What Difference Would an Inflation Target Make?

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Numerous economists have advocated an inflation target for the United States (see, for example, Mishkin [1999] and Goodfriend [2005]). What, if anything, would an inflation target change about the way the Federal Reserve makes monetary policy? To answer this question, one must be explicit about the strategy used to achieve that target. Such a strategy might not even include inflation as an operational target. An answer to this question therefore requires specification of a policy rule—an explicit formulation of the objectives of monetary policy and the strategy for achieving those objectives.

A policy rule would clarify what, if anything, an explicit inflation target implies about other objectives. Are real output and unemployment also objectives? If a tradeoff between fluctuations of inflation around its target and fluctuations of real output around potential or trend output exists, real output and unemployment must be included as objectives along with inflation. Whether this tradeoff exists depends upon the structure of the economy. Therefore, to evaluate the prospective working of an inflation target requires explicit specification of both a policy rule and a model of the economy. Different models possess different implications for how a central bank would make an inflation target operational. How does one choose such a model?

There are two different frameworks for explaining how central banks control inflation. One framework makes an "exploitable" Phillips curve the central behavioral relationship in the control of inflation. That is, the central bank can use the real-nominal (unemployment-inflation) correlations in the empirical data as a reliable lever with which to trade off between these variables.

The other tradition, the quantity theory, makes monetary control the central behavioral relationship. That is, to control inflation, the central bank must control the rate at which nominal money grows relative to real money demand by the public. The former tradition, but not the latter, implies that the control of inflation imposes a tradeoff between variability in real output and inflation.

Two problems arise in choosing the correct model. The first is the lack of consensus over the empirical generalizations that should serve as a basis for choosing one model over the other. What lessons does one draw from the recent historical experience in the United States of rising inflation followed by disinflation? How does one summarize this experience in a way that allows a choice between competing models?

Section 1 lists four empirical and theoretical generalizations that I consider consistent with this experience and with the quantity theory framework. Section 2 discusses the consensus that exists over these generalizations. (The central bank must provide a nominal anchor.) Section 3 discusses the disagreement. (What is the nature of the Phillips curve?)

The second problem is that no exposition of a model in the quantity theory tradition exists that is useful for explaining monetary control applicable to a central bank that uses an interest rate instrument. The central insight of the quantity theory is that the nominal quantity of money can change without a prior change in real money demand. When it does, the price level must change to restore the real quantity of money demanded by the public (Friedman 1969).[1] However, existing expositions of the quantity theory assume that the central bank employs a money target. They leave unclear how a central bank, when it uses an interest rate instrument, achieves monetary control. That is, how does it avoid changes in money that produce undesired changes in prices?

Section 4 discusses monetary control when the central bank uses an interest rate instrument. Section 5 illustrates these ideas of monetary control through a model simulation that highlights periods when the central bank does and does not achieve its inflation target. The final section explains how an inflation target increases the demands placed on a central bank to communicate clearly to the public.

1.   FOUR QUANTITY THEORY GENERALIZATIONS

The current monetary standard did not emerge as an explicit choice among alternative policy rules with clearly defined nominal anchors. Nevertheless, its adoption occurred as part of the debate engendered by the intellectual ferment that accompanied the 1970s stagflation. Two sets of ideas came together to

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[1] Hetzel (2004a), which places the monetary policy of the Fed in a quantity theoretic framework, is complementary to this article. Goodfriend (forthcoming) and Nelson (2003) offer alternative arguments for incorporating money into models of price level determination.

provide the intellectual basis for the new standard. One set derived from the quantity theory, a tradition as old as the discipline of economics.[2] The other set, the rational expectations revolution, was new.[3] The quantity theory, with its fundamental distinction between nominal and real variables, explained the need for a nominal anchor that only a central bank could provide. Rational expectations, which emphasized the importance of policy rules in the formation of expectations, explained the importance of a credible rule. A model useful for explaining how central banks control inflation will incorporate four generalizations shaped by these two sets of ideas.

First, the price system works well to clear markets. Conceptually, a monetary economy possesses a real business cycle core that would emerge with complete flexibility of the price level (Kydland and Prescott 1982; Prescott 1986). Allowed to operate in an unhindered fashion, the price system embodied in this core allocates resources efficiently. A useful conceptual benchmark for assessing monetary policy is the difference between the values of real variables and their "natural" values represented by equilibrium in this real core.

Second, individual welfare depends upon real variables (real quantities and relative prices), not nominal magnitudes (dollar amounts). For this reason, only the central bank can give fiat money (a nominal variable) a well-defined value. The way that it does so determines the nature of the nominal anchor and the monetary standard.

An implication of the first and second generalizations is that central banks control the price level through their control of nominal money relative to real money demand. The price level is a price—the money price of goods. The assumption that the price system works means that the price level varies to clear the market for the quantity of money.[4] That is, it varies to endow the nominal quantity of money with the real quantity of money (purchasing power) desired by the public.[5] In this sense, the price level is a monetary phenomenon.

Third, individuals use information efficiently (form their expectations rationally). This generalization, plus the monetary character of the price level, implies that individuals base their expectation of the future price level on the systematic, predictable part of monetary policy (Lucas [1972] 1981). Be-

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[2] Expositions of the quantity theory go back to David Hume ([1752] 1955). The most recent expositions are Friedman (1969, 1974). Friedman (1989) summarizes these earlier expositions. See also Brunner (1971).

[3] See Lucas ([1972] 1981; [1973] 1981) and Sargent ([1971] 1981).

[4] The equilibrating role played by the price level changes with fixed, rather than floating, exchange rates. In the former case, the price level varies to equilibrate the balance of payments. The nominal anchor is the foreign price level. Through the balance of payments, nominal money adjusts to provide the real money desired by the public.

[5] The real quantity of money possesses a well-defined value—the natural value associated with complete price flexibility. This value is not unique but varies with the cost of holding money (the nominal interest rate).

cause individuals' welfare depends upon their ability to distinguish real from nominal changes (an absence of money illusion), they will use the systematic part of monetary policy to forecast inflation. Of course, the central bank can render this task difficult by following a rule that yields unpredictable changes in prices.

Given that individuals base their expectations and behavior on the systematic part of the central bank's actions, it follows that achievement of an inflation target (any nominal equilibrium) requires a monetary rule—a consistent procedure by the central bank for pursuing the target (Lucas [1980] 1981). If the central bank does not target money directly, this rule must tie down the expected future value of money (the inverse of the price level, the goods price of money). Stated alternatively, in a fiat money regime, money, which is intrinsically worthless, possesses value because individuals expect it to possess value in the future. Individuals part with goods for money today only because they believe that others will accept goods for money tomorrow. The central bank must provide a nominal anchor that determines how the public forms an expectation of the future price level. To do so requires the central bank to behave in a consistent, predictable manner, that is, to follow a policy rule.

