quantity* of liquid balances.

More generally, it is often observed that the basic New Keynesian model abstracts from financial frictions of all sorts, when it refers to a single interest rate that is taken to be both the central bank's policy rate and the unique measure of the relative cost of current and future expenditure by the private sector. This is obviously an over-simplification, and some feel that a more complete account of the monetary transmission mechanism, distinguishing among the variety of interest rates and asset returns that co-exist in a typical economy, would inevitably restore an important role to monetary aggregates as a key determinant (or crucial indicator) of changes in the structure of asset returns.[25] This is too large a topic to address here in detail, but two brief comments are appropriate.

First, there is nothing essential to the logic of the New Keynesian model that requires that it abstract from financial frictions, and extensions of the basic New Keynesian model to incorporate various types of credit-market frictions have been proposed by Bernanke *et al.* (1999), Christiano *et al.* (2003, 2007), and Goodfriend and McCallum (2007), among others. To the extent that such frictions are judged to be of quantitative importance for monetary policy analysis, they can be incorporated into a mainstream New Keynesian framework; belief that they are important is neither a reason to reject the empirical relevance of such a framework, nor a reason to consider

[25]Nelson (2003) argues for this view, though without offering a specific theory of how money is related to other asset returns and how these matter to the monetary transmission mechanism. Goodfriend and McCallum (2007) present an explicit model with financial frictions that result in multiple interest rates, and use it to argue for the quantitative importance of "money and banking" to the transmission mechanism.

money and credit developments within a wholly distinct and competing analytical framework, as under the ECB's "two pillar" strategy.[26]

Second, it is far from obvious that assigning an important role to *credit* frictions in the monetary transmission mechanism implies that the monetary aggregates stressed in the traditional monetarist literature should be important state variables. For example, in the influential "financial accelerator" model of Bernanke *et al.* (1999), the key innovation relative to a standard New Keynesian model is the introduction of an endogenous wedge between the required ex ante rate of return on investment projects and the rate of return received by savers, the size of which depends on the aggregate net worth of entrepreneurs; the evolution of the net worth of entrepreneurs, in turn, depends mainly on the equilibrium returns to capital. The size and evolution of this friction have no essential connection with any monetary aggregate, and indeed, it would be possible to simplify the model, abstracting from the use of cash to facilitate transactions altogether, without any fundamental change in the model's predictions with regard to the response of output and inflation to either real disturbances or monetary policy (specified in terms of an interest-rate rule such as (2.3)).[27]

In this, as in other models of the "financial accelerator" type, the key impediment to efficient financial intermediation derives from the circumstances of the borrowers (a lack of internal funds or of suitable collateral), rather than some inability of intermediaries to obtain sufficient funds to lend, as in traditional discussions of the "bank lending channel" of monetary policy. Credit frictions of this kind seem more likely to be quantitatively significant for economies like the U.S., where there are many substitutes for bank credit and banks have many sources of funds other than the supply of transactions deposits; so it is not obvious that variations in the money supply should have much connection with the relevant credit frictions. Moreover, even if lending by banks is assumed to play a crucial role (on the ground that other sources of finance are imperfect substitutes), it would seem to be variations in the volume of *bank credit* that would be of greatest macroeconomic significance, rather than variations in the volume of those specific bank liabilities that are counted as

[26] The suggestion of ECB Vice President Lucas Papademos (2006) that one can eventually imagine the two separate analyses being combined in a "single ... larger pillar" is surely a sensible one, though it remains to be seen how "prominent" a role there is for money in the eventual synthesis.

[27] This is illustrated by the work of Cúrdia (2007), who develops an open-economy extension of the model of Bernanke *et al.* that is purely "cashless."

part of the money supply.[28]

3 Implications of the Long-Run Relationship Between Money and Prices

The monetarist argument for the importance of attention to monetary aggregates in a strategy to control inflation is above all an empirical one. The association of money growth with inflation is argued, as an empirical matter, to be highly robust, confirmed by data from different centuries, from different countries, and from economies with different financial institutions and different monetary and fiscal policies. Empirical work in the monetarist tradition often emphasizes simple correlations (and sometimes lead-lag relationships) rather than structural estimation; but it may be argued that the relations thus uncovered represent more certain knowledge, because they are independent of any maintained assumption of the correctness of a particular structural model. Monetarists argue that the causal relation between money growth and inflation is as a consequence one that can more safely be relied upon in designing a policy aimed at controlling inflation than the relations (such as the Phillips curve) that make up a structural macroeconometric model.

It is important, then, to consider the nature of the long-run evidence to which the monetarist literature frequently refers. My goal here will not be to criticize the soundness of the statistical evidence itself, but rather to ask — even taking the evidence at face value — how much of a case one can build on it for the importance of using monetary aggregates in assessing the stance of monetary policy.

While early advocacy of money-growth targets was often based on analyses of the correlation between money growth and real and/or nominal national income at business-cycle frequencies, these correlations have broken down in the U.S. since the 1980s, [29] and the more recent monetarist literature has instead emphasized the wide

[28]Although Goodhart (2007) argues that central banks ought still to pay attention to "monetary aggregates," his argument is primarily for the significance of variations in the efficiency of intermediation by commercial banks, and indeed he remarks that he "believe[s] that the rate of growth of bank lending to the private sector is as, or a more, important monetary aggregate than broad money by itself" (p. 60).

[29]See, for example, Estrella and Mishkin (1997), Hafer and Wheelock (2001), and Walsh (2003, Fig. 1.3). More recently, relations of this kind have been much less stable in the euro area as well.

range of evidence that exists for a long-run relationship between money growth and inflation. This relationship is argued to be more robust, and to suffice as a justification for controlling money growth given a central bank's proper concern with the character of long-run inflation trends.

Studies of the long-run or low-frequency relationship between money and prices are of several types. First, cross-country correlations between money growth and inflation, averaged over long periods, typically show a strong positive relationship, and even a certain tendency of the data points for different countries to fall near a line with a slope of 45 degrees, as predicted by the quantity theory of money, at least when countries with very high average inflation rates are included in the sample. McCandless and Weber (1995) provide a number of plots of this kind, one of which (comparing 30-year averages of M2 growth and CPI inflation for a sample of 110 countries) was included in Robert Lucas's (1996) Nobel lecture as empirical confirmation of that theory.[30] Further cross-country comparisons are presented by King (2002) and Haug and Dewald (2004).[31]

Second, low-frequency movements in money growth and in inflation can be compared in a single country, if sufficiently long time series are available to allow consideration of how low-frequency trends change over time. Bandpass filtering of the respective time series has become a popular method in studies of this kind; essentially, this means taking long moving averages of the data, so as to average out high-frequency fluctuations. For example, Benati (2005) compares the low-frequency variations in money growth and inflation in both the U.K. and the U.S., using various measures of money and prices, and data from the 1870s to the present; his bandpass filters retain only fluctuations with a period of 30 years or longer. Even with this

For a recent discussion of the stability of M3 demand in the euro area, and its implications for the usefulness of "excess liquidity" measures based on cumulative M3 growth, see Bordes *et al.* (2007). Fischer *et al.* (2007) document the reduced reliance on estimated money-demand relations in recent years in the monetary analysis of the ECB.

