Vol. 32, No. 2

ECONOMIC REVIEW

1996 Quarter 2

FEDERAL RESERVE BANK
OF CLEVELAND

ECONOMIC REVIEW

1996 Quarter 2
Vol. 32, No. 2

The authors of this paper explore some of the benefits of interest rate targeting in both partial equilibrium and general equilibrium environments. They find that an interest rate peg is desirable because such a policy mitigates the distortions that arise in a monetary economy. In order to achieve the interest rate peg, money growth should be procyclical. This increase in output variability is actually welfare-improving.

Deregulation and financial innovation have wreaked havoc on the relationship of traditionally defined money measures with economic activity and interest rates. In this article, the authors present some tentative evidence that an alternative measure of money—MZM—has endured these events reasonably well. MZM is broader than M1 but essentially narrower than M2, comprising all instruments payable at par on demand. Since 1974, MZM has exhibited a fairly stable relationship with nominal GDP and with its own opportunity cost, suggesting that the aggregate has a potential role for policy.

Economic Review is published quarterly by the Research Department of the Federal Reserve Bank of Cleveland. Copies of the *Review* are available through our Corporate Communications & Community Affairs Department. Call 1-800-543-3489 (OH, PA, WV) or 216-579-2001, then immediately key in 1-5-3 on your touch-tone phone to reach the publication request option. If you prefer to fax your order, the number is 216-579-2477.

Economic Review is also available electronically through our home page on the World Wide Web: http:// www.clev.frb.org.

Editors: Tess Ferg
Michele Lachman
Design: Michael Galka
Typography: Liz Hanna

ISSN 0013-0281

The Benefits of Interest Rate Targeting: A Partial and a General Equilibrium Analysis

by Charles T. Carlstrom and Timothy S. Fuerst

Charles T. Carlstrom is an economist at the Federal Reserve Bank of Cleveland, and Timothy S. Fuerst is an associate professor of economics at Bowling Green State University and a consultant at the Federal Reserve Bank of Cleveland.

Introduction

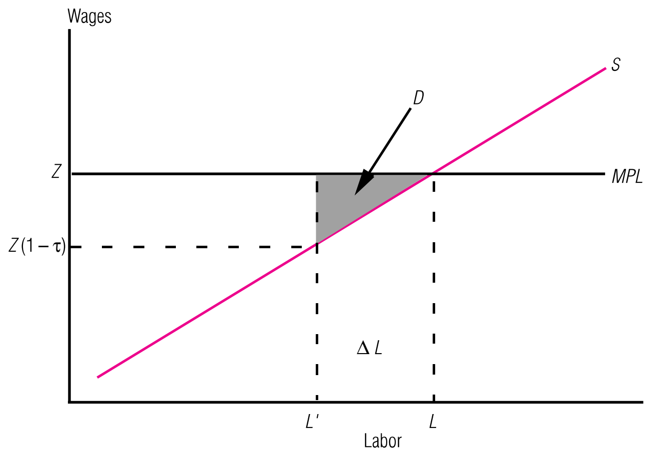
One of the oldest debates in monetary economics concerns the appropriate target for monetary policy. Two distinct camps emerge from this debate—those who favor interest rate targets and those who favor money growth targets. Poole (1970) first addressed this question in an aggregate demand framework of the IS-LM type. He showed that an interest rate rule is preferable if money demand shocks are more numerous than IS shocks, while a money growth rule is preferable in the opposite case. Yet, to obtain this answer Poole assumed that the monetary authorities would choose the money supply rule that minimized the variability of output. This assumption, however, begs the question of whether such stabilization is indeed optimal.

This article revisits Poole's original question. It argues that there are clear benefits to interest rate targeting, independent of what types of shocks hit the economy. Furthermore, these benefits arise even though money growth must be procyclical in order to keep interest rates constant, which increases the variability of output. The reason a constant interest rate will be optimal is that interest rates act like a tax on labor, and constant taxes are preferable to variable taxes. This is true whether the alternative to an interest rate target is a constant money growth rule or some general money growth specification. However, this paper places special emphasis on analyzing Poole's original question—the optimality of money growth versus interest rate rules.