It also follows that the rule determining the price level will possess a characterization in terms of monetary control (control of a nominal variable, money) rather than control of output or unemployment (real variables). If the welfare of individuals depends upon real—not nominal—variables, and they form their expectations of inflation conformably with the monetary rule, then the central bank either cannot manipulate real variables in a systematic manner (Sargent and Wallace [1975] 1981) or will not find it desirable to do so (Goodfriend and King 1997). At issue is the interpretation of the real-nominal (unemployment-inflation) correlations summarized in Phillips curves. Can the central bank use these correlations to influence predictably the behavior of the public? Can it systematically manipulate unemployment to control inflation—or manipulate inflation to control unemployment—or trade off between the two by increasing the variability of one to reduce the variability of the other?[6]

To make the importance of a rule concrete, note that the FOMC controls only an overnight interest rate—the funds rate. A stabilizing response of the yield curve to a real shock requires a widely understood, credible rule. Consider a persistent, positive shock. Credibility for price stability means that the public assumes that the central bank will raise the funds rate by what-

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[6] Milton Friedman (1968, 1977) and Robert Lucas ([1972] 1981; [1973] 1981; and 1996) argued that the real-nominal correlations summarized by Phillips curves represent a reduced form rather than a structural relationship. That is, these correlations are not invariant to the monetary rule. If the central bank attempted to "exploit" them to control unemployment, they would disappear. Similarly, they would disappear if the central bank attempted either to control inflation by manipulating unemployment or to control the joint variability of unemployment and inflation.

ever amount necessary to maintain price stability. With credibility, the entire upward shift in the yield curve will reflect higher expected future real rates of interest, not higher inflation. Conversely, with a persistent, negative real shock, credibility implies that the entire downward shift in the yield curve be real. The central bank gains nothing by attempting to offset the negative shock with inflation. Pursued as a systematic policy, the public will anticipate such behavior, and the expectation of inflation will offset the stimulative effect of the increased inflation.

The fourth and final generalization that I take as summarizing the quantity theory is that there is a fundamental difference between a relative price and the price level, which is an average of individual dollar prices. The price system decentralizes the information required to discover equilibrium relative prices (Hayek 1945) but does not do so for the price level. Price setters require some common coordinating device for changing their dollar prices that collectively allows the price level to change in a way that is compatible with the monetary policy rule and that avoids undesirable changes in relative prices. That coordinating device is a common expectation of inflation. It functions well only when the policy rule makes changes in the price level predictable.

Monetary nonneutrality arises when price setters lack a common expectational compass that provides for the coordination of the change in all dollar prices required by the policy rule.[7] Consider a policy that engenders monetary contraction requiring unpredictable reductions in the price level. Those reductions take place only through a discovery process—occurring without this coordination—by individual firms. The firm that moves first to lower its price faces the problem of strategic interaction with competitors.[8] There is a

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[7] This explanation is in the misinformational spirit of Lucas ([1972] 1981) rather than the sticky-price spirit of Calvo (1983). Consider two firms, $i = 1, 2$. A firm will change $\hat{p}_i$, its dollar price, by an amount, $\hat{r}_i$, equal to the desired change in relative price, plus $\hat{p}_i^e$, the expected change in the price level:

$$\hat{p}_i = \hat{r}_i + \hat{p}_i^e. \tag{1}$$

The monetary policy rule will be consistent with some change in price level $\hat{p}$. However, if that rule is only imperfectly known to firms, they will expect a change in the price level $\hat{p}_i^e = \hat{p} + \mu_i$. The actual inflation rate $\hat{p}^m$ will then differ from $\hat{p}$:

$$\hat{p}^m = \hat{p} + \omega_1 \mu_1 + \omega_2 \mu_2, \tag{2}$$

where ω_i is the expenditure share of firm i.

If the central bank announces an inflation target $\hat{p}^T$ and follows a policy rule consistent with that target, actual inflation will equal the inflation rate consistent with the rule and both will equal the inflation target ($\hat{p}^m = \hat{p} = \hat{p}^T$). In contrast, if the central bank behaves in a way that makes the inflation rate unpredictable, it will create relative price distortions that affect real variables. That is, as shown in (2), the behavior of relative prices will not wash out, but will instead affect inflation.

[8] Prices are sticky in the sense that this firm must change its price under the assumption that its competitors will not change their prices. Ball and Romer (1991) capture this strategic interaction through a multiplicity of equilibria.

positive externality to lowering one's price first that the individual firm does not capture.[9]

2.   THE CENTRAL BANK SHOULD CONTROL INFLATION

A consensus now exists that the central bank determines trend inflation and must provide a nominal anchor. That consensus derives from the results of the different policy rules followed by the Fed before and after 1980. Before 1980, monetary policy did not provide a nominal anchor.[10] Policymakers based policy on the assumption that inflation was a nonmonetary phenomenon; that is, inflation possessed many sources unrelated to the degree to which central bank procedures provided for monetary control. Consequently, the policy appropriate for the control of inflation depended upon the source of the inflation. Especially, cost-push inflation was better dealt with through incomes policies than through a restriction of aggregate demand, which would raise unemployment.[11] Incomes policies ranged from occasional government interference in price setting in particular markets to full-scale wage and price controls.

Universally, policies for the control of inflation based on incomes policies failed. By default, at the end of the 1970s, governments turned to central banks exclusively to control inflation. Because central banks are the organization with a monopoly on the monetary base, that decision vindicated Friedman's hypothesis that inflation is always and everywhere a monetary phenomenon.[12] The experiment created a consensus that the central bank must provide a nominal anchor.[13]

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[9] The externality comes from increasing the real quantity of money toward the amount demanded by individuals collectively.

[10] In the 1970s, through a continuing influence on expectations, the long historical experience with a commodity standard provided a nominal anchor. However, that influence disappeared by 1980.

[11] See Hetzel (1998, 2004a) for references.

[12] Friedman based his hypothesis on the empirical observation that high money growth accompanies high inflation. Once a central bank succeeds in restoring price stability, however, money loses its ability to predict prices. The apparent disappearance of money as a useful predictor obscures the validity of the Friedman hypothesis. I interpret the statement that inflation is a monetary phenomenon as follows: First, the central bank must supply the nominal anchor (provide for nominal determinacy). Second, different monetary policy rules determine different time series behavior of the price level. Third, the trend rate of inflation is under the complete control of the central bank. Note that the hypothesis does not imply that for a given rule real shocks exercise no influence on the price level.

[13] Bernanke (2005) reviewed a similar Latin American experiment. The structuralist theory of development attributed inflation to nonmonetary factors such as competition among groups for incompatibly large shares of national income. Policies based on such ideas led to high rates of inflation. Not until the end of the 1990s, when governments assigned responsibility for inflation to central banks, did Latin American countries achieve low inflation.

3. HOW DOES THE CENTRAL BANK CONTROL INFLATION?

Although there is a consensus that the central bank should control inflation, there is no consensus over how it does so. If the above quantity theory generalizations are correct, then central banks control inflation through procedures that provide for monetary control. The alternative is that they control inflation through manipulation of the unemployment rate according to a Phillips curve relationship. At issue is the nature of the Phillips curve and whether it offers a reliable lever for manipulating the behavior of the public.

Economists have suggested many possible Phillips curves.[14] Lucas ([1972] 1981) suggested the New Classical Phillips curve, and Calvo (1983) and Rotemberg (1987) suggested the New Keynesian Phillips curve. Each explain some aspects of the pre-1980 and post-1980 change in the monetary policy rule.[15]

The New Classical Phillips curve makes output fluctuations (deviations of real variables from their natural values) a function of forecast errors for inflation. Fluctuations in real variables are generated by the unpredictable component of monetary policy. Assuming that individuals form their expectations of inflation in a way that incorporates the systematic part of the monetary policy rule, the central bank cannot predictably manipulate nominal variables (inflation) to control real variables (an output gap or unemployment). Conversely, the central bank cannot manipulate these real variables to control inflation. The reason is that a systematic attempt to exploit the real-nominal correlations present in the data would make them disappear.