[30]Lucas argues that "it is clear from these data ... that ... the quantity theory of money ... applies, with remarkable success, to co-movements in money and prices generated in complicated, real-world circumstances. Indeed, how many specific economic theories can claim empirical success at the level exhibited in [the figure of McCandless and Weber]? ... The kind of monetary neutrality shown in this figure needs to be a central feature of any monetary or macroeconomic theory that claims empirical seriousness" (Lucas, 1996, p. 666). The same figure is repeated, with similar comments, in Lucas (2006).

[31]See, however, de Grauwe and Polan (2001) for criticism of evidence of this kind.

degree of smoothing of the data, several long swings in the rate of money growth have occurred in each country over the sample period, and the timing and magnitude of the shifts in the low-frequency trend are similar for both money growth and inflation. Similar results are obtained (albeit with shorter time series and hence averaging over a somewhat shorter window) for euro-area data on money growth and inflation by Jaeger (2003) and Assenmacher-Wesche and Gerlach (2006).

Another popular approach to studying the long-run relationship between money growth and inflation in a single country is cointegration analysis. Two (or more) non-stationary series are said to be cointegrated if there is nonetheless a linear combination of the series that is stationary. Assenmacher-Wesche and Gerlach (2006), for example, find that in the euro area, broad money growth and inflation are each non-stationary series (stationary only in their first differences), but that the two series are cointegrated. This implies that they have a common (Beveridge-Nelson) "stochastic trend": changes in the predicted long-run path of one series are perfectly correlated with changes in the predicted long-run path of the other series. Moreover, one cannot reject the hypothesis that the linear combination of the two series that is stationary is their difference (*i.e.,* real money growth), so that a one percent upward shift in the predicted long-run growth rate of broad money is associated with precisely a one percent upward shift in the predicted long-run rate of inflation, in accordance with the quantity theory of money. Cointegration analysis is similarly used to establish a long-run relationship between euro-area money growth and inflation by Bruggeman *et al.* (2003) and Kugler and Kaufmann (2005). Thus the results obtained from all three approaches to studying the long-run relationship between money growth and inflation are quite consistent with one another, and with the predictions of the quantity theory of money.

But what does the existence of such a long-run relationship imply for the use of monetary aggregates in the conduct of monetary policy? For the sake of argument, I shall take for granted that the empirical case has been established, and ask what would follow from this for policy. Of course, there are always questions that can be raised about the certainty with which econometric results have been established — claims about the "long run" in particular are notoriously difficult to establish using short time series — and about whether correlations observed under historical conditions should be expected to persist under an alternative policy, designed in order to exploit them. But I think that the monetarist interpretation of these data is indeed the most plausible one, and I shall not challenge it.

In particular, I shall suppose that it has been established that — for example, in the euro area — there really is a reliable structural equation of the form

$$\log M_t - \log P_t = f(X_t), \tag{3.1}$$

representing money demand behavior, and holding independently of the monetary policy that may be followed by the central bank.[32] Here $f(X_t)$ represents some function of both real and nominal variables with the property that, given the exogenous processes for real disturbances, $f(X_t)$ will be a *difference-stationary* process in the case of any monetary policy that makes the inflation rate a difference-stationary process, with an unconditional growth rate

$$g \equiv E[\Delta f(X_t)]$$

that is independent of monetary policy. If this is the case, then if inflation is difference-stationary (or I(1)), money-growth will also have to be difference-stationary, and money growth and inflation will have to be cointegrated, with a cointegrating vector $[1\ -1]$, since first-differencing (3.1) implies that $\mu_t - \pi_t$ must equal the stationary process $\Delta f(X_t)$. Moreover, the unconditional mean of this process is

$$E[\mu_t - \pi_t] = g, \tag{3.2}$$

so that over the long run, the average rate of inflation will be the average rate of money growth minus g, regardless of what that rate of money growth may be. The hypothesis of a relation of the form (3.1) is thus a simple interpretation of the empirical relations asserted in the literature just mentioned.

The important question is, even granting the existence of a reliable structural relation of this kind, what are the implications for the conduct of monetary policy? A first proposal might be that the existence of a well-established empirical relation of this kind implies that "cashless" models of inflation determination are incorrect, and hence not a sound basis for policy analysis. But this would not follow. As explained in the previous section, the possibility of explaining inflation dynamics without any

[32] Benati (2005) argues that because (in the case of UK data since 1870) the low-frequency relation between money growth and inflation has remained similar despite a succession of fairly different monetary policy regimes, one can best interpret the relation as structural. The same argument had earlier been made by Batini and Nelson (2001).

reference to monetary aggregates does not depend on a denial that a stable money-demand relation exists — it requires only that the system of equilibrium conditions (including the quantity equation) have a certain recursive structure. I have shown that a cashless model can be consistent with a standard form of money-demand relation, and one can also easily show that such a model is consistent with the existence of a cointegrating relation between money growth and inflation of the kind often found empirically.

Let us consider again the same log-linear "new Keynesian" model as above, extended to include a money-demand relation of the form (2.10), and assume once more a monetary policy of the form (2.3), with an inflation target that evolves as a random walk (2.4) just as in the empirical model of Smets and Wouters (2003). Finally, let us suppose either that both r_t^n and r_t^* are stationary processes, or at any rate that the difference $r_t^n - r_t^*$ is stationary, indicating that the central bank succeeds in tracking variations in the natural rate of interest, at least over the long run. Then the solution (2.9) implies that the inflation rate π_t is an $I(1)$ random variable, with a stochastic trend equal to $\bar{\pi}_t$. First-differencing (2.10) furthermore implies that

$$\mu_t - \pi_t = \eta_y \gamma_t - \eta_i \Delta i_t + \Delta \epsilon_t^m, \tag{3.3}$$

where $\gamma_t \equiv \Delta \log Y_t$ is the growth rate of output. Solution (2.8) similarly implies that the output gap is stationary, so that as long as the (log) natural rate of output is at least difference-stationary, γ_t will be stationary. Moreover, (2.2) implies that

$$\begin{aligned} i_t &= r_t^n + E_t \pi_{t+1} + \sigma^{-1} E_t[\gamma_{t+1} - \gamma_{t+1}^n] \\ &= r_t^* + \pi_t + (r_t^n - r_t^*) + E_t[\Delta \pi_{t+1}] + \sigma^{-1} E_t[\gamma_{t+1} - \gamma_{t+1}^n], \end{aligned}$$

where γ_t^n is the growth rate of the natural rate of output, so that $i_t - r_t^n - \bar{\pi}_t$ is a sum of stationary variables and hence stationary. Since the last two of these terms have been assumed (or just shown) to be difference-stationary, i_t must also be difference-stationary. Then if we also assume that ϵ_t^m is at least difference-stationary, every term on the right-hand side of (3.3) is stationary, so that $\mu_t - \pi_t$ is predicted to be stationary.

