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Why Money Growth Determines Inflation in the Long Run: Answering the Woodford Critique

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Why Money Growth Determines Inflation in the Long Run:
Answering the Woodford Critique

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Abstract

Woodford (2007) argues that it is not appropriate to regard inflation in the steady state of New Keynesian models as determined by steady-state money growth. Woodford instead argues that the intercept term in the monetary authority's interest-rate policy rule determines steady-state inflation. In this paper, I offer an alternative interpretation of steady-state behavior, according to which it is appropriate to regard steady-state inflation as determined by steady-state money growth. The argument relies on traditional interpretations of the central bank's power in the long run and appeals to model properties that are common to textbook and New Keynesian analysis. According to this argument, the only way the central bank can control interest rates in the long run is via affecting inflation, and its only means available for determining inflation is by determining the money growth rate.

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Key Words: money growth, inflation, interest rates, steady state.

1. Introduction

Several economists familiar with New Keynesian models have argued that these models imply that money growth determines inflation in the long run. For example, Ireland (2004, p. 979) concluded an analysis of an estimated New Keynesian model by observing that "the monetary authority must choose the steady-state rate of inflation, which is ultimately determined by the rate of nominal money growth…" Woodford (2007), however, argues that economists who believe that money growth determines inflation in the long run in New Keynesian models do so because of their own "misunderstanding" of how these models work. In this paper I provide a rebuttal to this argument and make the case that, in New Keynesian models, money growth indeed determines inflation in the long run. I do not want this discussion to overshadow substantial areas of agreement with Woodford (2007), so I state those areas of agreement first and explore their implications for work on monetary policy. The areas of agreement are covered in Section 2, and the long-run money growth/inflation relationship is the subject of Section 3. Section 4 considers possible objections, and Section 5 provides brief concluding remarks.

2. Areas of agreement

Three major areas of agreement with Woodford are on (1) emphasizing the contribution of monetarism to present-day monetary analysis; (2) the false leads provided by some advocates of monetary aggregates; and (3) distinguishing money and credit. What follows is not a simple catalogue of agreement. Instead, my intention is to bring out some points not covered by Woodford: connections of monetarism to New Keynesian economics beyond those he listed; common elements in Woodford's (2007) views on money and credit, and those in the monetarist literature; and how the criticism of New Keynesian models made by Alvarez, Lucas, and Weber (2001), though motivated by appealing to the quantity theory of money, actually finds no support in the work of Milton Friedman.

2.1 Contributions of monetarism

While the topic of Woodford's paper is "How Important Is Money in the Conduct of Monetary Policy?," his Section 1 deals with "The Historical Significance of Monetarism." It is very appropriate that a discussion of money's present status should begin with a discussion of monetarism. It is as natural and essential to consider

monetarism in a discussion of today's role for money as it is to consider the Great Inflation in a discussion of the Great Moderation. Many of the policymaking principles put into practice in major countries today are inherited from ideas articulated by monetarists during earlier periods. Moreover, the durability of monetarist ideas is also manifested in research that improves upon and extends New Keynesian models. The study by Christiano, Motto, and Rostagno (2003) is a leading example of the productive interaction of the monetarist literature and state-of-the-art modeling. Their work proposes several modifications to a New Keynesian baseline model, with the added model elements inspired by the desire to test hypotheses advanced in the monetarist literature. The result is a much more rigorous foundation for the frictions mentioned in monetarist work than achieved in the existing New Keynesian, or any preceding, literature. Another example of a productive synthesis of the monetarist literature and modern macroeconomic modeling is that in Dotsey and King (2005, pp. 214, 227), who connect the properties of their state-dependent pricing model to the list of empirical propositions about the effects of monetary policy given in Friedman (1987).

Clarifying the enduring contribution of monetarism is especially important because many prior discussions provide quite a misleading picture. I find the contributions of Alan Blinder and Willem Buiter to be particularly interesting in illustrating the problems of correctly disentangling the legacy of monetarism. These authors hold special positions in that they both contributed prominent papers on the Keynesian side during the years of Keynesian-monetarist debate (see Blinder and Solow, 1973; Tobin and Buiter, 1976). Moreover, they both later served as monetary policy makers (on the Federal Open Market Committee in Blinder's case; on the United Kingdom's Monetary Policy Committee in Buiter's case) in an era where policymaking and monetary policy thinking had more or less reached their modern-day configuration. Given this background, it might seem that these authors are in an ideal position to judge how monetarism has contributed to modern policymaking and to present-day views of monetary policy. But I find, on the contrary, that these two authors' writings, in contrast to Woodford (2007), give an unhelpful account of the enduring contributions of monetarism. Both Blinder and Buiter could have done much more by way of acknowledging the extent to which monetarist propositions have become standard.

The problem with Blinder's accounts is that while he emphasizes the durability of Keynesian economics (see, for example, Blinder, 1984, 1987), he fails to acknowledge the influence monetarism has had even on the development of his own views. The fact is

that, at the same time that big movements in velocity got all the publicity in the 1980s, and so produced many "monetarism is dead" judgments, key aspects of the monetarist-Keynesian debate were being tacitly settled on the monetarists' terms. This capitulation on Keynesians' part is as evident in Blinder's work as much as anyone's. For example, Baumol and Blinder (1979, p. 288), taking a Keynesian perspective, argued that "demand fluctuations are not the only cause of inflation, and, in particular, they have played a rather minor role in the inflation we have been experiencing since 1973." Moreover, to the extent that Baumol and Blinder acknowledged a role for demand in determining inflation, they saw it as working via a *permanent-trade-off* Phillips curve, not a Phillips curve embedding long-run natural-rate properties: "the inference that therefore the trade-off no longer exists was, and still is, unwarranted" (1979, p. 287). In Baumol and Blinder (1982, pp. 301–303), however, this discussion was dropped in favor of an exposition of the temporary nature of the trade-off and of the tendency for the economic system to return to the natural rate of unemployment. Another example of monetarists' influence on Blinder (and on the profession) deals with the issue of lags in effect of monetary policy. Blinder (1984) rejected the Friedman dictum that "inflation is always and everywhere a monetary phenomenon" and suggested that it was contradicted by the fact that inflation in specified periods did not move in the same direction as same-period money growth. Blinder (1997), by contrast, argues that the lag in the effect of monetary policy is a very important consideration that must be taken into account.

Whereas Blinder tends to describe as "Keynesian" the set of views that he has converged to in the wake of the Keynesian-monetarist debate, Buiter (2003) tends to attribute to James Tobin the aspects of the modern monetary policy framework that Buiter likes. Moreover, Buiter casts monetarism in negative terms, building Tobin up by attributing to monetarists views they did not hold and giving Tobin credit he happens not to deserve. So Buiter attributes to Milton Friedman the view that money demand is interest inelastic, a view to which Friedman clearly did not subscribe,[1] while Buiter claims that the modern monetary policy framework is in keeping with Tobin's views, which it clearly is not. In fact, Tobin was a longtime advocate of nonmonetary approaches to the analysis and control of inflation (see Nelson and Schwartz, 2008, pp. 841–842), and such nonmonetary approaches are anathema to the modern way of thinking about monetary policy.