We use both a partial equilibrium model and a monetary general equilibrium model with sluggish portfolio adjustments to analyze the benefits of interest rate targets. The general equilibrium analysis shows that an interest rate target will undo the distortion caused by sluggish portfolios. This occurs because, to keep interest rates constant, the monetary authority will supply the reserves that would have been supplied by households in a frictionless environment. Even if private savings cannot respond to current economic conditions, an interest rate target will enable output and employment to respond to them efficiently. Which rule will a benevolent central banker prefer—a constant money growth rate or an interest rate peg? Unlike Poole's analysis, which suggests that the optimality of an interest rate rule depends on the source of the shock affecting the economy, this paper concludes that an interest rate peg

FIGURE 1

Supply and Demand for Labor



SOURCE: Authors' calculations.

will be the benevolent central banker's choice, whatever one's view about the types of shocks most likely to buffet the economy.

We proceed as follows: Section I sets out a partial equilibrium model of the labor market in order to discuss the benefits of an interest rate peg, and section II does the same for the credit market. Section III integrates these partial equilibrium analyses into a general equilibrium framework. Section IV discusses how the economy will behave with both interest rate targets and money growth targets. It demonstrates that if the economy is buffeted by supply shocks, interest rate rules will dominate any other policy rule. Section V extends this analysis by assuming that the economy is subject to demand shocks. Section VI discusses further possible extensions, and section VII concludes.

I. A Partial Equilibrium Analysis of the Labor Market

This section develops the partial equilibrium analogue of the general equilibrium economy contained in the third section. We investigate a model economy where money is introduced by imposing a cash-in-advance (CIA) constraint on market transactions, so that consumers must hold cash in order to purchase consumption goods. We also assume a CIA constraint on the part of firms, which must hold cash in order to pay their workers. This assumption seems reasonable because there is a lag between the time when workers are paid and when a firm receives payment for its product. This means that firms cannot use cash from sales of their product to pay their workers, but must borrow funds in order to obtain the necessary cash. Sales receipts are then used to repay these loans.

This friction leads to a key distortion in the economy. Since firms must borrow money to pay their wage bill, the nominal interest rate (and hence inflation) acts like a tax on a firm's ability to hire workers. For example, assume that the demand for labor is perfectly elastic, that is, the marginal productivity of labor is constant at the pre-tax market wage, Z. Thus, L hours of work translates into $Z * L$ units of output, where Z can be thought of as a productivity shock term that is assumed to be random over time. A firm that needs cash to pay its workers can borrow $Z * L/R$ dollars (where $R > 1$ is the gross nominal rate of interest) in order to generate $Z * L$ units of output after paying off its loan. Defining $(1-\tau) = 1/R$, we see that a nominal interest rate of R translates into a wage tax of $\tau = 1 - 1/R$.

What are the benefits of a constant interest rate? Such a rate implies that the resulting wage tax, τ, will be constant over time. A constant money growth rule, by contrast, may imply a fluctuating interest rate, and hence a fluctuating wage tax. To understand the conditions under which a constant interest rate—that is, a constant wage tax—is preferred, see figure 1, which plots the supply and demand for labor.[1] Labor supply is standard and is assumed to have a constant elasticity of η. The deadweight loss associated with the CIA constraint is given in figure 1 by triangle D. The average distortion from the inflation (wage) tax is approximately[2]

$$(1) \quad D = \frac{1}{2}\eta E[Z_t L_t (\tau_t)^2].$$

A constant tax rate is usually preferred to a variable tax rate over time.[3] Since positive nominal interest rates act like a wage tax, this suggests that constant interest rates will prove superior to a policy that allows interest rates to

---

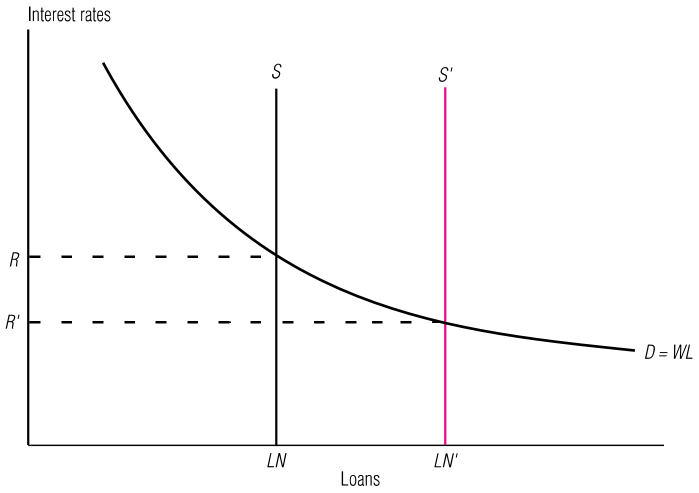
[1] It may seem peculiar to look at the inflation-tax distortion in the labor market rather than the money market, but it can be measured in either. However, one cannot count the distortion in both markets, because to do so would be double counting.