Stated another way, an implication of the New Classical Phillips curve is that the inflation-unemployment correlations in the data will not survive changes in the monetary policy rule (Friedman 1968; Sargent [1971] 1981; Lucas [1972] 1981, [1973] 1981). As predicted, in the 1970s, the negative correlation between unemployment and inflation disappeared in the face of sustained inflation. Furthermore, in the post-1980 period, in stabilizing inflation, monetary policy not only reduced inflation, but also maintained it without unemployment above its natural level. Moreover, both the variability of output and inflation fell. Orphanides and van Norden (2004) find parameter instability in a variety of Phillips curves estimated over the intervals 1969 to 1982 and 1984 to 2002. This evidence of structural instability runs counter to formulations of the Phillips curve that offer the policymaker a predictable tradeoff between inflation and unemployment. Examples are the original permanent trade-off formulation of Samuelson and Solow (1960) or the later NAIRU formulation of Modigliani and Papademos (1975).

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[14] See McCallum (2002, footnote 38) for a long list.

[15] The former is used in flexible price rational-expectations natural-rate models (see Sargent and Wallace [1975]). The latter is used in sticky price New Keynesian models. See Goodfriend and King (1997), who use the term New Neoclassical Synthesis.

An alternative to the New Classical Phillips curve is the New Keynesian Phillips curve shown in (3).[16] Like the New Classical Phillips curve, it makes expected inflation central. Contemporaneous inflation, π_t, depends upon expected future inflation, π_{t+1}^e, and a real variable measuring the intensity of resource utilization. In a world of monopolistic competition, the latter could be the markup (price over marginal cost) relative to its profit-maximizing (natural) value (Goodfriend 2004a). Alternatively, it could be an output gap (the difference between output, y_t, and the natural or potential level of output, y_t^*). The output gap measures the extent to which price rigidities produce variations in labor supply that move output away from its natural (flexible price) value (King and Wolman 1999):

$$\pi_t = \pi_{t+1}^e + b(y_t - y_t^*). \tag{3}$$

This Phillips curve contrasts with the traditional Keynesian Phillips curve (4), where inflation depends upon lagged inflation, an output gap that measures idle (unemployed) resources, and an inflation shock, ε_t. Equation (4) captures the view that inflation shocks (changes in relative prices that pass through to the price level) initiate inflation. The lagged inflation term π_{t-1} expresses a structural persistence in inflation that exists independently of whether the monetary policy rule accommodates (propagates) the impact of relative price shocks on the price level.[17] With (4), in response to, say, a positive inflation shock ε_t, the central bank creates a negative output gap $(y_t - y_t^*)$ to limit the increase in inflation. In a model of sticky prices, a Phillips curve like (4) requires that the central bank increase output variability to reduce inflation variability:[18]

$$\pi_t = \pi_{t-1} + b(y_t - y_t^*) + \varepsilon_t. \tag{4}$$

The expectational Phillips curve (3) expresses the importance of credibility in controlling inflation. That is, in the post-1989 period, the Fed has stabilized actual inflation by stabilizing expected inflation. FOMC behavior during inflation scares provides evidence that the policy rule that provided a nominal anchor in the post-1980 period entailed a consistent effort to stabilize expected inflation at a low level (Goodfriend 1993, 2004b, and 2005; Goodfriend and King 2004; and Hetzel 2005). For example, during the 1984

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[16] One reason economists turned to the New Keynesian Phillips curve is that the New Classical Phillips curve does not explain why monetary shocks impact output and employment before inflation. For a derivation of (3), see Rotemberg and Woodford (1997).

[17] That is, given the structure of the economy assumed in (3) but not (4), in empirical estimation, lagged inflation terms would appear only to that extent that the monetary rule makes them useful for predicting inflation (Sargent 1971).

[18] Based on a Phillips curve like (4), Ball (1999, Figure 3.1) and Rudebusch and Svensson (1999, Figure 5.2) present model-based estimates of a tradeoff between the standard deviation of the output gap and inflation.

inflation scare, characterized by a sharp rise in bond rates, the FOMC raised the funds rate despite falling actual inflation and a negative output gap.

Before 1980, the idea of an expectational nominal anchor would have seemed implausible. The popular consensus, formed by Keynesians and businessmen, held that powerful private sector forces (weather, the OPEC cartel, oligopolistic market structure, militant labor unions, etc.) and government deficits and regulation powered inflation. Expectations unmoored by monetary policy also drove inflation (the wage-price spiral). Only a high rate of unemployment could counter these real forces.[19]

The Volcker disinflation and its aftermath changed attitudes in two respects. The reduction of inflation from double digits to 4 percent demonstrated that central banks could control inflation. Just as important was the aftermath when monetary policy maintained moderate inflation without either sustained high unemployment or periodic recourse to high unemployment. A consensus then emerged that credibility was paramount for central bank control of inflation. A credible monetary policy can always and everywhere control inflation without resorting to high unemployment.[20]

Credibility or its absence can explain the failure of Phillips curves like (4) to explain particular episodes. Despite extreme tightness in labor markets and a positive output gap in 1999 and early 2000, inflation remained low. This episode was the converse of the early 1970s experience where inflation remained high despite an apparent negative output gap. Credibility in the first episode and in its absence in the second can explain this behavior.

Another kind of evidence in favor of an expectational Phillips curve like (3) is the failure of relative price shocks to exercise a persistent influence on inflation when the central bank possesses credibility.[21] Relative price shocks do occasionally pass through to the price level.[22] With credibility, however, a positive, relative price shock, for example, that passes through to the price

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[19] This view still appears in the Phillips curve (4), where inflation shocks initiate inflation and intractable inflation persistence propagates them. To maintain expected inflation equal to its target, the central bank must raise unemployment to counter these shocks.

[20] After 1979, the Fed abandoned its former policy rule without committing to a new one in a credible, public way. The public had to learn the new rule over time. While this learning occurred, expectations were not "rational" in the sense of being consistent with the new rule. The Fed had to incur costs to establish credibility. During inflation scares, it had to shock the economy through unanticipated monetary contractions. The real-nominal tradeoffs of the Phillips curve occur in establishing credibility but not in controlling inflation with credibility.

[21] Consider oil price shocks. In early 1999, the price of a barrel of crude oil was around $10. In March 2005, it reached $55. The unemployment rate, which fell from July 2003 onward, did not provide an offset to this "inflation shock" in the last part of this period. As indicated by the behavior of bond rates, financial markets have not expected this increase in the relative price of oil to increase inflation other than transitorily.