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[1] See, for example, Friedman (1972).

These examples show that it is hard to determine the influence of monetarism because several of Friedman's critics tended to adopt his positions without explicitly conceding defeat. Woodford's balanced evaluation of the historical significance of monetarism is a valuable tonic. It should be noted, however, that there is an aspect of monetarist analysis that is still discussed in the literature today and is covered in Woodford's paper, but which does not appear in his section on the legacy of monetarism. This is the view that monetary policy operates through a spectrum of asset prices and that the effect of monetary policy on these asset prices goes beyond what can be summarized by a single, observable interest rate.[2]

It is difficult to disagree with Woodford's contention that the literature has not provided a satisfactory microfoundation for why money should be a good proxy for asset price variation, and so why money has a role as an index of the determinants of aggregate demand beyond short-term interest rates.[3] But I believe that finding such a microfoundation is an important priority in the modeling of money, because the empirical evidence is supportive of money having that role. One can take one's pick among recent empirical studies of money like Leeper and Roush (2003), Reynard (2006), Favara and Giordani (2007), Assenmacher-Wesche and Gerlach (2007), and Castelnuovo (2008). But whichever of these studies one finds most convincing, I believe that between them they have established that money has explanatory power for output and inflation beyond what the standard New Keynesian model predicts money should have, and exhibits this power across a number of different monetary policy regimes. In a standard model as exemplified by Woodford's equation (2.10) or in equation (4) below, any movement in real money balances not attributable to current output or current short-term interest-rate variations is just extraneous noise—the money demand disturbance. Evidence that money has considerable marginal value as an indicator of future output and inflation variations contradicts the standard New Keynesian characterization of the behavior of money balances.

2.2 False leads from advocates of money

Woodford writes that the statements about modern models made by Alvarez, Lucas, and

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[2] Brunner and Meltzer often emphasized this channel (see, for example, Brunner and Meltzer, 1976). See also Friedman (1972, pp. 944–945) and Friedman and Schwartz (1982, pp. 56–57) for related discussions.
[3] For a recent generalization of New Keynesian models that goes in this direction, see Canzoneri *et al* (2008).

Weber (2001) are "incorrect." He is right to criticize Alvarez, Lucas, and Weber in such blunt terms. Alvarez, Lucas, and Weber proceed from the false (and undocumented) premise that New Keynesian models (and/or modern monetary policymaking) reject the quantity theory. The series of misstatements of fact in Alvarez, Lucas, and Weber's introduction should shatter any illusion that their subsequent discussion will either be a well-informed critique of existing models, or an authoritative road-map of where monetary policy modeling should go; and not surprisingly, what follows in Alvarez, Lucas, and Weber (2001) provides neither of these things.

Follow-up work on the part of one of the authors of Alvarez, Lucas, and Weber (2001) has persuaded me that the weakness of their critique stems not only from insufficient familiarity with New Keynesian work, but from inadequate consultation of the monetarist literature.[4] Alvarez, Atkeson, and Edmond (2008) study the sluggish behavior of inflation and use a regularity in the data as a metric for this sluggish behavior. The regularity in question is the short-run near-perfect negative correlation between money growth and velocity growth (a correlation which fades to zero at longer horizons). Judging from their lack of references to previous literature, I presume that Alvarez, Atkeson, and Edmond regard themselves as having discovered this regularity. I am at a loss how to persuade these authors that this is not the case, if reference to the monetarist literature is regarded as out of bounds. A moment's consideration should make it clear how unlikely it is that the older monetarists, after decades' study of the behavior of money and velocity and of the lag from money growth to inflation, never discovered this regularity and noted it. In fact, monetarists did note this regularity on many occasions.[5] New Keynesians can legitimately doubt that work on money like Alvarez, Atkeson, and Edmond (2008) materially adds to the profession's stock of knowledge.

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[4] Of course, one of the authors of Alvarez, Lucas, and Weber (2001), Robert Lucas, is steeped in the monetarist tradition. But monetarist authors are not cited in Alvarez, Lucas, and Weber (2001); and the key misstatements in Alvarez, Lucas, and Weber would not be supported by the core monetarists. For example, Alvarez, Lucas, and Weber (2001, p. 219) assert that the position that "inflation can be reduced by increasing short-term interest rates" is "a rejection of the quantity theory." By contrast, Milton Friedman once said, "if you really want to lower interest rates, the way to do it is by starting out to raise them" (quoted in Crawford, 1970).

[5] For example, Friedman (1983, p. 10): with "the lag in the effect of monetary change, ... velocity always tends to fall in the early stages of a monetary explosion." As noted above, a recent example of a study of the lags in effect of monetary policy that *does* take note of Friedman's contributions in the area is Dotsey and King (2005).

2.3 Money vs. credit

I have nothing but agreement with Woodford that an emphasis on credit frictions, or on
the volume of bank credit, should not be regarded in any way as a sound rationale for
looking at monetary aggregates. In fact, the discussion at the end of Woodford's Section
2 can be thought of as a parallel to Milton Friedman (1972, p. 929) observation: "There is
no necessary connection between a change in the quantity of money and in the volume of
outstanding debts…" Distinguishing between money and credit was a central part of the
core monetarist literature,[6] and Woodford's Section 2 amounts to an endorsement of that
position. To treat money and credit as automatically linked, or as variables that are
naturally treated together (as suggested by the title of Hauser and Brigden (2002),
"Money and Credit in an Inflation-Targeting Regime," as well as the text of their paper)
is to ride off in the wrong direction.

It may be worth setting out in slightly more detail, in a manner that complements
Woodford's discussion, just how separate money and credit are. Even if money and
credit were linked rigidly in an accounting sense, that would not justify treating the two
together, just as (e.g.) accounting identities linking saving and investment do not imply
these series should always be treated together. But in any case, money and credit are not
linked rigidly by bivariate identities. Some important monetary aggregates—currency
and monetary base—do not include deposits at all; most deposit-inclusive monetary
aggregates (including M2) do not include all types of deposit; and not all bank liabilities
are deposits. Moving to the asset side, earning assets of banks can be treated
synonymously with "bank credit" only if one defines credit as including loans to the
public sector (e.g., banks' investments in Treasury securities). And no matter how wide
the definition of bank credit, there are many channels of credit (to both the private and
public sectors) outside the deposit-taking banking system.

For broad measures of money and for measures of credit restricted to cover earning assets
of those institutions whose deposit liabilities are included in the monetary aggregate, the
relationship between money and credit will be closest. But even then, the identities that
connect the two series are not such as to make one confident that the two variables will
move together. The reason is that money and credit are not the only nonnegligible terms
in these identities; there are invariably extra variables that can and do produce

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[6] Including Brunner and Meltzer (1976).

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discrepancies between money and credit. The position that money and credit move rigidly together therefore rests on an illegitimate *ceteris paribus* assumption regarding the additional endogenous terms that appear in the relevant identities.