It would then follow that μ_t must be an $I(1)$ random variable, like π_t, but that the two variables are cointegrated, with a cointegrating vector equal to $[1\ -1]$. Hence the new Keynesian model is consistent with cointegration evidence of the kind found, for example, by Assenmacher-Wesche and Gerlach (2006). This in turn implies that the average growth rates of money and prices will necessarily be similar if one averages over a sufficiently long period of time, as the stationary difference between μ_t and π_t will have a long-run average value of zero. It follows that the theoretical model of the previous section is equally consistent with the other kinds of "long run" or "low frequency" evidence cited above. Hence such facts, no matter how thoroughly established, provide no evidence against the validity of non-monetary models of that type.[33]

A second view might be that the long-run relation between money and prices provides an argument for the desirability of a money-growth target. If a structural relation of the form (3.1) is believed to exist regardless of the monetary policy chosen, then it follows that as long as the central bank ensures that the money supply grows at some rate $\bar{\mu}$ — or at least that the rate of money growth μ_t fluctuates in a stationary way around the average level $\bar{\mu}$ — then over the long run the rate of inflation will have to equal $\bar{\mu} - g$, on account of (3.2). It is true that such a rule is only guaranteed to yield the desired rate of inflation as an average over a sufficiently long period of time. Nonetheless, it can be argued that such an approach is an especially *reliable* way of ensuring the desired long-run rate of inflation, founded as it is on a robust empirical relation; and that this is not only *one* goal of monetary policy, but perhaps the only one that can be reliably achieved.

But nothing in the argument just given implies that a money growth target is the *only* way in which a desired long-run inflation rate can be ensured. If a structural relation of the form (3.1) exists, it follows that any policy that succeeds in making the inflation rate equal some target rate $\bar{\pi}$ on average over the long run will *also* have

[33]In Woodford (2007) I illustrate this through simulation of a calibrated version of the new Keynesian model described above. When the simulated data for money growth and inflation are band-pass filtered, the low-frequency components exhibit strong comovement of the kind found in historical data by authors such as Benati (2005) and Assenmacher-Wesche and Gerlach (2006). (The low-frequency movements in money growth even appear to "lead" the low-frequency movements in the inflation rate, though this does not indicate any *causal* priority of the changes in the rate of money growth.) The simulated data are also consistent with the results obtained by Assenmacher-Wesche and Gerlach when they estimate reduced-form inflation equations using different frequency components of the data: low-frequency inflation is mainly "explained" by low-frequency money growth and output growth, whereas the output gap is instead the most significant of the regressors "explaining" high-frequency inflation. The success of this exercise shows that "two-pillar Phillips curve" estimates do not imply that standard new Keynesian models are incomplete as models of inflation determination.

to make the rate of money growth equal $\bar{\pi} + g$ on average over the long run. But this does not imply that a successful policy must involve a target for money growth; it need not involve measurement of the money supply at all.

In fact, if all that one cares about is whether an average inflation rate of two percent is maintained over a period of several decades, this is quite easy to ensure. It is only necessary that one be able to measure the inflation rate itself — and not necessarily in real time; it suffices that the lag in data availability be one of weeks rather than years — and that one be able to tell whether policy is being adjusted in a way that should lower inflation as opposed to raising it (for which an interest-rate instrument suffices). A suitable policy is then one that monitors the cumulative increase in prices relative to the two-percent-per-year target, and tightens policy if prices have risen too much, loosening it if they have risen too little. One does not need to monitor money growth to tell if an undesirable long-run inflation trend is developing; measurement of *inflation itself* suffices for this! As long as one does in fact know how to measure price increases, and to use policy to accelerate or decelerate the rate of inflation (at least over the next few years), there is little difficulty in ensuring a desired rate of inflation over a sufficiently long period of time. Of course, there are significant practical questions connected with the measurement of current inflation *at high frequencies*, and even greater difficulties in assessing the near-term inflation outlook given the current stance of policy; but the existence of a *long-term* relation between money growth and inflation does not imply any advantage of money-growth statistics in addressing those questions.

Finally, it might be thought that the existence of a long-run relation between money growth and inflation should imply that measures of money growth will be valuable in forecasting inflation, over "the medium-to-long run" even if not at shorter horizons. But this is not the case. Cointegration of money growth with the inflation rate would imply that *if* one were to know what the average rate of money growth will be over some sufficiently long future horizon, one would need no other information in order to be able to forecast the average inflation rate over that same horizon. But one does not know in advance what the rate of money growth over the long run will be (that is, unless one knows it because the central bank is determined to adjust policy to ensure a particular rate of money growth). And there is no reason to assume that the *recent* rate of growth of the money supply provides the best predictor of the future long-run rate of money growth. If money were something exogenous with respect to the central bank's actions, like the weather, then it might make sense to try to discern long-run trends from moving averages of recent observations. But the long-run growth rate of the money supply will depend on future monetary policy decisions, and there is no sense in which the existence of a "trend" toward faster money growth in recent years dooms an economy to continue to have fast money growth over some medium-to-long term.

As a simple example, consider the new Keynesian model presented above, in the special case in which the interest-rate gap $r_t^g \equiv r_t^n - r_t^*$ is a white-noise process. (This could be true either because both r_t^n and r_t^* are white-noise processes, or because the central bank adjusts r_t^* to track the changes in the natural rate of interest that are forecastable a period in advance, setting $r_t^* = E_{t-1} r_t^n$.) In this case, the solution (2.8) is of the form

$$\begin{aligned} \pi_t &= \bar{\pi}_t + a r_t^g, \\ \log Y_t &= \log Y_t^n + b r_t^g, \end{aligned}$$

for certain coefficients a, b. If inflation evolves in this way, the optimal forecast of future inflation at any horizon $j \geq 1$ is given by

$$E_t \pi_{t+j} = \bar{\pi}_t = \pi_t + (a/b) \log(Y_t / Y_t^n). \tag{3.4}$$

Thus if one uses the current inflation rate and the current output gap to forecast future inflation, one cannot improve upon the forecast using information from any other variables observed at time t.