[22] If the central bank had to respond directly to such price level changes, it could adversely affect unemployment. The Friedman (1960) long-and-variable lag criticism of price level targeting would apply. If the central bank maintains expected inflation equal to its target and then moves the funds rate so that the real rate tracks the natural rate, money creation follows changes in real money demand. Money is not an independent influence (see Section 4). If the central bank

level does not create an expectation of further inflation. Consequently, there is no expectational coordinating mechanism to propagate a general price rise (note generalization (4) of Section 1). As a consequence of central bank use of an interest rate target as opposed to a money target, there is no real balance effect to reverse the contemporaneous price rise, and the price level can drift. However, over time, such changes tend to wash out.[23]

Unlike the Lucas Phillips curve of the New Classical model (2), the Calvo-Rotemberg Phillips curve of the New Keynesian model (3), which assumes sticky (infrequently changed) prices, does offer a predictable tradeoff between real and nominal variables. However, even though the central bank can systematically exploit a tradeoff between real and nominal variables, it should not. A policy of price stability is welfare maximizing because it avoids the relative price distortions that inflation causes with intermittent price setting.[24] With either type of Phillips curve, central bank control of inflation through manipulation of the real-nominal correlations of the Phillips curve is not an option, either because it is infeasible or because it is undesirable.

4.   MONETARY CONTROL WITH AN INTEREST RATE INSTRUMENT

If central bank control of inflation does not possess a characterization in terms of manipulation of a Phillips curve relationship, it must possess a characterization in terms of monetary control. However, with central bank use of an interest rate instrument, monetary control does not require a target for money.

An understanding of monetary control with an interest rate instrument begins with the fact that the market interest rate comprises a nominal and a real component. For each component, there is a unique value consistent with maintaining inflation equal to target. Monetary policy must set the first equal to its inflation target and discover the value of the second to make it equal the natural interest rate (the real interest rate that would prevail with complete price flexibility).

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created and destroyed money to offset transitory movements in inflation, money creation would become an independent influence with unpredictable results.

[23] The forecast error associated with a prediction of the future price level can still grow very large as the forecast horizon lengthens. If the central bank wanted to assure price stability as opposed to inflation stability, it would need to establish credibility for a negative correlation between actual inflation and expected inflation rather than just a zero correlation.

[24] See Goodfriend and King (1997, 2001) and Wolman (2001). Rotemberg and Woodford (1999, 74) state: "[E]ven though our proposed welfare criterion ... assigns ultimate importance only to the efficiency of the level of real activity..., it in fact justifies giving complete priority to inflation stabilization as opposed to output stabilization."

King and Wolman (1999, 350) state: "[T]he monetary authority should ... make the price level the sole objective of monetary policy .... [P]rice level stabilization policy is optimal in a very specific sense: it maximizes utility of the representative individual."

The central bank must stabilize the public's expectation of (trend) inflation by following a rule that keeps that expectation equal to its inflation target. Consider an inflation scare (Goodfriend 1993). To maintain expectational credibility (the nominal anchor), the central bank must be willing to create an unexpected negative output gap by imparting a monetary shock.[25]

Given equality between expected inflation and the central bank's inflation target, the central bank can take for granted stability in the inflation premium in the interest rate. It can then vary its interest rate instrument to produce predictable changes in the real rate. It can concentrate on the sole objective of making the real interest rate track the natural interest rate. In doing so, it allows the price system to maintain resource utilization at its natural level (keep $y_t - y_t^*$ at zero). Real output grows in line with potential output.

Expected inflation then drives both actual inflation and money growth beyond changes in real money demand, which the central bank accommodates as a consequence of maintaining an interest rate peg. In a sense, there is a Friedman k-percent rule for money growth, which equals the k-percent inflation target plus whatever additional amount is required to accommodate changes in real money demand. However, changes in nominal money rather than changes in the price level provide the public with desired changes in real money. The central bank provides for desired changes in real money (consistent with the behavior of natural output) through changes in nominal money, thereby obviating the need for price level changes (beyond those compatible with the inflation target).

A policy rule that works poorly to maintain equality between the real and natural interest rate engenders excess money creation (destruction). With a policy rule that permits base drift in the price level, these monetary emissions (absorptions) force changes in the price level. They are the real-world counterparts to the helicopter drop of money used by Friedman (1969) in expositions of the quantity theory. Now, changes in the price level provide the public with desired changes in real money. Although a central bank with an interest rate instrument does not target money directly, to stabilize the price level it must possess a rule that provides for monetary control in the sense that money creation only accommodates prior changes in real money demand rather than forcing changes in the price level.

One can use this definition of monetary control to understand FOMC procedures. Because the FOMC does not possess observations of the natural interest rate, it requires an indicator that registers misalignment between the real and natural rate. Hetzel (2004a, 2005) argues that the FOMC uses a growth gap indicator. It raises the funds rate when the economy is growing faster than its estimated potential growth, and conversely.

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[25] An ability to affect real variables through a monetary shock is different from controlling real variables in a systematic manner.

From a different but equivalent perspective, Broaddus and Goodfriend (2004) argue that FOMC procedures prevent emergence of a markup gap—the difference between the markup and its natural or profit maximizing value.[26] When the gap falls, the FOMC raises the (real and nominal) funds rate to restrain aggregate demand and restore the optimal output gap, and vice versa. Because the FOMC does not observe the output gap, it requires an indicator. The indicator is the degree of stress on resource utilization, which the FOMC synthesizes from extensive review of economic statistics.

5.   A REAL-WORLD HELICOPTER DROP OF MONEY

The language of economics is the language of tradeoffs. To use this language to understand the implications of an inflation target requires a model. I use the New Keynesian model to illustrate the control of inflation given that the central bank does not find it desirable to trade off inflation variability against output variability. The model places the control of inflation in the context of monetary control rather than manipulation of the real-nominal relationship of a Phillips curve. (The appendix exposits the model.)

The intent of the simulation is to provide a real-world counterpart to the exogenous increase in money assumed in expositions of the quantity theory. In the simulation, a persistent productivity shock raises the natural interest rate. Interest rate smoothing by the central bank causes the money stock to rise. Although money is endogenous, the price level must rise to maintain real money equal to the amount the public demands.[27]

With the policy rule (5), the nominal anchor is an inflation target. The central bank responds to the difference between actual (π) and targeted inflation (π^T). Changes in the interest rate (R_t) that the central bank sets exhibit inertia relative to a base value R_{t-1}^*, which is the average of the prior period's actual interest rate and the interest rate in the absence of shocks (the steady state interest rate), $\bar{R}_{t-1}$; that is, $R_{t-1}^* = \frac{1}{2}\left[R_{t-1} + \bar{R}_{t-1}\right]$:

$$R_t = R_{t-1}^* + \frac{1}{s}\left(\pi_t - \pi^T\right). \tag{5}$$

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[26] In a world of monopolistic competition, the markup is the difference between price and marginal cost. Firms raise prices when they expect the markup to remain persistently below its profit maximizing value.

[27] In his exposition of the quantity theory, Friedman (1969, 4) examines the consequences of the following conceptual event: "[O]ne day a helicopter flies over this community and drops an additional $1,000 in bills from the sky." In the simulation, the helicopter drop comes from interest rate smoothing by the central bank at the time of a real disturbance that raises the natural interest rate.