Moreover, banks' historical involvement in lending activities not listed on their balance sheets reinforces the presumption that money and credit creation will have a loose relationship. In the United States, regulations on banking activity led in the past to now well-publicized efforts on the part of commercial banks to participate in the spread of what Bernanke (2008) describes as "credit products and special-purpose investment vehicles" that were "circumventing the need for traditional bank financing." Though not categorized as balance-sheet items by banks, these vehicles sometimes did, as Bernanke notes, entail bank involvement in an advisory or underwriting capacity.[7] The channeling of banking business into off-balance-sheet activity was a prominent instance of credit expansion becoming further disconnected from deposit expansion.

Several aspects of the experience with monetary aggregates in major economies also suggest that the value of monetary aggregates does not come from any accounting relations with credit. First, base money and currency aggregates often outperform broader aggregates as indicators (e.g. in predictive power, or marginal predictive power, for output and inflation). Second, a much larger share of corporate lending is intermediated through banks in the euro area than in the United States (see e.g. De Fiore and Uhlig, 2005), but the previously-cited papers provide (when considered in total) favorable results regarding money using data for both economies. Third, commercial banks in the United Kingdom over the 1950s and 1960s and into the early 1970s generally refrained both from mortgage lending and from lending for corporate investment in physical capital; but broad monetary aggregates tended to have better relations with major macroeconomic variables in those years than they did subsequently, when the scope of bank lending broadened considerably.

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[7] Similar behavior by banks for the purpose of avoiding regulation had been observed in other countries. See, for example, Battelino and McMillan (1989, pp. 136−138) on Australian commercial banks' efforts during the 1980s to expand their involvement in the credit market by methods that did not involve deposit creation.

3. Money growth and inflation in the long run

Many specialists on monetary policy issues view inflation in the long run as pinned down by money growth in the long run. Woodford notes that I argued along those lines myself in Nelson (2003) and that I claimed that the steady-state properties of New Keynesian models supported such a view. Woodford (2007, p. 13) states, "But this is a misunderstanding." In this section, I make the case that such a view does not reflect a misunderstanding, but instead an attempt to take into account basic properties about the effect of monetary policy in the long run. I first present a version of Woodford's critique that is convenient for later discussion (Section 3.1). Then I discuss the properties of the economy in the steady state (Sections 3.2 and 3.3), and on that basis defend the proposition that money growth does actually determine inflation in the long run (Section 3.4).

3.1 Determination of steady-state inflation

Woodford's approach can be thought of as one of counting equations and unknowns in a New Keynesian model. Woodford notes that a version of the New Keynesian Phillips curve is (his equation (2.1), p. 6):

$$(\pi_t - \pi_t^*) = \kappa \log(Y_t / Y_t^n) + \beta E_t(\pi_{t+1} - \pi_{t+1}^*) + u_t \qquad (1)$$

where π_t is quarterly inflation, Y_t is the level of output, Y_t^n is the natural level of output, u_t is a zero-mean Phillips curve shock, $\kappa > 0$, and $0 < \beta < 1$; and π_t^* is the steady-state inflation rate.

The time subscript in π_t^* allows the steady-state rate of inflation to vary across periods; it appears in the Phillips curve due to assumed continuous indexation of nominal price contracts to steady-state inflation. As Woodford notes, the time-variation in the steady-state inflation rate reflects fluctuations in the central bank's inflation target. Allowing the inflation target to vary over time makes the policy rule more general;[8] in particular, the

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[8] More general, that is, in the sense that shifts in the steady-state inflation rate have occurred historically so that a policy rule that recognizes this could be more realistic as a description of historical experience. Other aspects of the realism of this specification may be questioned, however. In particular, the monetary authorities of the United States and other countries in the 1970s denied that inflation was a monetary phenomenon; so while whatever monetary policy actions they took inevitably implied a certain steady-

generalization accommodates nonstationary behavior of inflation. The generalization does imply that one cannot speak of a constant, steady-state rate of inflation. But the generalization does not appear to bear materially on the question of whether money growth determines inflation in the long run. For example, Woodford's (2007) discussion uses the time-varying-target version of the New Keynesian model to dispute interpretations about inflation determination made in papers that assumed a constant inflation target.[9] It seems appropriate to conclude that Woodford's argument that money growth does not pin down inflation in the long run does not depend on his assumption of a time-varying target inflation rate. So for simplicity I assume that π_t^* is constant.

The other equations in this model are:

IS equation:

$$\log(Y_t / Y_t^n) = E_t[\log(Y_{t+1}/Y^n_{t+1})] - \sigma[R_t - E_t\pi_{t+1} - r_t^n], \qquad (2)$$

where $\sigma > 0$, r_t^n is the short-term natural real rate of interest, and R_t is the short-term nominal interest rate.

Policy rule (assumed to be a Taylor-type rule, incorporating a response to the model-consistent output gap):

$$R_t = R_t^* + \phi_\pi(\pi_t - \pi^*) + \phi_y \log(Y_t / Y_t^n), \qquad (3)$$

where R_t^* is a time-varying intercept term, and $\phi_\pi > 1$, $\phi_y \geq 0$.[10]

Money demand equation:

$$(m_t - p_t) = c_0 + c_1 \log Y_t + c_2 R_t + \eta_t , \qquad (4)$$

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state inflation rate, it attributes too much knowledge on the part of policymakers to label the resulting series their "target."

[9] For example, he disputes my (2003) interpretation of McCallum (2001), who assumed a constant inflation target.

[10] The assumption that $\phi_\pi > 1$ follows McCallum's (2001) exposition of the New Keynesian model. It is a special case of the analysis in Woodford (2007), where equilibrium is obtained under the assumption that a weighted combination of ϕ_π and ϕ_y is sufficiently large. This more general formulation reflects the recognition that under sticky prices, responses to the output gap can substitute for responses to inflation.

where $(m_t - p_t)$ is log real balances, $c_1 > 0$, $c_2 < 0$, and η_t is a zero-mean money demand shock. While Woodford's (2007) framework can accommodate economic growth, I assume here that output does not have a trend.

As this loglinear system has explicit constant (or time-varying intercept) terms, long-run solutions for variables can be derived from the equations. Woodford argues that the last equation (the money demand equation) is not required to study the determination of steady-state inflation. To see his argument, one first needs to decompose the intercept of the monetary policy rule. Woodford (2007, p. 8) defines the intercept as the central bank's "estimate of where the intercept needs to be in order for this policy rule to be consistent with the inflation target"; if the central bank's estimate of the steady-state natural rate is accurate, the long-run value of this intercept is $E[R_t^*] = E[r_t^n] + \pi^*$ where π^* is the constant inflation target. Then equations (1)–(3) in steady state imply:

$$E[\pi_t] = \pi^*. \tag{5}$$

$$E[\log Y_t] = E[\log Y_t^n]. \tag{6}$$

$$E[R_t^*] = E[r_t^n] + \pi^*. \tag{7}$$

These conditions indicate that steady-state inflation is equal to the policy-determined inflation target; that output is equal to its natural level; and that the steady-state policy rule devolves into a steady-state Fisher condition, with inflation equal to the inflation target. So there are three unknowns—i.e., the expectations of the endogenous variables π_t, $\log Y_t$, and R_t on the left-hand sides of conditions (5)-(7)—matched by three equations giving solutions for each of these unknowns in terms of exogenous variables.