[2] By definition, $\Delta L = \eta \frac{\Delta w}{w}$ and $L_t = \eta \tau_t L_t$. Therefore, $D \approx \frac{1}{2} \Delta L \tau_t Z = \frac{1}{2} L_t Z (\tau_t)^2$.

[3] See Sandmo (1974) and Barro (1979, footnote 7).

FIGURE 2

Supply and Demand for Loans



SOURCE: Authors' calculations.

vary. Why one might suspect that constant tax rates and interest rates are preferable to variable ones is apparent in figure 1 and equation (1). The distortion from a tax is triangle *D* in figure 1 and is thus proportional to the square of the tax. Therefore, a tax that stays at 15 percent over time will usually be better than one that fluctuates from zero to 30 percent. With a constant 15 percent tax, the associated loss is proportional to 15 squared, or 225; however, the loss with a tax that is either zero or 30 percent is proportional to either zero (zero squared) or 900 (30 squared). If both of these are equally likely, the average loss associated with a time-varying tax rate is 450 (versus 225 for a constant tax).

II. A Partial Equilibrium Analysis of the Credit Market

Although intuitive, this partial equilibrium analysis is incomplete. It ignores the general equilibrium effects that the labor market has on other markets—and vice versa. For example, the distortion in the labor market spills over into the credit market because a higher interest rate lowers a firm's demand for labor, which in turn decreases the firm's demand for loans. Thus, these two markets become intimately linked. The general equilibrium section shows that this link is crucial if we are to understand the costs and benefits of interest rate rules.

Before developing this general equilibrium model, it is useful to discuss the market for loans, because it is so closely connected with the labor market. Besides the wage-tax distortion caused by the CIA constraint, another important friction in the economy is that households can adjust their consumption and savings decisions only sluggishly in response to new conditions. This is the so-called "sluggish portfolio adjustment" or "limited participation" assumption, first proposed by Lucas (1990) and further analyzed by Fuerst (1992).[4] This friction affects the loan market directly, but, as we will show, it also spills over into the labor market.

We employ this assumption because it predicts that monetary surprises will increase output *and* lower nominal interest rates.[5] Both of these predictions are crucial to understanding how the Federal Reserve operates. For example, if the Fed wishes to lower interest rates and stimulate economic activity, it increases money growth. Despite the nearly universal agreement that faster money growth lowers nominal interest rates in the short term, very few economic models generate this prediction.[6]

However, models with sluggish portfolio adjustments (households' inability to immediately adjust their consumption and savings decisions to shocks) can cause a liquidity effect. In these models, the key assumption is that households adjust their portfolios more slowly than firms do. Christiano, Eichenbaum, and Evans (1996) present evidence that there is a liquidity effect and that households do indeed adjust their portfolios more slowly than firms.

By plotting the supply and demand for loans (equilibrium in the credit market), figure 2 helps illustrate why sluggish portfolios may produce a liquidity effect. The demand for loans slopes downward, meaning that as interest rates decrease, the quantity demand for loans increases. This occurs because a rise in the nominal interest rate is equivalent to an increase in the wage tax; its result is less employment and thus a reduction in the demand for loans. However, the supply of loans is perfectly inelastic because sluggish portfolio adjustments imply that the

---

[4] For an eminently readable paper that provides a detailed discussion of this economy, see Christiano (1991).

[5] The ability of surprise monetary injections to lower nominal interest rates is called the liquidity effect. For empirical evidence of a liquidity effect, see Christiano, Eichenbaum, and Evans (1996).