Figure 1 Interest Rate
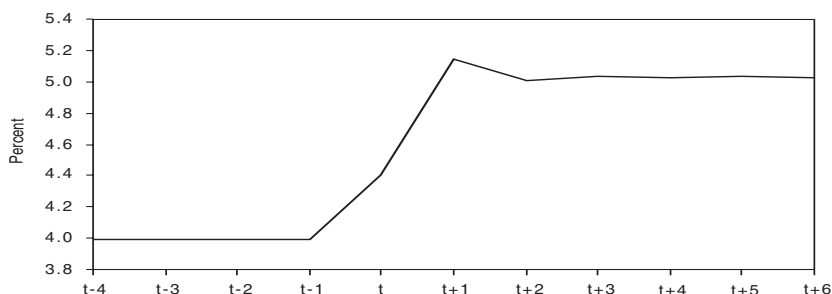
Because of this interest rate smoothing, the interest rate set by the central bank responds only with a lag to changes in the natural interest rate. That lag causes money creation and fluctuations in inflation around the inflation target. The point is that inflation control requires both a credible inflation target and procedures that vary the interest rate instrument so that it tracks the natural interest rate.

By definition, a central bank is the organization with a monopoly on the creation of the monetary base (money in the model). Consequently, a relationship will exist between the monetary base and the central bank's policy instrument, the interest rate. Equation (6) specifies the relationship consistent with (5):

$$\Delta ln\,(M_t) = \pi^T + \Delta lnc_t + v\Delta lnX_t + s\left(R_t - R^*_{t-1}\right).\tag{6}$$

The inflation target π^T determines expected and actual trend inflation. Money growth increases one for one with increases in π^T. (Δln is the change in the natural logarithm.) The interest rate peg causes changes in nominal money to move with changes in the public's demand for real money. The two terms Δlnc_t and $v\Delta lnX_t$ capture the effect of changes in real money demand on nominal money. Under the assumption of an elasticity of demand for real money with respect to real consumption (c_t) of one, a 1 percent change in real consumption produces a 1 percent change in nominal money. The $v\Delta lnX_t$ term captures the effect on nominal money of changes in the opportunity cost

of holding money.[28] The last term of (6), $s\left(R_t - R_{t-1}^*\right)$, relates the interest rate smoothing of the central bank to its money creation.[29]

The real disturbance is a technology shock that raises trend output (consumption) growth from zero to 1 percent in period t.[30] The natural (steady state real) interest rate rises commensurately with the growth rate of consumption. The price of contemporaneous consumption, the real interest rate, must rise to reconcile the consumer to a pattern of consumption that now favors the future. With an assumed rate of time preference β equal to 0.97125, before the increase in productivity growth, the real interest rate is 3 percent. With an inflation target π^T of 1 percent, the nominal interest rate is 4 percent. After the productivity shock raises the trend growth rate of consumption to 1 percent, the trend nominal interest rate rises to 5 percent.

Figure 1 displays the behavior of the interest rate. In the initial period of the productivity increase, the central bank limits the interest rate increase by pulling the interest rate toward a base value (the average of the prior period's interest rate and the prior period's steady state interest rate). In period t, through money creation, the central bank keeps the interest rate at about 4.4 percent. A one-time increase in the nominal money stock of 1 percent occurs about equally in periods t and $t + 1$ (Figures 2 and 3).

The increase in consumption increases the demand for real money while the increase in the nominal interest rate decreases it. As a consequence of its interest rate target, the central bank accommodates the net change in demand. The situation is different for the money the central bank creates through its interest rate smoothing. That money creation emerges as a consequence of the central bank's effort to resist the rise in the interest rate. The public must adjust to it. Now, portfolio balance by the public requires a rise in the price level commensurate with the rise in money. With no change in the price level, there is an excess supply of money and an excess demand for bonds.[31]

The jump in real consumption in period t makes consumption in t high relative to consumption in $t + 1$ (Figure 4). In t, despite the rise in trend

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[28] $X_t = \frac{R_t}{1+R_t} \cdot \frac{c_t}{w_t}$. X_t measures percentage changes in real money demand from (22). Because c_t and w_t (the real wage) move together leaving the ratio unchanged, the X_t term measures the change in the demand for money arising from changes in the interest rate, R_t.

The elasticity of the demand for real money with respect to the interest rate, υ, is set at -0.038. The number is the estimate from Porter and Small (1989, 247) of the long-run elasticity of money demand. They assume that the effect of a change in the opportunity cost of holding money requires six quarters to work itself out fully. Because I assume that a period is one year, the number used here is two-thirds of the number they estimate.

[29] In the simulation, the interest rate smoothing parameter (s) equals 1.3.

[30] In (26), a_t increases by one percentage point.

[31] To see the need for portfolio rebalancing, consider the marginal return and cost for holding money. The nominal interest rate is the cost for holding money. Equating the far left and far right sides of (15) and rearranging yields (7), which expresses the interest rate as a price that relates flows to stocks (the ratio of the flow of liquidity services from an additional dollar to the discounted marginal value of an additional future dollar of resources):

Figure 2 Money
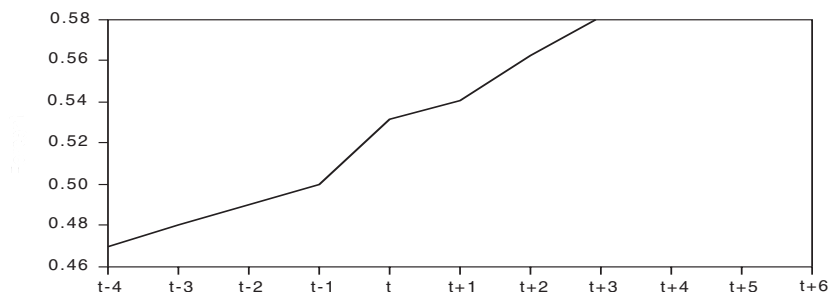
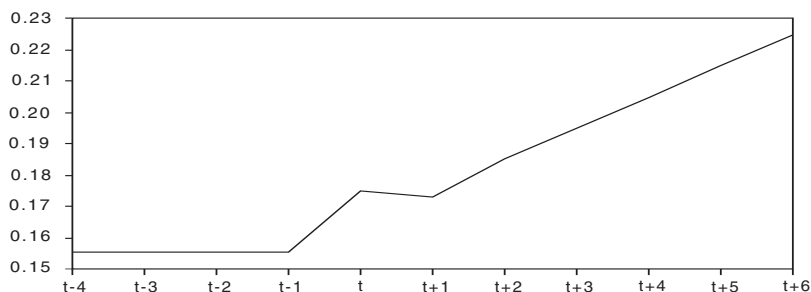Notes: Natural log of money.

Figure 3 Change in Money Due to Rate Smoothing
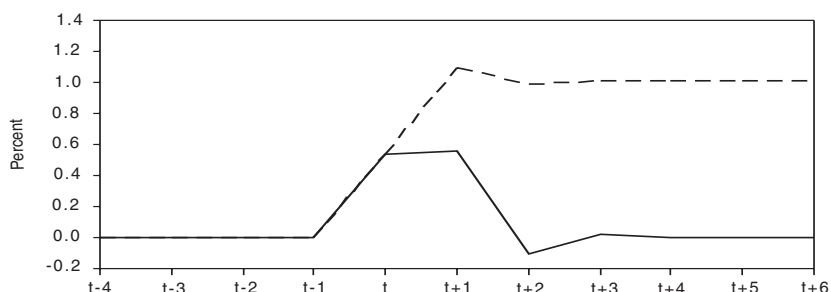
Notes: The solid line shows the changes in each period due to interest rate smoothing. The dashed line shows the cumulative changes.

$$-\frac{\mu_t h'(\cdot)\left(\frac{1}{P_t c_t}\right)}{\beta E_t \frac{\lambda_{t+1}}{P_{t+1}}} = R_t. \tag{7}$$

The money creation from interest rate smoothing reduces the marginal benefit from holding money. The marginal value of real money—that is, the magnitude of $h'(m_t c_t)$—declines. The return to money then falls short of the return on bonds, R_t. The individual rebalances his/her portfolio by attempting to move from money to bonds. Without a rise in the price level, this rebalancing raises the yield on bonds. The fall in the bond yield stimulates consumption. Because of price stickiness, increased nominal demand translates into increased real consumption (Figure 4).