The system is self-contained, leaving the money demand function redundant. In particular, equations other than the money demand function feature the inflation-target term, and the money demand function is not needed to obtain expression (5) where inflation is equal in the long run to the exogenous policy target. The money demand equation adds one equation and one unknown, so can be dropped altogether, or can be thought of as determining steady-state log real money balances, $E[(m - p)_t]$, or steady-state nominal money growth ($E[\mu_t] \equiv E[\Delta m_t]$), given determination of the inflation rate using the other equations.

Woodford emphasizes that in addition to appearing in the Phillips curve, π^* also appears in the intercept of the interest-rate rule that describes monetary policy behavior. Steady-state inflation can therefore be derived using this rule in conjunction with the IS and Phillips curve relations. According to this critique, there is no distinction between the dynamics of inflation and steady-state inflation as far as the status of money is concerned; the money demand function is not required in either case to solve for inflation. Therefore, New Keynesian models that omit money are self-contained in the sense that steady-state inflation, not just the dynamics around the steady state, is determined within the system. Or as Woodford (2007, p. 13) puts it, "the trend inflation rate… is *also* determined within the system: it corresponds to the central bank's target rate, incorporated into the policy rule…" According to this argument, while monetary policy indeed determines long-run inflation, money growth has no role that emerges in the long run; money growth, it is claimed, is not what pins down steady-state inflation, and those that contend otherwise are guilty of a misunderstanding.

But Woodford has not established such a misunderstanding, and on further consideration I reaffirm that money growth does have the role attributed to it by myself and others. Establishing this point does not involve denying or overturning the counting-equations-and-unknowns procedure described above. Instead, it arises from a consideration of how the steady state of a model used for monetary policy behaves.

A useful way to confront the issues involved is to consider the following quotation from Bernanke (2003):

> You may have noted that I did not include money growth in this list of inflation determinants. Ultimately, inflation is a monetary phenomenon, as suggested by Milton Friedman's famous dictum. However, no contradiction exists, as the expectational Phillips curve is fully consistent with inflation's being determined by monetary forces in the long run. This point, originally made by Friedman himself, has been demonstrated in many textbooks and so I will not discuss it further here.

This passage raises several points that are germane to the present discussion. First, it shows that the view that money growth determines inflation in the long run is not something likely to be embraced only by those unfamiliar with the properties of modern models; it is held by someone who has worked on New Keynesian models with

Woodford (see Bernanke and Woodford, 1997). Second, the reference to "monetary forces" rather than "money growth" is not really denying money growth center stage for long-run analysis, since Bernanke is explicitly tying the statement to both textbooks and Friedman's work, which both refer to monetary aggregates. Third, the reference to "many textbooks" suggests that the considerations that lead to the position that money growth determines inflation come from model properties that are common to both New Keynesian models and more traditional, textbook models—in particular, from steady-state properties of the models.

It is the third of these points that I pursue in the remainder of this section. In the spirit of Bernanke's reference to "many textbooks," my answer to the Woodford critique relies on propositions about the steady state that are common to both textbook macroeconomics and the New Keynesian model. As intermediate steps, it is worth spelling out an explicit definition of the "long run" (Section 3.2) and considering the properties of the economy consistent with this long run (Section 3.3).

3.2 Defining the long run

What is the appropriate definition of the "long run" in monetary policy analysis? Almost tautologically, the "long run" is the steady state of a model[11] or, equivalently, the version of the economy that pertains when unconditional expectations (where they exist) are taken of model variables. But prominent discussions in the literature, discussed below, allow more economic content to be put into the discussion of "long run," while still producing definitions that are consistent with interpreting the "long run" as referring to the steady state or to unconditional means.

Specifically, there is support for the following position: In monetary analysis, the long run is defined as the economic conditions prevailing *after prices have fully adjusted to monetary policy actions*. For example, Baumol and Blinder (1982, p. 301), having, as noted above, brought the natural rate hypothesis into their framework, described the "vertical (long-run) Phillips curve" as the position to which the economy reverted as a result of its "self-correcting mechanism," consisting of gradual adjustment of wages and

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[11] For example, McCallum (1990, p. 988) notes that the "long run" is a "concept… presumably related to steady-state properties." This is a rare case of the two concepts being explicitly linked; many other discussions, however, could be cited where "long run" and "steady state" implicitly are taken to be interchangeable concepts, and the present discussion does so.

prices to a monetary policy action. The "long run" accordingly corresponds to the state of the economy prevailing after any inertia in nominal prices and wages has passed. In the context of the preceding Phillips curve (1), the process of price adjustment tends to close the output gap and to line up the path of inflation with the path of the steady-state inflation rate π_t^*.

The corollary of this conception of "long run" is that price stickiness is a temporary—that is, short-run—phenomenon. That perspective is made explicit in a description of wage and price stickiness given by John Taylor:

> One of the central reasons that the economy departs from the natural rate for prolonged periods is the existence of nominal wage and price rigidities that prevent the economy from adjusting quickly to disturbances. But these wage and price rigidities are temporary; they lead to temporary fluctuations in employment… Eventually the economy tends to return to the natural rate of unemployment, and (on average) unemployment is equal to the natural rate. (Taylor, 1987, p. 351.)

Taylor's perspective is consistent with other discussions of sticky-price models that are restricted to satisfy the natural rate hypothesis.[12] For example, the classic analysis of Dornbusch and Fischer (1978, p. 347), states that "[w]e should expect to converge to the neoclassical equilibrium in the long run," but that "in the short run… stickiness of wages and prices… will affect the adjustment process."

As price stickiness is a temporary phenomenon, it should not be assumed to hold when studying steady-state behavior. Analyzing the long run, including the long-run determination of inflation, implies analyzing conditions where prices have adjusted fully to monetary policy actions.

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[12] I.e., the restriction that the economy converges to the flexible-price steady state, so that the mean value of output in the sticky-price model coincides with the mean of output of a flexible-price version of the economy. In this discussion, I further assume that the mean values of output and real interest rate in the flexible-price economy (and so the mean values in the sticky-price model too) are invariant to different monetary policy rules and different inflation rates, implying that there is no violation of superneutrality. See McCallum (1990, 2004) for further discussion of superneutrality.

3.3 Economic conditions in the long run

The short-run/long-run distinction has important implications for the ability of the central bank to affect interest rates. The mechanism through which monetary policy actions (open market operations) have their usual effect on interest rates relies on price stickiness, and so wears off in the long run. Abel and Bernanke (1992) observe that it is nominal rigidity that allows manipulation of the real interest rate by open market operations in the short run:

> [B]ecause of slow price adjustment… monetary expansion causes output and employment to rise and the real interest rate to fall… (1992, p. 139.)

But they note that the impact on real interest rates wears off in the long run:

> [A]fter the adjustment of the price level, [an] increase in the nominal money supply has had no effect on output or the real interest rate… [There is] monetary neutrality in the long run (after prices adjust) but not in the short run. (1992, pp. 138, 139.)