Forecasting future inflation using the output gap *alone* would not be accurate, since inflation has a stochastic trend while the output gap is stationary; one needs to include among the regressors some variable with a similar stochastic trend to that of inflation. But this need not be money growth; *inflation itself* is also a variable with the right stochastic trend, and using current inflation to forecast future inflation means that one need not include any other regressors that track the stochastic trend. What one needs as additional regressors are *stationary* variables that are highly correlated with the current *departure* of inflation from its stochastic trend, *i.e.*, the Beveridge-Nelson "cyclical component" of inflation. In the simple example presented above, the output gap is one example of a stationary variable with that property. More generally, the thing that matters is which variables are most useful for tracking relatively high-frequency (or cyclical) variations in inflation, and *not* which variables best track long-run inflation. This is true regardless of the horizon over which one wishes to forecast inflation.

Of course, this hardly proves that monetary statistics cannot be of any use as indicator variables. In general, central banks use measures of a wide range of indicators in assessing the state of the economy and the likely effects of alternative policy decisions, and it is right for them to do so. There is no *a priori* reason to exclude monetary variables from the set of indicators that are taken into account. But the mere fact that a long literature has established a fairly robust long-run relationship between money growth and inflation does not, in itself, imply that monetary statistics must be important sources of information when assessing the risks to price stability. Nor does that relationship provide the basis for an analysis of the soundness of policy that can be formulated without reference to any structural model of inflation determination, and that can consequently be used as a "cross-check" against more model-dependent analyses. To the extent that money growth is useful as an indicator variable, its interpretation will surely be dependent on a particular modeling framework, that identifies the structural significance of the state variables that the rate of money growth helps to identify (the natural rate of output and the natural rate of interest, in their example). Thus a fruitful use of information revealed by monetary statistics is more likely to occur in the context of a model-based "economic analysis" of the inflationary consequences of contemplated policies than in some wholly distinct form of "monetary analysis."

4 Pitfalls of Phillips-Curve-Based Monetary Policy Analysis

One of the most important arguments given by the ECB for its "two-pillar" strategy is a desire to ensure a more robust framework for deliberations about monetary policy than would result from complete reliance upon any single model or guideline.[34] "The two-pillar approach is designed to ensure ... that appropriate attention is paid to different perspectives and the cross-checking of information.... It represents, and conveys

[34] This consideration is emphasized by Otmar Issing (2006), who stresses that in adopting a monetary policy strategy for the ECB, the Governing Council was equally unwilling to rely upon monetary analysis *alone*.

to the public, the notion of diversified analysis and ensures robust decisionmaking" (ECB, 2004, p. 55).[35]

The issue of robustness is certainly an important concern in choosing a monetary policy strategy, and skepticism is appropriate about the accuracy of any currently existing quantitative models of the monetary transmission mechanism. But is the practice of "cross-checking" the conclusions of "economic analysis" by monitoring money growth (along with other related statistics) the most appropriate way of ensuring robustness? In order to consider the possible advantages of such an approach, it is necessary to consider what some of the more obvious pitfalls might be of making policy on the basis of a Phillips-curve-based model of inflation dynamics alone.[36]

4.1 The Pitfall of Reliance upon Inaccurate Estimates of Potential Output

One obvious potential problem with basing monetary policy on forecasts of the near-term outlook for inflation is that the forecasts may be biased. In such a case, it might be possible for policy to be more inflationary than is intended, perhaps even for many years, because the central bank's biased forecasts persistently predict a lower inflation rate than actually occurs on average. One obviously should not wish to make it too easy for such an outcome to occur, and this is a reason for caution about making policy on the basis of a single, possibly unreliable, forecasting model.

A Phillips-curve-based short-run forecasting model might be especially vulnerable to problems of this kind, owing to the crucial role in such a model of the "output gap" as a determinant of inflationary pressures. In fact, real-time measures of the output gap are notoriously controversial, because of the difficulty of recognizing changes in

[35]The asserted greater robustness of policies that respond to monetary developments is an important theme of the defense of the monetary pillar by Masuch et al (2003), one of the background studies for the ECB's re-evaluation of its monetary policy strategy in 2003.

[36]Here I consider only the question whether the use of information from monetary aggregates as a "cross-check" (as part of a two-pillar framework) is a particularly suitable way of curing specific potential defects of a Phillips-curve-based policy analysis. A somewhat different argument, often made by monetarists, asserts that a monetary targeting rule is more robust than an "activist" policy based on a specific economic model, precisely because it requires no model for its implementation. Von zer Muehlen (2001) — originally written in 1982 — remains a useful discussion of the reasons why there is no logical connection between a preference for robustness to Knightian uncertainty and choice of a "non-activist" policy.

the "natural" (or potential) level of output at the time that they occur. Orphanides (2003a) illustrates how large the mistakes are that may easily be made by comparing "real-time" measures of the U.S. output gap available to the Fed during the 1970s to the Fed's subsequent assessment of what the output gap during that period had been. According to the view at the time (based on estimates of potential output by the President's Council of Economic Advisors), the output gap was negative throughout the 1970s, often by 5 percent or more (including the entire five-year period between 1974 and 1979), and reached a level as low as -15 percent in 1975. Based on this statistic, policy might have been viewed as relatively "tight". But from the vantage point of the 1990s,[37] the Fed had substantially revised its view of the output gap during the 1970s: according to the revised data, the output gap was instead *positive* during much of the 1970s, and only negative by a few percent even during the worst quarters of the 1974-75 recession. (The key to the change in perspective was an eventual recognition that productivity growth had been lower during the 1970s than during the previous two decades — something that had not been immediately recognized at the time.)

This type of mistake — persistently over-estimating potential output for many years in sequence — could easily result in a persistent inflationary bias to policy, at least if the output gap estimate were used to assess the stance of policy in a naive or mechanical way. This is in fact the explanation of the U.S.'s "Great Inflation" of the 1970s proposed by Orphanides (2003a, 2003b). According to Orphanides, the Fed's target for the federal funds rate throughout the 1970s was set in almost exactly the way that would be implied by a "Taylor rule", with the same inflation target and other coefficients said by Taylor (1993) to characterize Fed policy during the early Greenspan years. In his interpretation, the similar policy rule resulted in much higher inflation during the 1970s because interest rates were kept low in response to the (incorrectly) perceived large negative output gaps.