Figure 4 Consumption
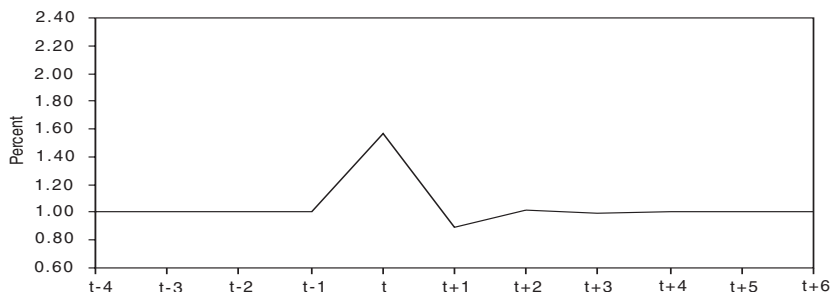

Notes: Natural log of consumption.

Figure 5 Expected Consumption Growth
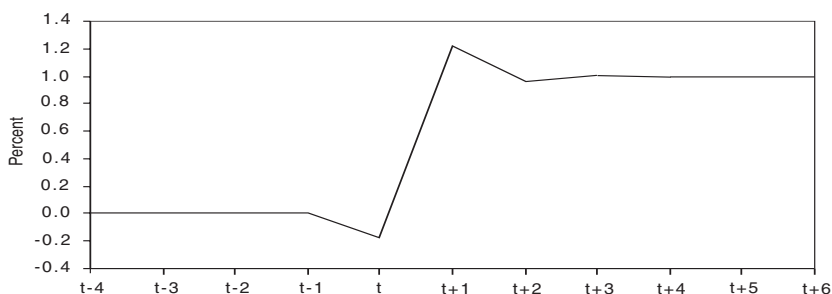
Notes: This series shows the expected percent change in consumption, $ln(C_{t+1}) - ln(C_t)$.

productivity growth, expected consumption growth is therefore negative (Figure 5), which temporarily restrains the rise in the interest rate.

Offsetting this negative influence is a rise in expected inflation above its trend level of 1 percent. In t, the public expects in $t + 1$ an additional rise in prices of 0.6 percent due to the catch-up price rises from firms whose price setting was constrained in t (Figure 6). On net, in t, the interest rate rises about 0.4 percent.

As shown by Figure 7, the money creation that arises out of interest rate smoothing causes the price level to rise by 1 percent relative to trend. The increase in money per unit of consumption is less because of the fall in the demand for real money due to the increase in the bond rate and the accommo-

Figure 6 Expected Inflation

Notes: This series shows the expected inflation, $ln(P_{t+1}) - ln(P_t)$.

**Figure 7 Price Level With and Without Interest Rate Smoothing**
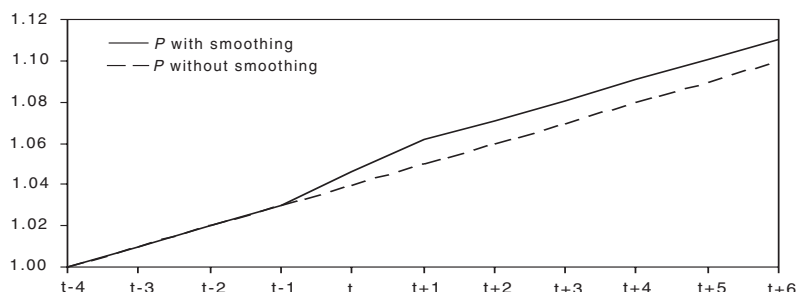
Notes: Natural log of price level, normalized so that $P_{t-4} = 1$. The solid line shows the price level with interest rate smoothing. The dashed line shows it without interest rate smoothing.

dation of this fall in demand due to the central bank's rate peg. Figure 8 shows a fall in the ratio of the real money the public desires relative to consumption, $[M_t/(P_t c_t)]$. Figure 9 shows the ratio of money per unit of consumption and the price level. The 1 percent rise in the price level (relative to trend) requires only a 0.2 percent rise in money per unit of consumption because of the 0.8 percent fall in the demand for money per unit of consumption.[32]

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[32] Note that the individual price setters cannot index the change in their dollar prices to the money stock as protection against monetary disturbances. The relationship between money and

Figure 8 Money Demand
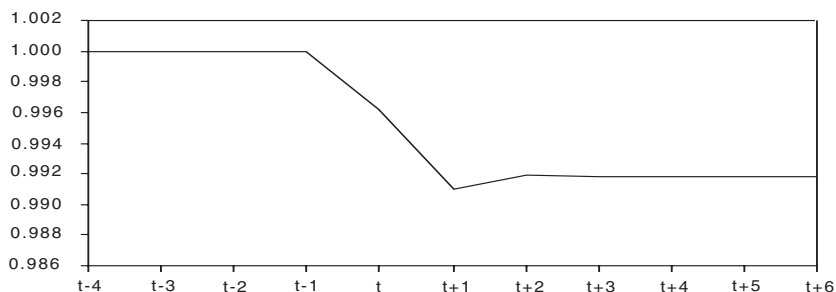
Notes: Natural log of inverse of velocity, $ln(m/(CP))$, normalized so that $ln(m/(CP))_{t-4}$ equals 1.

Figure 9 Money per Unit of Consumption and the Price Level
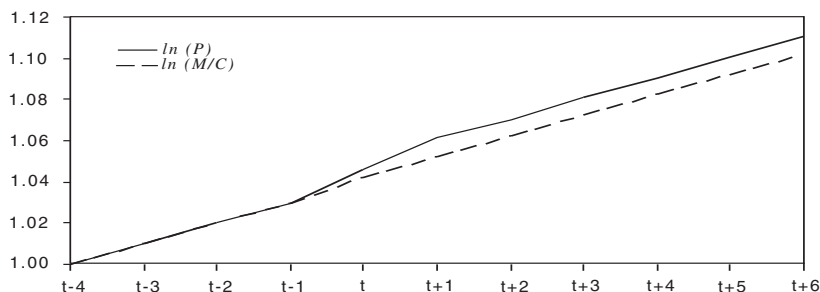
Notes: The solid line is the log of the price level; the dashed line is $ln(M/C)$. Series normalized so that $ln(Pt-4)$ and $ln((M/C)t-4)$ equal 1.