The observation that central banks cannot influence real interest rates in the long run has a venerable history, with Humphrey (1983, p. 15) offering an 1819 quotation from David Ricardo in which the latter argued that a central bank can "not permanently alter the market rate of interest." Early discussions like Ricardo's were flawed by their neglect of the expected-inflation component of nominal interest rates. When the Fisher effect on nominal interest rates is allowed for, central banks can "permanently alter" *nominal* interest rates by taking actions that permanently lower inflation. This possibility is considered further below. But the key point that real interest rates cannot be influenced by monetary authorities does endure from Ricardo's work and remains a property of textbook models, as the Abel-Bernanke quotation attests, and the New Keynesian model studied by Woodford (2007). Open market operations are not available as a long-run means of affecting the real interest rate, because their effect rests on nominal rigidity.

3.4 The answer to Woodford's critique

With this background established, I can now present the answer to Woodford's critique.[13] In opposition to my characterization of steady-state inflation as pinned down by steady-state money growth, Woodford emphasizes the fact that the intercept term of the monetary authority's interest-rate rule includes an inflation-target component. My emphasis on money growth as the determinant of inflation in the long run, however, was not meant to imply a denial on my part that the interest-rate rule incorporates an inflation target. In fact, as Woodford notes, my discussion was accompanied by a citation of McCallum (2001), who wrote down an interest-rate rule with an inflation-target term as part of the intercept.[14] The issue is not money growth vs. the rule intercept as determinants of inflation, but whether appealing to the intercept term gives a deep enough answer. My contention is that pointing to the intercept does not deliver a satisfying answer to the question of how a central bank determines inflation in the long run.

To describe the long-run determination of inflation, one must, as discussed above, consider the properties of the economy in steady state. Whereas my focus was on the money growth/inflation connection that can be derived from the steady-state money demand function, Woodford's approach is to treat the short-term nominal interest rate as a choice variable—a policy instrument—in the long run. Alternatively, he could be regarded as treating the steady-state inflation rate as a policy instrument in the long run. Under either interpretation, Woodford is making a high-level assumption. My less high-level approach involves considering the behavior of the economy in steady state, the curbs that exist in the steady-state economy on the power of monetary policy to affect real variables, and the central bank's continuing power to affect nominal variables in that steady state. That continuing power does give the central bank the ability to determine inflation and the nominal interest rate in the long run, but not in such a direct manner that either should be treated as a policy instrument.

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[13] The argument developed here appeared in skeletal form in Nelson (2007).

[14] Woodford contends that my interpretation "is not an obvious reading of what McCallum (2001) actually says." Perhaps not, but I did not refer to McCallum (2001) in isolation; I cited both McCallum (1990) and McCallum (2001). McCallum (1990) discusses the Friedman (1963) view of inflation as a monetary phenomenon, argues that Friedman's view implies that long-run money growth determines steady-state inflation, and endorses that view. The cited passage of McCallum (2001), on the other hand, rejects the view that inflation is a nonmonetary phenomenon in the long run in New Keynesian models. If inflation is not a nonmonetary phenomenon, it is a monetary phenomenon. So McCallum's rejection in 2001 of the view that inflation is a nonmonetary phenomenon means that his 1990 interpretation of inflation as a monetary phenomenon, with its emphasis on money growth, can be taken as applicable.

To bring out the role of money, let's write the steady-state money demand function in first differences:

$$E[\mu_t] = E[\pi_t] + c_1 E[\Delta \log Y_t] + c_2 E[\Delta R_t].$$

In the steady state, models like Woodford's satisfy the generic monetary neutrality feature highlighted in the Abel-Bernanke (1992) passage quoted above; output and real interest rates are equal in the long run to their steady-state natural values—both of them constant here. Accordingly, $E[\Delta \log Y_t] = E[\Delta \log Y_t^n] = 0$ and the expectation of the change in the real rate is zero. Moreover, my assumption of a constant steady-state inflation rate makes $E[\Delta \pi_t]$ and so $E[\Delta R_t]$ zero, with the consequence that the preceding long-run first-differenced money demand condition becomes

$$E[\mu_t] - c_1 E[\Delta \log Y_t^n] = E[\pi_t], \tag{8}$$

implying that the inflation rate and the rate of growth in nominal money have a one-for-one long-run relationship, adjusted, as usual in quantity-theory analysis, for steady-state growth in potential output. (Average growth in potential is typically nonzero in actual data; I keep the $c_1 E[\Delta \log Y_t^n]$ term in equation (8) as a reminder of this general case, though it is zero under the assumption of no output trend.)

The steady-state system therefore consists of equations (5), (6), (7), and (8). How have things changed in the steady state compared to the dynamic case? As discussed in Section 3.1, they have not changed in a mathematical sense. We still have a self-contained system of three equations in y, R and π plus a fourth equation (the money demand equation) relating these variables (or, in steady state, a subset of them) to money. But, economically, things have changed. Mechanical application of the analysis of the dynamic model to the steady-state case requires treating the R equation (7) as a policy rule. Equation (7), however, is a steady-state version of the Fisher equation, with the real-rate term exogenous. So treatment of the R equation as a policy rule now requires taking the position that R is a policy instrument in (7) (as in the dynamic equation) or that π is a policy instrument.

But I believe that neither position is really tenable. I believe that the condition

$$E[R_t^*] = E[r_t^n] + \pi^* \tag{9}$$

16

cannot be regarded as an equation determining $E[R_t^*]$ in terms of policy variables unless one explains how the central bank enforces its inflation target π^*. That is, one should explain how the central bank *makes* the inflation rate equal to its desired rate. Likewise, it is not satisfactory to rearrange the condition to

$$\pi^* = E[R_t^*] - E[r_t^n] \tag{10}$$

and then claim that the equation is solving for target inflation in terms of the policy variable $E[R_t^*]$. Such a claim can be justified only when accompanied by an explanation for how the policymaker can control the nominal interest rate in the long run. And here one must bear in mind that from the propositions given above, its short-run method of R_t control is unavailable in the long run.

It is a *short-run* deviation from monetary neutrality, arising from the temporary nominal rigidities, that allows New Keynesian modelers to treat R_t as a policy instrument, and the R_t equation as a policy rule, in the equations describing variables' dynamics. In the short run, with gradual price adjustment, open market operations are not met by a complete, instantaneous reaction of the price level. Consequently, these operations, on impact, not only affect nominal balances, but also real balances in the same direction. An enlargement of real money balances in turn produces an R_t fall—the liquidity effect—in order for the money demand equation to be satisfied; conversely, R_t rises in the case of a reduction in real balances. The monetary authority is able to affect both real and nominal interest rates via the liquidity effect produced by the change in real balances. In these circumstances, it is legitimate to follow the standard practice of studying dynamic systems which make R_t (or R_t relative to its steady-state value) the policy instrument, and then (assuming that the interest-rate rule features no reaction to money) the money demand equation assumes its familiar status of a redundant condition. But in the long run, things change: nominal price stickiness dissipates completely; monetary neutrality prevails; prices move by the same percentage as the nominal money stock; the determination of real money balances is separate from that of nominal balances; and the liquidity effect is gone.