[6] Even dynamic optimizing versions of sticky-price models cannot generate the liquidity effect. While real interest rates may decrease with monetary expansions, this decline is not large enough to undo the increase in the expected inflation component of the nominal interest rate.

supply of credit (savings by households) is predetermined. That is, households cannot adjust their savings decisions in response to changes in either money growth (interest rates) or productivity.

When the Fed increases the money supply, it injects reserves into the financial system, thereby shifting the supply of loans outward. With sluggish portfolios, this results in lower interest rates, which in turn induce firms to expand employment and boost output.[7] If portfolios were not sluggish, this increase would be completely offset because households would save less, thereby shifting the supply of loans inward.

To understand the distortion caused by sluggish portfolios, consider the effects of a positive productivity shock. A productivity increase (in figure 1, an increase in Z) induces firms to hire more workers. The greater demand for workers in turn shifts out the demand for loans in figure 2. In an economy without portfolio rigidities, households respond to a productivity shock by saving more. Their extra savings increase the cash that intermediaries have on hand to loan out to firms, thereby shifting out the supply of credit (loans) as well.

However, when savings behavior is sluggish, the supply of credit does not increase. It can do so only if the monetary authority steps in and supplies extra reserves, which by assumption would not be forthcoming if money growth were constant. The effective supply curve with an interest rate peg is therefore perfectly elastic (horizontal) at R. With constant money growth, however, the supply curve is completely inelastic, so that interest rates must increase substantially with productivity shocks in order to clear the loan market. With sluggish portfolios, keeping money growth constant is especially costly, because it implies that interest rates must be quite variable in order to clear the loan market.

With an interest rate peg, the credit for loans to firms is supplied by the monetary authority rather than by the private sector. That is, in order to keep interest rates from rising, the monetary authority supplies reserves to the banking sector, enabling firms to borrow more and thereby increase their employment. This allows the economy to respond more efficiently and quickly to potential economywide shocks, like productivity shocks. Analogous to revenues and losses in the labor market, the same variables can be measured in the loan market instead. One can calculate the deadweight loss from the CIA constraint in either the labor market or the loan market, but not in both.

The next section combines the major features of the partial equilibrium models discussed above into a general equilibrium model where firms must borrow cash to pay their workers, and households can adjust their savings decisions only sluggishly. The first of these distortions, which arises from the firm's CIA constraint, implies that if the nominal interest rate is positive, there will be too little labor supplied (or, equivalently, too little savings or loans demanded) in equilibrium. The second distortion results from the sluggish portfolio assumption, which implies that interest rates will vary too much and that this variability is bad precisely because the interest rate is acting like a wage tax (or a tax on the demand for loans).

We show that the benefit of an interest rate peg is that it essentially eliminates the distortion caused by sluggish portfolios. The real sides of two economies—one with portfolio rigidities and an interest rate peg, the other with an interest rate peg and instantaneous portfolio adjustments—will be identical. However, there will also be a cost associated with pegging interest rates. Because of the precautionary demand for savings, variability in interest rates will tend to increase savings. This increase spills over into the labor market, mitigating the distortion caused by the CIA constraint. Despite these costs and benefits, we show that a constant interest rate will still be preferable to a policy that allows interest rates to vary.

III. The General Equilibrium Analysis

The model economy consists of four different types of agents: households, firms, financial intermediaries, and the government. At the beginning of each period, all money in the economy is in the hands of households, which accumulated it in the previous period from labor, dividend, and interest earnings. Households decide how much of this money they wish to save (loan to the financial intermediary) for future consumption, and how much they wish to pay to firms in order to consume today. We assume that households must hold money in order to purchase consumption goods.

As discussed earlier, portfolio adjustments are assumed to take time. The simplest way of

---

[7] This is a partial equilibrium story, so we have obviously ignored the roles of price adjustments and expected inflation, which are crucial to understanding the whole story. Readers interested in the conditions under which a liquidity effect arises in a general equilibrium model with sluggish portfolios are encouraged to see Christiano (1991).

modeling this sluggishness is by positing that households make consumption and savings decisions before they identify the various shocks that buffet the economy. This less-than-perfect flexibility is meant to reflect that continually changing one's behavior with every bit of new information would be prohibitively costly. We first consider the case of productivity shocks (supply shocks). We then examine the case where there are shocks to government spending (demand shocks).