6.   WHAT DIFFERENCE WOULD AN INFLATION TARGET MAKE?

Goodfriend (2005) argues that an inflation target need not change the way that the Fed operates because it already uses an implicit inflation target. His argument, however, does not address concerns of critics of an explicit target. They argue that such explicitness might cause the Fed to abandon its dual mandate

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prices is a complicated one that depends upon the behavior of the interest rate and real money demand.

by reducing inflation variability by increasing output variability. However, I argue here that the concern is misplaced. The control of inflation requires monetary control rather than manipulation of output and unemployment in a way constrained by the tradeoffs apparently offered by a Phillips curve.

An inflation target would require better communication with the public. Like all institutions in a constitutional democracy, the long-run viability of the Fed as an institution depends upon public support, which derives from public understanding of its objectives and the procedures for achieving those objectives. An inflation target possesses the potential for enhancing that understanding. However, the standard for communication becomes more demanding than it would in a world without explicit objectives. At present, justification of changes in the funds rate can rely on a commonsense appeal to the contemporaneous behavior of the economy. In contrast, with an inflation target, justification of changes in the funds rate will derive from a need to achieve the inflation target.

The difficulty of communication arises because the funds rate may need to change in a counterintuitive way, given the behavior of inflation and the inflation target. The Fed will need a model to explain the relationship between funds rate changes and achievement of its inflation objective. For example, the funds rate may need to change continually (to track the natural interest rate) even though inflation stays on target. In this event, the public will see a positive correlation between strength in real economic activity and the funds rate, but no correlation between inflation and the funds rate. Despite appearances, monetary policy is controlling inflation, not real growth.

Adoption of an inflation target is just one step on a longer journey of making monetary policy procedures explicit. An inflation target is only the starting point for full communication with the public. Clarification of its implications for monetary policy requires specification of the policy rule that supports it. Clarification of its implications for the tradeoffs required to achieve it requires specification of the structure of the economy (a model). Although the required communication will be intense and challenging, it will advance the communication necessary for any institution that is part of U. S. constitutional democracy.

APPENDIX: THE MODEL

The model is from Wolman (1998).[33]   Equation (8) represents consumers'
preferences. The consumption aggregate is c_t; leisure, l_t; the discount rate, β;
and a parameter measuring the value of leisure, χ:[34]

$$E_t = \sum_{t=0}^{\infty} \beta^t \cdot [ln(c_t) + \chi \cdot l_t].   \tag{8}$$

The consumer's budget constraint is

$$c_t + \frac{M_t}{P_t} + \frac{B_t/P_t}{1 + R_t} = \frac{M_{t-1}}{P_t} + \frac{B_{t-1}}{P_t} + w_t n_t + d_t + \frac{S_t}{P_t},   \tag{9}$$

where the price level is P_t; the nominal money the consumer carries over into
$t + 1$ is M_t; the quantity of one-period nominal zero-coupon bonds that mature
in $t + 1$ is B_t; the market interest rate on these bonds, R_t; the real wage, w_t;
work time, n_t; real dividend payments by firms, d_t; and lump sum transfers of
money from the central bank, S_t.

The time constraint is

$$n_t + l_t + h[M_t/(P_t c_t)] = E,   \tag{10}$$

where E is the time endowment. Transactions time, $h[M_t/(P_t c_t)]$, varies in-
versely with real money balances (liquidity services) measured as the fraction
of expenditures the consumer holds as money balances. With $M_t/P_t = m_t$,
transactions time is $h(m_t/c_t)$, $\partial h/\partial c > 0$, and $\partial h/\partial m < 0$.

1.   CONSUMER CHOICE AND THE DEMAND FOR MONEY

The individual maximizes utility by choosing c_t, l_t, n_t, B_t, and M_t to maximize
(8) subject to (9) and (10). The Lagrange multipliers on the latter two budget
constraints are, respectively, λ_t (the marginal utility value of an extra unit of
goods) and μ_t (the marginal utility value of time). The first order conditions
are as follows:

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[33] For further exposition, see Wolman (1997, 1999, and 2001). For a definition of equilibrium,
see Wolman (1998). Goodfriend (2004a) provides an heuristic overview.

[34] $\chi = 0.77$ (Wolman 1998).

$$\frac{1}{c_t} = \lambda_t - \mu_t \cdot h'\left(\cdot\right)\left(\frac{m_t}{c_t^2}\right), \tag{11}$$

$$\chi = \mu_t, \tag{12}$$

$$\mu_t = w_t \cdot \lambda_t, \tag{13}$$

$$\frac{\lambda_t}{P_t} = \beta \cdot (1 + R_t) \cdot E_t \frac{\lambda_{t+1}}{P_{t+1}}, \text{ and} \tag{14}$$

$$-\frac{\mu_t}{P_t} \cdot h'\left(\cdot\right)\left(\frac{1}{c_t}\right) = \frac{\lambda_t}{P_t} - \beta E_t \frac{\lambda_{t+1}}{P_{t+1}} = \beta E_t \frac{\lambda_{t+1}}{P_{t+1}} R_t. \tag{15}$$

According to (11), the individual equates the marginal value of consumption, $\frac{1}{c_t}$, with the marginal value of real resources, λ_t, and the marginal value of the time foregone from that consumption, $\mu_t \cdot h'\left(\cdot\right)\left(\frac{m_t}{c_t^2}\right)$. The marginal value of time comes from (12). From (13), the individual allocates time between labor and leisure to equate the marginal rate of substitution between goods and leisure, μ_t/λ_t, to the wage rate, w_t. In (14), $\frac{\lambda_t}{P_t}$ measures the marginal utility value of an additional dollar of goods. (A doubling of the price level halves the real value of a dollar of goods.) The gross rate of interest, $(1 + R_t)$, equates the marginal value of a dollar today with the discounted expected marginal value of a dollar tomorrow.

The first order condition (15) expresses the equality between the marginal benefits and costs of holding money.[35] The utility value of the time gained from holding an additional dollar equals $-\frac{\mu_t}{P_t} \cdot h'\left(\cdot\right)\left(\frac{1}{c_t}\right)$ with $h'\left(\cdot\right) < 0$. The marginal cost of holding an additional dollar equals the marginal value of a dollar of goods today minus the discounted value of the expected gain from having an additional dollar of goods tomorrow, $\frac{\lambda_t}{P_t} - \beta E_t \frac{\lambda_{t+1}}{P_{t+1}}$. From (14), the latter equals the discounted expected future nominal value of the interest paid on bonds, $\beta E_t \frac{\lambda_{t+1}}{P_{t+1}} R_t$. The reason for the discount factor β is that the marginal benefit of holding an additional dollar is measured for the current period and the marginal cost, R_t, for the future period.

One can also make the measurement of marginal benefit and cost comparable by comparing the return from investing to the marginal cost.[36] The gain

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[35] McCallum (1983) and McCallum and Goodfriend (1987) derive a money demand function within the above optimizing framework.