Thus the behavior of the economy in steady state is characterized by Milton Friedman's observation, "The central bank cannot determine interest rates except by producing

inflation."[15] This observation is reflected in textbook analysis—implicitly in the Abel-Bernanke (1992) quotations above, and explicitly in other textbook discussions, such as Ritter and Silber's (1983, p. 431) statement that under price flexibility (and so in the steady state of any sticky-price model that satisfies the natural rate hypothesis), "A change in the money supply cannot alter the real rate; it can only influence nominal rates by changing inflationary expectations." Accordingly, the task for a monetary policy analyst interested in steady-state inflation determination is to describe how central bank actions determine the long-run expectation of inflation when they cannot affect the real interest rate.

We therefore come to why the steady-state inflation rate is pinned down by steady-state money growth. Though they no longer affect real interest rates, and no longer can affect nominal rates *via a liquidity effect*, the central bank's open market operations continue in the long run to affect nominal money growth. So nominal money growth is unambiguously susceptible to central bank influence even in the long run. The preceding steady-state money demand equation consequently provides the guide for hitting a desired inflation rate π^*. Reaching that inflation target means a specified quantity of open market operations in the steady state; specifically, open market operations that deliver a steady-state money growth of $\mu^* \equiv \pi^* + c_1 E[\Delta \log Y_t^n]$. There it is: the sense in which steady-state inflation can be regarded as pinned down by steady-state money growth. It is not a denial of the long-run nominal interest-rate equation, but instead is an account of how the central bank makes the nominal variables in that condition take the values that the central bank wants.

The interdependent positions that (*a*) long-run money growth determines long-run inflation, and (*b*) the monetary authority cannot treat the nominal interest rate as an instrument in the long run, are widely shared. It is common to find in discussions by policymakers and policy advisors statements to the effect that the short-term nominal interest rate is not a variable permanently at their disposal as an instrument, but rather, in keeping with the preceding discussion, a variable that is a policy instrument only in the short run. To this end, a particularly notable statement is that of Goodhart (1992, p. 315): a "central bank's control over short-term interest rates… is relatively short, in terms of weeks, quarters or a few years. In the long term, nominal interest rates will be

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[15] Quoted in Crawford (1970). There, Friedman added that he was referring to the case where "you want the central bank to affect interest rates over more than the immediate short-term period"; that is, to long-run control of the interest rate.

determined by real (international) forces and the expected rate of inflation." Another quotation that goes to the heart of the matter is due to then-Federal Reserve Bank of St. Louis President Darryl Francis, who said in 1973: "It is wrong to accept at face value the statement [that] the 'Fed can control interest rates' without the corresponding explanation of *how* the Fed can do this…" (Francis, 1973, pp. 8–9.) Francis might have added that such an explanation is especially needed for the study of long-run interest-rate and inflation determination.

This does not preclude using frameworks like Woodford's that refer to the inflation target in the interest-rate rule as the determinant of steady-state inflation; rather, what needs to be kept in mind is that such an approach is a shortcut or abstraction that takes for granted the underlying operations involving money on the part of the central bank that secure long-run control of the interest rate and inflation.

Even if one is satisfied with viewing the inflation-target portion of the interest-rate rule as what determines the steady-state inflation rate, and wishes to implement this approach empirically, one must face the fact that the inflation target is often not measured directly. Information from monetary aggregates might be valuable in this context. Episodes in the U.S. experience suggest that estimates of the long-run inflation rate implied by Federal Reserve policy would be improved by allowing data on monetary aggregates to affect the estimates. For example, Ireland's (2007, Figure 4) inflation-target series, estimated from interest-rate, output, and inflation data, suggests that the steady-state inflation rate leveled off and fell slightly over 1971 and 1972. This presumably reflects the impact on the target estimate of the combination of rises in the short-term interest rate and declines in measured inflation during 1972. But actually monetary policy was very expansionary in 1972, and inflation was being held down by price controls. Correctly measured steady-state inflation rate rose in 1972, and consideration of data on money growth—rapid during 1972—would have helped move Ireland's estimate of steady-state inflation in the right direction. Likewise, data on money growth are revealing about periods (such as the 1980 credit-controls episode) in which monetary policy is tight but interest rates are nevertheless falling sharply.

4. Clarifications and objections

It is useful to clarify the argument outlined above by highlighting some distinctions from other discussions of interest-rate rules in the literature. In this section, I emphasize that

my argument does not have anything to do with appealing to the danger of multiple model equilibria (Section 4.1). It is also important to consider the changing status of the IS equation when one is studying the long run (Section 4.2). Finally, Section 4.3 points out some discontinuities between sticky-price models and flexible-price models such as the one studied by Woodford (2003, Chapter 2).

4.1 Feasibility is the problem, not indeterminacy

My opposition to representing steady-state monetary policy as an interest-rate setting decision does not rest on any appeal to the possibility of multiple equilibria.[16] In fact, there is no danger of multiple model solutions in the steady state studied above. From inspection of equation (9), it is clear that no uniqueness problems exist: given the steady-state inflation rate π^*, $E[R_t^*]$ has a unique value, since the difference between them (the steady-state natural real interest rate) is an exogenous constant. The problem is instead the *inadequacy* of the level of explanation. Simply assuming that the mean of the nominal interest rate can be selected by the central bank is hardly a satisfying basis for describing determination of mean inflation. On the contrary, it begs the question of how the central bank determines long-run inflation. As discussed above, long-run monetary policy influence on the nominal interest rate is not possible other than via policy's influence on long-run inflation, so explaining long-run inflation outcomes as the result of an interest-rate choice is inadequate.

The argument outlined in Section 3.4 above therefore differs from critiques of interest-rate rules or of interest-rate pegging because mine is not a claim about the undesirable consequences of certain interest-rate policies. Instead, it is a *neutrality* claim that denies the feasibility of affecting interest rates in the long run, other than through the Fisher effect. This neutrality result rules out viewing interest rates as a long-run policy instrument. Money growth, on the other hand, is a variable that the central bank can view as an instrument in the long run, and its long-run influence on inflation and interest rates comes from having this instrument at its disposal.

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[16] See instead Christiano and Rostagno (2001) and Christiano, Motto, and Rostagno (2007) for analyses of the interaction between multiple-equilibria problems and the role of money in monetary policy. In particular, these authors argue that policymaking strategies that assign a role to money can help avoid multiple equilibria of the sort claimed by Benhabib, Schmitt-Grohé, and Uribe (2001) to arise from interest-rate rules.