This is clearly an important practical problem. Avoiding a repetition of the "Great Inflation" of the 1970s should be a key goal in the choice of a monetary policy strategy. It is perhaps too much to expect any strategy to ensure against all possible policy errors; but a wise policymaker will surely strive at the least not to commit exactly the *same* mistake twice.

To what extent would a reliance upon monetary indicators in the conduct of

[37] At the time of Orphanides' study, the most recent Federal Reserve estimates of historical output gaps that had been made public dated from 1994.

policy solve this problem? It is true that, in a model like the one sketched above (to which we adjoin a standard money-demand relation, such as (2.10)), an inflationary policy that arises from an over-estimate of potential output through the mechanism hypothesized by Orphanides would be associated with a high rate of money growth. Hence a policy committed to a money growth target, or that would at least respond to persistent observations of excessive money growth by subsequently tightening policy, would not allow the inflationary policy stance to continue, even if the over-estimate of potential output were to persist for many years (as was the case in the US in the 1970s).

But this is hardly the *only* kind of policy that would preclude the possibility of an entire decade of undesirably high inflation. One did not need the signal provided by money growth to realize that policy was allowing inflation to remain high in the 1970s; the inflation data themselves were evident enough, for many years prior to the eventual dramatic shift in policy under Paul Volcker (beginning in the fall of 1979).[38] According to Orphanides' interpretation of the policy mistake, the Fed was aware of the rate of inflation, but nonetheless believed that tighter policy would be inappropriate, because of the severely negative output gap.[39] (Tighter policy, to bring down inflation at the cost of an even more negative output gap, would not have struck a proper balance between the two objectives of stabilization policy.) The additional information provided by statistics on money growth would not have dispelled this misconception. There is not, for example, any reason to suppose that if the output gap really *had* been so negative, money would not have grown at a similar rate, so that the facts about money growth should have disconfirmed the policymakers' analysis of the situation. For money demand depends on the actual level of transactions in an economy, *not* on how that level of activity compares to the "natural rate" — and as a result money is not especially useful as a source of information about the mistake

[38]Here I refer to the period following the removal of price controls in 1974. In the presence of price controls, there is obviously a particular need for indicators of the stance of policy other than the inflation rate itself. But signs of distortions created by the controls, of the sort that eventually required them to be abandoned, should provide an important clue even in the presence of price controls.

[39]As noted in section 1, other intellectual errors may have contributed to the explanation of policy in the 1970s as well, such as skepticism about the ability of monetary policy to restrain inflation. But as discussed there, attention to money would not be necessary in order to avoid those mistakes either.

that was made in the 1970s.

One thing that *would* help to avoid this kind of mistake would be the use of information other than direct measures of real activity and estimates of trends for those variables (by filtering the observations of these variables alone) in constructing one's estimate of the current "output gap".[40] An optimal estimate, based on a Kalman filter, would take into account the fact that an observation of higher inflation than had been expected should lead one to question one's view of how much "slack" there currently is in the economy, so that inflation outcomes should themselves be an important factor in the central bank's estimate of the output gap, as discussed by Svensson and Woodford (2003). Of course, money growth could also be one among the indicator variables used in such a filtering exercise, but once again, there is no reason to suppose that it should receive particular weight, given its lack of any direct causal connection with the underlying state variable that one is trying to estimate.

Of course, the construction of an optimal Kalman filter is only a complete solution to the problem of conducting policy under uncertainty when the only uncertainty is about the economy's current state,[41] rather than uncertainty about the correct *model* to use. And one should be equally concerned about the possibility of systematic policy mistakes owing to the use of a model that is incorrect in more fundamental ways. But the most obvious approach to that problem, in my view, is also one under which it is important to closely monitor *inflation outcomes,* but under which there is no obvious importance to monitoring money growth as well.

The key to avoiding the possibility of an entire decade of inflation well above the target level, even when the model that one uses to judge the current stance of policy may produce biased forecasts of near-term inflation, is to be committed to *correct past*

[40]In particular, measures of labor costs should be an important additional source of information. The output gap appearing in (2.1) as a source of inflationary pressures appears there because, in the basic new Keynesian model, the average real marginal cost of supplying goods covaries with the output gap; it is really real marginal cost that should appear in a more general version of the aggregate-supply relation (Woodford, 2003, chap. 3). This suggests that measures of marginal cost relative to prices should be valuable in judging when policy is generating inflationary pressure. In empirical estimates of the New Keynesian Phillips curve (*e.g.,* Gali and Gertler, 1999; Sbordone, 2002), the level of real unit labor costs has proven to be a useful proxy for this variable.

[41]Here the "state" is understood to mean the current value of a vector of additive stochastic terms in the structural equations of one's model, rather than (for example) the current values of the coefficients that multiply the state variables in those equations.

target misses, rather than conducting policy in a *purely forward-looking* fashion.[42] That is, a year or two of inflation higher than was desired should result in policy that deliberately aims at an inflation rate *lower* than the long-run inflation target for the next few years, so as to correct the overshoot and keep a long-run average of the inflation rate close to the target despite the temporary deviation. In this way, even if the central bank uses a model that produces a downward-biased forecast of inflation for many years in a row (due, for example, to a persistent over-estimate of potential output), it will not allow excess inflation to occur for very long before policy is tightened.

One simple way to institutionalize this kind of error-correction would be through commitment to a target path for the *price level*, rather than only to a prospective *inflation rate*. The two targets are equivalent if the target is always hit, but not in what they imply about the consequences of target misses for subsequent policy — thus it is precisely the issue of robustness to model errors (or other failures of policy implementation) that gives one a reason to choose between them.[43] A price level target path is especially simple to explain, but much the same kind of error-correction could alternatively be achieved through a commitment to a target for the *average* inflation rate over a period of years, where the period in question would not be wholly in the future.[44]

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[42]Orphanides and Williams (2002) propose an alternative way of insulating policy from the consequences of inaccurate estimates of the natural rate of output and/or the natural rate of interest, which is to set interest rates in accordance with a "difference rule" rather than a Taylor rule of the form (2.3). In the rule that they propose, the *change* in the interest-rate operating target is a function of inflation and the *growth rate* of output, so that there is no need for any measure of the *levels* of the interest rate or of output that are consistent with the inflation target. As with the proposal discussed here, the Orphanides-Williams policy is one that makes no use of measures of money. The desirable features of the Orphanides-Williams rule are related to those the desirable consequences of price-level targeting described below. For example, in the case of the basic new Keynesian model presented above, the Orphanides-Williams rule implies a trend-stationary price level, so that departures of the price level from its deterministic trend path are subsequently corrected.