[36] The remainder of this section is from Wolman (1997, 6).

in transactions time from holding an additional dollar is $-h'(m_t/c_t) \cdot \frac{1}{P_t c_t}$. The value of an additional unit of time spent working when invested in a bond is $P_t \cdot w_t \cdot (1 + R_t)$. The return to holding an additional dollar, therefore, is $-P_t \cdot w_t \cdot (1 + R_t) \cdot h'(m_t/c_t) \cdot \frac{1}{P_t c_t}$. On the other hand, the cost of holding an additional dollar is the interest forgone, R_t. Equating the marginal benefit and cost of liquidity services, after rearrangement, yields

$$-h'(m_t/c_t) = \frac{R_t}{1 + R_t} \cdot \frac{c_t}{w_t}. \tag{16}$$

Equation (17) is a particular functional form for $h(\cdot)$ that relates real money balances inversely to transactions time:

$$h(m_t, c_t) = \kappa \cdot (m_t/c_t)^{\frac{-1}{\gamma}}, \gamma \in (0, 1). \tag{17}$$

Using (17) in (16) yields a money demand function,

$$\frac{\kappa}{\gamma} \cdot (m_t/c_t)^{-1-1/\gamma} = \frac{R_t}{1 + R_t} \cdot \frac{c_t}{w_t}, \gamma \in (0, 1). \tag{18}$$

With (18), real money becomes infinite as the interest rate goes to zero. A liquidity trap arises in that there is no point at which the public becomes satiated with real money. However, a liquidity trap has never been observed. For the case of Japan, see Hetzel (2003, 2004b) and, for the United States, see Wolman (1997). Satiation is the empirically relevant case.[37]

In order to attain satiation, shopping time must cease falling at some finite level of real money balances. This phenomenon cannot occur with (17) because the function asymptotes to zero. However, adding a constant to $h'(\cdot)$ makes $h(\cdot)$ cease falling and turn up at some point. At this point, satiation occurs. That is, the public has no reason to hold additional real money balances. Wolman (1997) reformulates (17) in this fashion: $h'(m_t/c_t) = \phi - (\kappa/\gamma) \cdot (m_t/c_t)^{-1-1/\gamma}$, $\phi \geq 0$. With $\upsilon \equiv -\gamma/(1 + \gamma)$ and $A \equiv (\kappa/\gamma)^{-\gamma/(1+\gamma)}$, then

$$h'(m_t/c_t) = \phi - A^{-1/\upsilon} \cdot (m_t/c_t)^{1/\upsilon} \text{ with } \upsilon < 0, A > 0. \tag{19}$$

The transactions time function then becomes

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[37] The issue is important in dealing with the zero bound problem. If the market interest rate falls to zero, the central bank can switch to a reserve aggregate target (Goodfriend 2000; Hetzel 2003, 2004b). Money creation then exerts its influence on nominal expenditure through portfolio rebalancing. One can see the power of this effect in the historical data during periods when monetary policy procedures did not provide for monetary control. Nominal and real expenditure followed money creation, on average, with a two-quarter lag (Friedman and Schwartz 1963; Friedman 1989).

$$h\left(m_t/c_t\right) = \phi \cdot \left(m_t/c_t\right) - \frac{v}{1+v} A^{-1/v} \cdot \left(m_t/c_t\right)^{\frac{1+v}{v}} + \Omega \qquad (20)$$

when $m_t/c_t < A \cdot \phi^v$ and $h\left(m_t/c_t\right) = h\left(A\phi^v\right) = \Omega + \frac{1}{1+v} A\phi^{1+v}$ when $m_t/c_t \geq A \cdot \phi^v$ with Ω a nonnegative constant equal to the minimum amount of shopping time. Shopping time decreases until real money balances reach $A \cdot \phi^v$ and then remains unchanged.

With (21), the expression for the equality of the marginal cost and benefit of holding money becomes

$$-\phi + A^{-1/v} \cdot \left(m_t/c_t\right)^{1/v} = \frac{R_t}{1+R_t} \cdot \frac{c_t}{w_t}. \qquad (21)$$

The public's demand for money function then becomes[38]

$$m_t/c_t = A \cdot \left[\frac{R_t}{1+R_t} \cdot \frac{c_t}{w_t} + \phi\right]^v. \qquad (22)$$

Sticky Prices

Aggregate consumption is a weighted average of different goods, $c_t = \left[\int c(w)^{\frac{\varepsilon-1}{\varepsilon}} d\omega\right]^{\frac{\varepsilon}{\varepsilon-1}}$. Firms divide into two groups, which set their product prices either in odd numbered or even numbered periods.[39] Because all firms face demand curves with constant elasticity ε, aggregate consumption equals

$$c_t = c(c_{0,t}, c_{1,t}) = \left(\frac{1}{2} \cdot c_{0,t}^{\frac{\varepsilon-1}{\varepsilon}} + \frac{1}{2} \cdot c_{1,t}^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}, \qquad (23)$$

where $c_{o,t}$ and $c_{1,t}$ represent consumption in period t of goods with prices set, respectively, in the current and previous period.

The demand for each good equals

$$c_{j,t} = \left(\frac{P_{t-j}^*}{P_t}\right)^{-\varepsilon} \cdot c_t \text{ with } j = 0, 1. \qquad (24)$$

P_{t-j}^* is the time t price in dollars of the good with price set in period $t - j$. The time t price level is

$$P_t = \left[\frac{1}{2} \cdot (P_t^*)^{1-\varepsilon} + \frac{1}{2} \cdot (P_{t-1}^*)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}. \qquad (25)$$

The firms' production functions are

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[38] The following parameter values are from Wolman (1998): $A = 0.017$ and $\phi = 0.0014$.
[39] $\varepsilon = 10$ (Wolman 1998).

$$c_{j,t} = a_t \cdot n_{j,t}, \tag{26}$$

where $n_{j,t}$ is the amount of labor employed in period t by a firm that set its price in period $t - j$. Labor productivity is a_t. Firms' real profits are

$$\frac{P^*_{t-j}}{P_t} \cdot c_{j,t} - w_t \cdot n_{j,t}. \tag{27}$$

The firms that are free to set prices in period t set a relative price $\frac{P^*_t}{P_t}$ that maximizes the present discounted value of expected profits (28) derived from (27) using (24) and (26):

$$c_t \cdot \left[\left(\frac{P^*_t}{P_t} \right)^{1-\varepsilon} - \frac{w_t}{a_t} \cdot \left(\frac{P^*_t}{P_t} \right)^{-\varepsilon} \right] + \tag{28}$$

$$\beta E_t \frac{\lambda_{t+1}}{\lambda_t} \cdot c_{t+1} \cdot \left(\frac{P^*_t}{P_{t+1}} \right)^{1-\varepsilon} - \frac{w_{t+1}}{a_{t+1}} \cdot \left(\frac{P^*_t}{P_{t+1}} \right)^{-\varepsilon}.$$

The optimal price comes from differentiating (28) with respect to P^*_t, setting the result equal to zero, and solving for P^*_t:[40]

$$P^*_t = \frac{\varepsilon}{\varepsilon - 1} \cdot E_t \left(\rho \frac{P_t w_t}{a_t} + (1 - \rho_t) \frac{P_{t+1} w_{t+1}}{a_{t+1}} \right) \tag{29}$$

with

$$\rho_t \equiv \frac{\lambda_t c_t}{\lambda_t c_t + \beta \lambda_{t+1} c_{t+1} \left(\frac{P_{t+1}}{P_t} \right)^{\varepsilon-1}}.$$

The firm sets its dollar price as a constant markup over the present discounted value of a weighted average of the nominal marginal cost in the two periods for which the price is fixed. The weights on marginal cost in the two periods are given by the fraction of marginal revenue contributed in the particular period.

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[40] For a derivation of (3) from a relationship like (28), see Rotemberg and Woodford (1997) and Woodford (2003).

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