4.2 Interest rates and aggregate demand

The perspective offered here on money's role in the long run is not simply a version of the point that behind the determination of aggregate demand by interest rates, there are open market operations supporting the central bank's chosen interest rate. That point is frequently made in characterizing dynamics in the three-equation New Keynesian dynamic model, and is consistent with the money demand equation being redundant.[17] That particular point, however, does *not* carry through to the long run; indeed, the equation connecting aggregate demand to interest rates (the IS equation) has no terms that monetary policy can affect in the long run. The Euler equation that underpins the IS equation implies a relation connecting steady-state economic growth and the steady-state real short-term interest rate,[18] neither of which monetary policy can affect. To find where steady-state inflation is determined, one must look at other steady-state conditions. In this regard, Woodford points to the intercept of the interest-rate policy rule. I argue that such a perspective is a shortcut, in the absence of a story of how the central bank can affect the interest rate in the long run—given that its main short-run manner of influence (the liquidity effect of open market operations) is *absent* in the long run.

4.3 Dichotomy between flexible-price and sticky-price models

The argument made here about long-run inflation determination rests on an asymmetry between the central bank's power over interest rates under sticky prices and under flexible prices (and therefore, in the long run of a sticky-price model). Woodford (2003, Chapter 2) analyzes interest-rate rules in a flexible-price model before moving to sticky-price models in the rest of his monograph. Does that mean that my claimed dichotomy between flexible-price and sticky-price models is invalid? The answer is no. The central bank's means of affecting interest rates are different in a flexible-price model. Consequently, specifying monetary policy in terms of an interest-rate rule when prices are flexible amounts to a high-level assumption (or shortcut) in a way that the same specification in a sticky-price model is not.

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[17] It is not sufficiently appreciated that the redundancy of the money demand equation in solving for inflation and output dynamics under interest-rate rules is *not* a feature that makes New Keynesian models different from earlier model generations. In fact, the same redundant status pertained to money demand functions in traditional IS-LM analysis under interest-rate rules, a point that Christiano, Motto, and Rostagno (2007, pp. 3–4) make very clearly.
[18] Obtaining this condition involves using a standard resource constraint to substitute output for consumption.

In Woodford's (2003) Chapter 2, as in other flexible-price environments such as Barro (1989), the *ex ante* real interest rate is exogenous, and the only way the central bank can control the interest rate is via the Fisher effect. For example, in Woodford (2003, Chapter 2, p. 97), the real interest rate is assumed to follow an AR(1) process, in keeping with its exogenous status. Key properties of the New Keynesian model analyzed in Woodford (2003, 2007)—e.g. the central bank's ability to influence real interest rates— do not have counterparts in his (2003, Chapter 2) model.

Thus in Woodford's (2003, Chapter 2) framework it is possible to write the (linearized) Fisher equation, $R_t = E_t\pi_{t+1} + r_t$ (with r_t being the real interest rate) as

$$R_t = E_t\pi_{t+1} + t.i.p. \tag{11}$$

where, as in Woodford (2003, p. 395), "*t.i.p.*" denotes "terms independent of policy." In a sticky-price model such as that in Woodford (2007), however, such a representation of the Fisher equation is *not* admissible: rather

$$R_t \neq E_t\pi_{t+1} + t.i.p , \tag{12}$$

because the dynamics of the real interest rate are not independent of monetary policy. In the sticky-price model, then, R_t is susceptible to central bank influence for given $E_t\pi_{t+1}$; whereas in the flexible-price model the *only* way the central bank can control R_t is by control of $E_t\pi_{t+1}$. Woodford's (2003, Chapter 2) model therefore has the property of flexible-price models described in the Ritter-Silber (1983) observation given above, a property shared, as noted, with the *steady state* of any sticky-price model that satisfies the natural rate hypothesis.

The dichotomy between sticky-price and flexible-price models is illustrated in Figures 1 and 2. Figure 1 describes the period-*t* reaction of interest rates and money to an expansionary open-market purchase in a typical sticky-price model (including standard New Keynesian models). The signs of responses depicted in this figure would be those typically associated with a positive exogenous shock to a univariate money growth rule.[19]

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[19] In the case of sticky prices, they also correspond to the sign responses associated with an open market purchase designed to deliver an expansionary shock to an interest-rate policy rule. The real rate, nominal rate, and inflation sign responses, for example, are consistent with the impact effects of a monetary policy shock implied by the "$\rho = 0.6$" parameterization in Woodford (2003, Figure 4.8, p. 283).

Underlying the figure are standard assumptions that (*a*) the expansion is expected to be followed by another expansionary action in the following period (and so makes period-*t* expectations of period-*t*+1 nominal money growth higher than they would be in the absence of the expansionary action),[20] and (*b*) the liquidity effect on the nominal interest rate initially outweighs the Fisher effect on the nominal interest rate. The expansionary open market operation is associated with an expansion of nominal and real money balances, higher inflation expectations for period *t*+1, and with declines in the nominal and real interest rate.[21]

Figure 2 depicts the corresponding sequence in a flexible-price model. There is no central bank influence on real interest rates even in the short run, and the central bank's scope for affecting nominal interest rates is limited to the Fisher effect. The open market purchase does not produce a short-run expansion of real money balances; in fact, the Fisher effect on nominal interest rates will increase the opportunity cost of holding real balances and lead households to reduce their real money holdings (the reduction, in aggregate, being achieved by an upward shift in the price level). Since Figure 2 describes Woodford's (2003, Chapter 2) model, it is clear that there are limitations on the central bank's power over interest rates in that model that are not present in the short run of a sticky-price model. In particular, in both the short run and the long run of a flexible-price model, the only influence the monetary authority can exert on nominal interest rates is by affecting the expected-inflation portion of the nominal interest rate.

The contrast between Figures 1 and 2 is underscored by considering standard descriptions of the transmission mechanism. Ramey (1993, p. 2) describes the standard view of the transmission mechanism as one where central bank injections of nominal base money also initially raise the quantity real base money; the increase in the latter induces a decline in the nominal interest rate; and the decline in the nominal rate contributes to a decline in the real rate. As Ramey notes, this view of the transmission mechanism rests on the existence of price stickiness. All of her description carries through to the adjustment process in Woodford's (2007) model, which has nominal rigidity. None of it

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[20] This assumption would be appropriate, for example, if the monetary policy rule was a stationary AR(1) money growth rule with positive AR parameter.

[21] The figure depicts the behavior within a single period of several simultaneously determined endogenous variables. The arrows employed in the figure serve, as in (e.g.) Dornbusch and Fisher (1978, p. 362), to lay out how monetary policy transmission works in the model; they do not depict a timing sequence. Note also that while higher money growth tends, as indicated, to raise expected inflation in both sticky-price and flexible-price models, in the former case this typically occurs via an output-gap channel (see e.g. Svensson, 2001, p. 15).