[43]Even if, as is true for most if not all central banks, one does not aim at complete inflation stabilization, but is instead willing to trade off some short-run variation in inflation for the sake of greater stability of real activity, a corresponding contrast remains possible between commitment to an output-gap-adjusted inflation target and commitment to an output-gap-adjusted price-level target path.

[44]This was pointed out by King (1999), who suggested that inflation targets may lead to error-correcting behavior, to the extent that a central bank expects its success at meeting its target on

Many central bankers seem to be resistant to error-correction as an aim in the conduct of policy, on the ground that "bygones should be bygones" — however disappointed one may be with past outcomes, one should always aim to do the best thing for the economy from the present time onward, which implies that only purely forward-looking considerations should be relevant. But this is incorrect reasoning, even in the case that the central bank has complete certainty about the correctness of its model of the economy (and about the private sector's understanding the economy in exactly the same way), to the extent that private-sector behavior is *forward-looking,* as models derived from intertemporal optimization imply that it should be. For if private-sector behavior depends on anticipations of the subsequent conduct of policy, then the way that the central bank can be counted on to respond subsequently to target misses has an important effect on what is likely to occur on the occasions that generate those target misses.

For example, in the context of the simple new Keynesian model presented above, let us consider the policy that would minimize a loss function of the form

$$E_0 \sum_{t=0}^{\infty} \beta^t [(\pi_t - \pi^*)^2 + \lambda(x_t - x^*)^2], \tag{4.1}$$

representing dual inflation and output-gap stabilization objectives (with some relative weight $\lambda > 0$ on the output objective), in response to exogenous cost-push shocks of the kind represented by the term u_t in (2.1). One can show[45] that the optimal policy is one that will allow inflation to temporarily increase above the long-run target level π^* in response to a positive (temporary) cost-push shock, but that will be committed to subsequently bring the price level back to the path (a path growing deterministically at the rate π^* per period) that it would have been predicted to follow in the absence of the shock. It is desirable for people to be able to rely upon the central bank's tendency to react in this way, for then a positive cost-push shock will bring with it an *expectation of subsequent policy tightening,* the anticipation of which gives people a reason to moderate their wage and price increases despite the current cost-push shock. The shift in inflation expectations will partially offset the effect of the cost-push shock on the short-run aggregate-supply tradeoff, so that the central bank would not face so painful a choice between allowing significant inflation

average over a period such as a decade to be a subject of scrutiny.

[45] See Clarida *et al.* (1999) or Woodford (2003, chap. 7) for details of this analysis.

or reducing output substantially below potential.[46]

Eggertsson and Woodford (2003) similarly show that there are important advantages to a commitment to error-correction in the case that a central bank is temporarily unable to hit its inflation target owing to the zero lower bound on nominal interest rates. In the case of a purely forward-looking inflation target, a period when the natural rate of interest is temporarily negative — as arguably occurred in Japan in the late 1990s — can lead to a prolonged contraction and deflation, owing to the expectation that prices will not be allowed to rise even when the central bank regains the ability to hit its inflation target at a non-negative level of short-term interest rates. A price level target would instead imply that a period of reflation should be expected following any period of price declines due to the binding lower bound on interest rates; because a greater price level decline would then automatically create expectations of more future inflation (causing the zero nominal interest rate during the constrained period to correspond to a lower real interest rate), such a policy would if credible limit the price declines (and the associated contraction of real activity) during the period of the binding zero lower bound.

Thus a commitment to error-correction can be valuable even if the central bank can be certain of the effects of its policy decisions; the argument is only strengthened when one also considers the uncertainty under which monetary policy is actually conducted. In an analysis that is especially apposite to our discussion of the policy errors of the 1970s, Gorodnichenko and Shapiro (2006) note that commitment to a price-level target reduces the harm done by a poor real-time estimate of productivity (and hence of the natural rate of output) by a central bank.[47] If the private sector

[46] The optimality of this kind of response to cost-push shocks depends, of course, on details of the correct dynamic specification of the inflation-output tradeoff, as stressed by Batini and Yates (2003). It is sometimes argued that subsequent reversal of price increases due to cost-push shocks is only optimal in the case of a "purely forward-looking" version of the new Keynesian Phillips curve that cannot account for observed inflation inertia. However, the specification (2.1) proposed here is able to account for the observed inertia in inflation dynamics over the past few decades — *i.e.,* the failure of inflation to revert rapidly to a "long run" value that is constant over time — as due to variation over time in the inflation target $\bar{\pi}_t$ of the kind found by Smets and Wouters (2003). Other interpretations of observed inflation inertia that would also imply that it is optimal to subsequently undo price increases due to cost-push shocks are discussed in Woodford (2006).

[47] Gorodnichenko and Shapiro argue that uncertainty about a possible change in the trend rate of productivity growth in the US in the late 1990s did not cause the kind of inflation instability observed in the 1970s precisely because the Greenspan Fed followed an error-correction policy, as

expects that inflation greater than the central bank intended (owing to a failure to recognize how stimulative policy really was, on account of an overly optimistic estimate of the natural rate of output) will cause the central bank to aim for lower inflation later, this will restrain wage and price increases during the period when policy is overly stimulative. Hence a commitment to error-correction would not only ensure that the central bank does not exceed its long-run inflation target in the same way for many years in a row; in the case of a forward-looking aggregate-supply tradeoff of the kind implied by (2.1), it would *also* result in less excess inflation in the first place, for any given magnitude of mis-estimate of the natural rate of output.

Similarly, Aoki and Nikolov (2005) show that a price-level rule for monetary policy is more robust to possible errors in the central bank's economic model. They assume that the central seeks to implement a "target criterion", using a quantitative model to determine the level of the short-term nominal interest rate that will result in inflation and output growth satisfying the criterion. Aoki and Nikolov compare two alternative target criteria, one specified as an output-gap-adjusted target for the inflation rate, and the other as a gap-adjusted target for the price level; the two policy rules would be equivalent if the target criterion could be fulfilled at all times, but they have different dynamic implications in the case of target misses owing to errors in calculating the interest rate required to hit the target. They find that the price-level target criterion leads to much better outcomes when the central bank starts with initially incorrect coefficient estimates in the quantitative model that it uses to calculate its policy, again because the commitment to error-correction that is implied by the price-level target leads price-setters to behave in a way that ameliorates the consequences of central-bank errors in its choice of the interest rate.

Some of the advantages of a price-level target (or alternatively, a commitment to error-correction) can also be achieved by a money-growth target, if this is understood as commitment to a target *path* for the money supply that is not reset each time money growth differs from the target rate — that is, if one does not allow "base drift". The ECB's computation of an "excess liquidity" statistic based on the cumulative growth in broad money over several years relative to its "reference value" for money growth would be consistent with a target of this kind. If excess liquidity results

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if it had a price-level target. Their argument assumes that this feature of Fed policy was correctly understood by the public, despite its not being made explicit in the Fed's public discussions of its policy.

in policy being tighter than it would otherwise be, this would tend to correct the consequences of excessively inflationary policy (resulting in excess money growth) due, for example, to an overly optimistic estimate of potential output. This is presumably the reasoning behind Jürgen Stark's statement that "evaluating the money stock and liquidity situation helps to ensure that central banks look at developments in the level of key nominal variables, and not just their rate of change" (Stark, 2006).

While this is a valid point, one should note that tracking cumulative excess *inflation* — *i.e.,* departures from a "reference path" for the price level — would be even more effective for this purpose than tracking excess money growth. Excess money growth is an equally useful indicator only to the extent that excess money growth (over a period of a year or two) is a reliable measure of excessively inflationary policy. But money growth can diverge widely from inflation over a period of several years, while inflation itself can be measured fairly accurately within a few months. Thus the superior method for ensuring robustness against the type of policy error discussed above would seem to be a commitment to respond to the measured evolution of the price level itself, without any need to track measures of the money supply.

4.2 The Pitfall of Ignoring the Endogeneity of Expectations

Another well-known potential problem with policy based on an estimated Phillips curve is the trap of failing to recognize the difference between the *short-run* tradeoff between inflation and real activity, that is available for given inflationary expectations, and the *long-run* tradeoff that is available when the eventual adjustment of expectations is taken into account. The best-known exposition of this trap is in the analysis of discretionary policy by Kydland and Prescott (1977) and Barro and Gordon (1983). These classic expositions assumed a particular type of expectations-augmented Phillips curve that was popular in the "New Classical" literature of the 1970s, but discretionary policy has a similar inflationary bias in a new Keynesian model of the kind expounded above, as shown in Clarida *et al.* (1999) and Woodford (2003, chap. 7).

Suppose that each period, the central bank chooses a nominal interest rate i_t so as to minimize its loss function

$$(\pi_t - \pi^*)^2 + \lambda(x_t - x^*)^2, \tag{4.2}$$

given the tradeoff between inflation and output implied by the Phillips-curve relation

(2.1) and the effects of interest rates on expenditure implied by (2.2). Suppose furthermore that in its evaluation of these structural relations, the central bank takes as given the inflation trend $\bar{\pi}_t$ to which price-setters index their prices, and current private-sector expectations $E_t\pi_{t+1}, E_t x_{t+1}$; it assumes that none of these are affected by its choice of policy in period t, so that it simply faces tradeoffs of the form

$$\begin{aligned} \pi_t &= a_t + \kappa x_t, \\ x_t &= b_t - \sigma i_t, \end{aligned}$$

where the intercepts a_t and b_t are independent of the choice of i_t. Note that the static loss function (4.2) is consistent with the intertemporal objective (4.1) assumed above, if the central bank acts in a discretionary fashion (never making any advance commitments regarding its future policies) and understands (as is true in the Markov equilibrium of this model) that the choices of π_t, Y_t, and i_t have no consequences for equilibrium outcomes in any periods after t. Similarly, the assumption that the central bank's policy decision will not affect expectations (including expectations regarding the inflation trend[48]) is correct if the private sector has rational expectations and the economy evolves in accordance with the Markov equilibrium. Thus the assumed behavior of the discretionary central bank does not involve any incorrect understanding of the effects of its policy decision, given that it is only deciding what to do in the current period.

Given the slope of the (correctly) perceived Phillips-curve tradeoff, the central bank will choose to achieve the point on that tradeoff that satisfies the first-order condition

$$(\pi_t - \pi^*) + \frac{\lambda}{\kappa}(x_t - x^*) = 0. \tag{4.3}$$

Let us suppose furthermore, for simplicity, that there are no cost-push shocks u_t. Then since both the objective and the constraints are the same (in terms of the variables π_t, x_t, and $i_t - r_t^n$) in all periods, a Markov equilibrium involves constant values for each of those variables, and the constant value of π will also be the constant value of the inflation trend $\bar{\pi}$. Substitution of identical constant values for π and $\bar{\pi}$ into (2.1) indicates that any Markov equilibrium must involve a constant output gap $x = 0$.

[48]Here the indexation rate $\bar{\pi}_t$ is understood to be defined by (2.5), so that it depends only on expectations regarding policy far in the future.

Condition (4.3) then implies that the constant equilibrium inflation rate is equal to

$$\pi = \pi^* + + \frac{\lambda}{\kappa} x^*, \tag{4.4}$$

which is necessarily greater than the target inflation rate π^*, under the assumptions that $\lambda > 0$ and $x^* > 0$ in (4.2).

This is not, however, an optimal policy, from the standpoint of the bank's own objectives. In the case of any constant inflation rate π, (2.1) implies a constant output gap $x = 0$. Hence the loss function (4.2) is equal to

$$(\pi - \pi^*)^2 + \lambda x^{*2}$$

each period. This expression is minimized at $\pi = \pi^*$, and not at the higher inflation rate (4.4). The lower value of losses could easily be achieved by committing to a policy that delivers the target inflation rate π^* each period. Thus discretionary policy results in an inflationary bias, as in the analysis of Kydland and Prescott and of Barro and Gordon, even when the central bank correctly assesses the current values of Y_t^n and r_t^n, and more generally, when it correctly assesses the consequences of alternative possible choices. The bank's mistake is that it only considers the action to take in the current period, and so fails to realize how it could shape expectations (and hence the location of the Phillips-curve tradeoff between inflation and output) by committing to a policy in advance.

An approach to policy choice of this kind clearly leads to an unsatisfactory outcome, despite being based on optimization, and I believe that it is generally what central bankers have in mind when they speak of the importance of maintaining a "medium-run" or "long-run orientation" for monetary policy, rather than allowing policy to be dictated by "short-run" considerations alone. It thus represents one possible interpretation of what the ECB seeks to guard against by insisting that its "economic analysis" of short-term inflation risks be subject to a "cross-check" from a monetary analysis that takes a longer-term perspective.