Figure 1. Reaction of period-*t* variables and period-*t* expectations to period-*t*
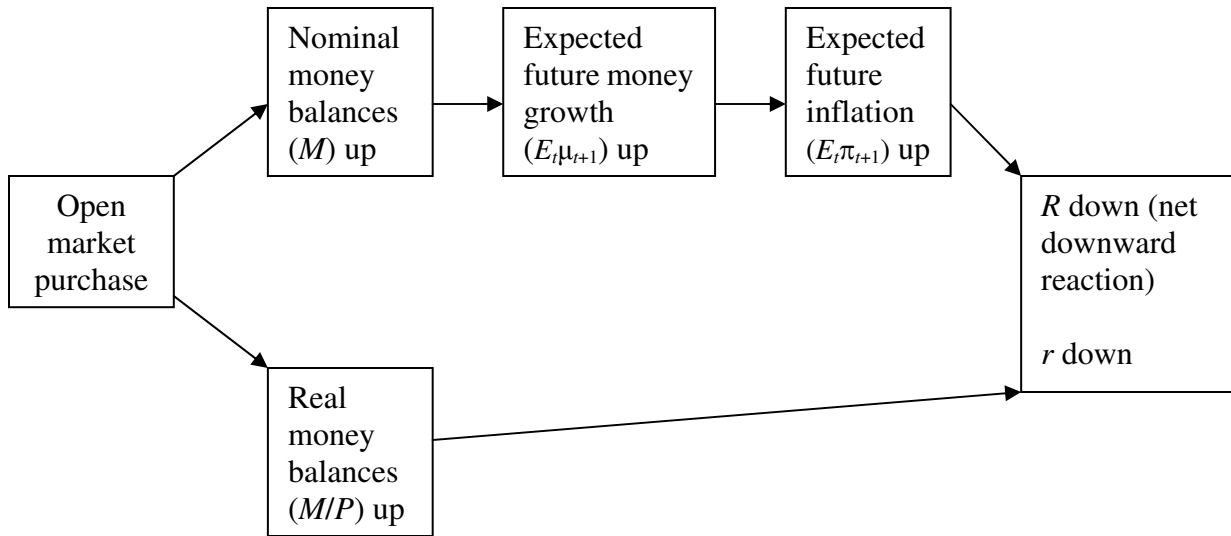open market purchase: sticky-price model

	Nominal money balances (*M*) up	Expected future money growth ($E_t\mu_{t+1}$) up	Expected future inflation ($E_t\pi_{t+1}$) up	

Open market purchase				*R* down (net downward reaction) *r* down

| | Real money balances (*M/P*) up | | | |

Figure 2. Reaction of period-*t* variables and period-*t* expectations to period-*t*
open market purchase: flexible-price model

	Nominal money balances (*M*) up	Expected future money growth ($E_t\mu_{t+1}$) up	Expected future inflation ($E_t\pi_{t+1}$) up	

Open market purchase				*R* up *r* unaffected

| | Real money balances (*M/P*) *not* increased | | | |
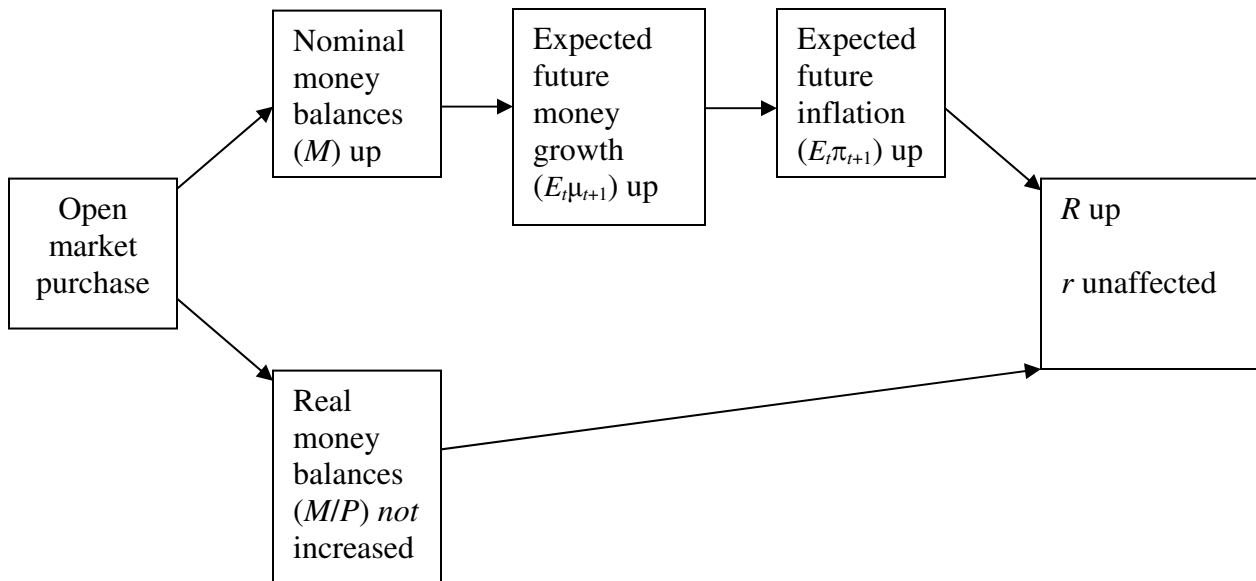
Table 1. Comparison of properties of Woodford (2003, Chapter 2) and Woodford (2007) models				
	Characteristics of:			
	Woodford (2007) sticky-price model with monetary frictions		Woodford (2003, Ch. 2) flexible-price model with monetary frictions	
	Dynamics near steady state	Steady state	Dynamics near steady state	Steady state
Can monetary policy affect real interest rate?	Yes	No	No	No
Does open market purchase reduce nominal interest rate?	Yes	No	No	No
Do open market operations affect money growth?	Yes	Yes	Yes	Yes

carries through to the model in Woodford (2003, Chapter 2), because that model has no nominal rigidity.

Woodford's (2007) model in the long run has the same limitations on central bank power as those that prevail every period in a flexible-price economy. This is brought out in Table 1, which reworks elements of Figures 1 and 2 and also states steady-state properties of the Woodford (2003, Chapter 2) and Woodford (2007) models. The steady-state properties listed for Woodford's (2007) model coincide with the properties (both in steady state and for dynamics near steady state) of the flexible-price model. In particular, as one moves from the short run to the long run in a sticky-price model, one reaches a situation where open market operations cannot influence the real interest rate but can still influence money growth, and these operations can only influence nominal interest rates via affecting inflation. The link between open market operations and inflation as recorded in the (first-differenced) steady-state money demand equation accordingly assumes importance as one moves to long-run analysis.

Therefore, unless one is satisfied with the high-level assumption that the central bank can treat $E_t\pi_{t+1}$ as a policy instrument, one must see the interest-rate rule in a flexible-price model as derived from the influence on $E_t\pi_{t+1}$ of the only variable that is a *bona fide* policy instrument in the long run: money growth. The fact that Woodford (2003) looks at both sticky-price and flexible-price models thus does not mean that all interest-rate results carry across both models. In particular, the underlying mechanism for central

bank influence on interest rates is distinct in flexible-price models, with these models implying exclusive reliance on the Fisher effect for interest-rate control.

5. Conclusion

To summarize, Woodford's (2007) analysis is algebraically correct but rests on high-level assumptions about the central bank's long-run control of the interest rate. By contrast, the proposition that inflation, in the long run, is determined by money growth, goes beneath those high-level assumptions and provides an underpinning for the conviction that the central bank can deliver the long-run inflation rate at its target value (and so deliver the corresponding implied nominal interest rate).

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