But would attention to the growth rate of monetary aggregates solve the problem illustrated by the above analysis? If we adjoin a money-demand relation such as (2.10) to our model, then the Markov equilibrium with overly inflationary policy will also involve a correspondingly high rate of money growth; but once again, one need not monitor money growth in order to see that the policy is inflationary. (In the equilibrium just described, the central bank is under no illusions about the inflation rate resulting from its policy.) Supposing that the central bank monitors the money supply, that it is aware of the structural relation (2.10), and indeed that it chooses a target for M_t (rather than i_t) each period — but again, in a discretionary fashion, with no commitment regarding future policy — would change nothing about our analysis above of the inflation rate resulting from discretionary policy.

Of course, the famous diagnosis of the problem by Kydland and Prescott (1977) was that monetary policy should be conducted in accordance with a *policy rule*, rather than on the basis of a procedure aimed at minimization of an objective such as (4.1). And at the time that they wrote, a money-growth rule of the kind advocated by Milton Friedman was clearly what they had in mind. But there is no reason why a policy rule, intended to prevent the central bank from giving in to the temptation to exploit the short-run Phillips-curve tradeoff, would have to involve a target for money growth. If all one cares about is eliminating the undesirably high average rate of inflation — or if one ignores the existence of random shocks, as in the simple analysis above — then *any* policy rule that implies a suitably low average inflation rate would work as well. In particular, an *inflation target* will suffice to eliminate the problem, if it is taken seriously — if it does not simply mean that the central bank's loss function (4.2) penalizes deviations from a well-defined target π^*, but rather that the central bank is pledged to ensure that the long-run average inflation rate remains within a fairly narrow range.[49] As explained above, it is certainly possible to design a policy framework that will ensure the desired average inflation rate, over a sufficiently long period of time, without any reference to monetary aggregates.

Nor is it correct to say that in the discretionary "trap," the central bank's mistake is reliance upon an inadequate model of the determinants of inflation or of the effects of policy — one that is accurate in the short run but not in the medium-to-long run — so that the inflationary bias of policy could be avoided by basing policy on an alternative (presumably quantity-theoretic) model that gives a more accurate account of the determinants of long-run inflation trends. As I have just noted, the quantity-

[49] Proponents of "flexible inflation targeting" sometimes argue that it suffices that a central bank have a well-defined loss function of the form (4.1), to which it is publicly committed, and that the central bank be able to defend its policy decisions as being aimed at minimizing such an objective. But the discretionary policy, shown above to lead to undesirably high inflation, has all of these features. It is therefore important to recognize that a successful inflation-targeting regime must also involve a commitment to a decision procedure that does not allow discretionary choice of the policy action each period that would minimize the loss function.

theoretic relation (2.10) can be part of the model used to determine the optimal action each period, without this implying any change in the logic of discretionary policy. Nor is there any mistake in the central bank's forecast of the inflation rate resulting from its policy, either in the short run or later.

The central bank's mistake is instead one of failing to recognize that a sequence of optimizing decisions about policy in one period, taking as given the way that policy will be conducted subsequently, does not lead to an optimal overall pattern of action. It fails to see that committing to a *systematically* different policy that is maintained over time would make possible a different inflation-output tradeoff than the one that the central bank faces in each of the succession of periods in which it considers an alternative policy in that period only, owing to the endogeneity of inflationary expectations, and the relevance of those expectations to the inflation-output tradeoff in (2.1).

In order to avoid making this kind of error, a central bank that seeks to minimize an objective such as (4.1) needs to have a correct view of the nature of the aggregate-supply relation (2.1) and of the nature of private-sector expectations. Belief in a particular view of the relation between money growth and aggregate nominal expenditure is quite beside the point! While it is true that monetarists like Friedman and Lucas played a crucial role in the 1960s and 1970s as advocates of the view that the long-run Phillips-curve tradeoff should be vertical, this view does not follow from the quantity theory of money itself. The existence of a stable money-demand relation such as (2.10) implies nothing about the correct specification of the aggregate-supply relation. And one could accept the view that a permanent n percent increase in the rate of growth of the money supply will eventually result in a permanent n percent increase in the inflation rate while still believing in a (non-vertical) long-run Phillips-curve tradeoff; the type of long-run relation between money growth and inflation discussed in section 3 would exist even in this case, as long as permanently higher inflation has a permanent effect on only the *level* of output, and not its *growth rate*.

Thus what is needed to avoid such mistakes is not greater attention to the relation between money growth and inflation or to the estimation of money-demand relations; it is deeper study of the dynamics of wage- and price-setting, and especially of the role of expectations in such decisions. But this is precisely the topic of what the ECB calls "economic analysis" as opposed to monetary analysis. While the mistake illustrated above may result from an inadequate understanding of the nature of the Phillips curve, the problem cannot be solved by resort to an analytical framework that dispenses with a Phillips curve. And if excessive emphasis on the importance of monetary analysis draws resources within the central bank away from the task of improved modeling of wage and price dynamics, the likelihood of policy mistakes stemming from an inadequate understanding of aggregate supply will only be increased.

5 Conclusion

I have examined a number of leading arguments for assigning an important role to tracking the growth of monetary aggregates when making decisions about monetary policy. I find that none of them provides a convincing argument for adopting a money growth target, or even for assigning money the "prominent role" that the ECB does, at least in its official rhetoric. Of course, this is hardly a proof that no such reason will ever be discovered. But when one examines the reasons that have been primarily responsible for the appeal of the idea of money growth as a simple diagnostic for monetary policy, one finds that they will not support the weight that they are asked to bear. Thus while one must admit that it is always possible that monetary targeting might yet be discovered to have unexpected virtues, there is little ground for presuming that such virtues must exist, simply because of the familiarity of the hypothesis.

Nor do the arguments offered here imply that central banks should make a particular point of *not* seeking to extract any information from monetary aggregates. An inflation-targeting central bank should make use of all of the sources of information available to it, in judging the interest-rate policy that should be consistent with a projected evolution of the economy consistent with its target criterion (Svensson and Woodford, 2005). While I see no reason for either the policy instrument or the target criterion to involve a measure of the money supply, the model used to calculate the economy's projected evolution under alternative policy paths may involve a large number of state variables; and given that many of the state variables in such a model are not directly observed, or not with perfect precision, a large number of other variables may provide relevant information in judging the economy's state and hence the appropriate instrument setting. There is no reason why a variety of monetary statistics should not be among the large number of indicators that are used by a central bank in preparing its projections. But this appropriate use of the information contained in monetary statistics would not make money a target in its own right, and neither would it make monetary analysis a distinct basis for forming a judgment about the stance of monetary policy, independent of the considerations involved in an explicit economic model of wage and price-setting.

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