After households make their consumption and savings decisions, the productivity shock, Z, occurs and is costlessly observed by everyone.[8] Under an interest rate peg, the monetary authority then injects money into the economy through the financial intermediary, so that the productivity shock does not change nominal interest rates. Therefore, money growth will be endogenous, responding as necessary to keep the nominal interest rate from changing. With a constant money growth regime, there will be a fixed injection to the financial intermediary, and interest rates will respond endogenously.

The model's details are spelled out below. Since the purpose of this paper is to provide a simple example of the benefits of an interest rate peg, we abstract from capital accumulation and assume particular functional forms for utility and production. In addition, the productivity shock is assumed to be independently identically distributed (i.i.d.) over time. As Carlstrom and Fuerst (1995) show, none of these abstractions affects our results.

Households

Preferences are standard in that households derive utility from consumption, c_t, and disutility over labor, L_t, to maximize discounted expected utility subject to the CIA constraint and the resource constraint:[9]

$$\max E_0 \sum_{t=0}^{\infty} \beta^t [\ln(c_t) - AL_t^s], \text{ subject to}$$

$$\text{(i)} \qquad P_t C_t \leq M_t - N_t + W_t L_t^s$$

$$\text{(ii)} \qquad M_{t+1} \leq R_t N_t + D_t + F_t + (M_t - N_t + W_t L_t^s - P_t C_t).$$

The variables M_t, P_t, C_t, W_t, and L_t^s are the time t money holdings, nominal price level, consumption, nominal wage, and labor supply (or hours worked). The first constraint is the CIA constraint, which says that consumers must have enough cash on hand to finance consumption expenditures. This cash consists of the worker's wage earnings (which are paid in cash) and the fraction of period t money holdings left after the saving partner visits the financial intermediary to deposit N_t dollars.

The second constraint states that the cash sources the household carries into $t+1$ include interest on savings, dividends that the household receives from the firm F_t, and dividends it receives from the intermediary D_t. Since the household is an atomistic part of the economy, dividend payments are outside its control and are equivalent to lump-sum payments. Financial intermediaries' profits arise because of the monetary injection they receive. Firms' profits arise because a worker's average productivity is greater than his marginal productivity. The sum in parentheses is the cash that is not spent when the consumption market closes. In equilibrium, this will be zero.

Firms

The economy consists of one representative firm owned by a representative household. The firm produces one consumption good according to the production function

$$\text{(2)} \qquad y_t = \bar{K} + Z_t L_t^D.$$

The variable L_t^D is labor demand at time t, while Z_t is the productivity shock, which we assume to be i.i.d. over time. The unusual aspect of this production function is $\bar{K}$, which measures the contribution of capital to production and is assumed to be fixed. We have fixed capital entering additively in the production function because we wish to capture the observed phenomenon that labor increases with positive productivity shocks.[10] This feature arises in more complicated models with capital accumulation, where capital affects the marginal productivity of labor.

[8] The modeling fiction used is that households consist of a "worker–shopper" and a "saver" to conduct financial transactions. The assumption of sluggish portfolios implies either that the saver does not observe the shock contemporaneously, or that he leaves for the bank before Z is realized. After Z is realized, the worker–shopper leaves for work and then purchases consumption goods on the way home.

[9] The assumption that the disutility of working is linear in labor supply is equivalent to assuming that labor supply is indivisible. See Rogerson (1988) or Hansen (1985) for details.

[10] Without this assumption, the income and substitution effects of a productivity shock will cancel one another out, so that labor supply will be constant in equilibrium. Interest rates will also be constant, with or without portfolio rigidities.

Because firms are also subject to a CIA constraint, at the beginning of period t they borrow enough from the financial intermediary to finance their nominal labor costs, $W_t L_t^D$. Every firm then uses the proceeds from selling its consumption goods to pay off the labor loan that it took out when the period began, $R_t W_t L_t^D$. Since the firm is owned by the representative household, it maximizes

$$E\left\{\sum_{t=0}^{\infty}\left[\beta^{t+1}\frac{U_{c,\,t+1}}{P_{t+1}}\right]D_t\right\} \text{ subject to (2),}$$

where $D_t = P_t y_t - R_t W_t L_t^D$.

The term in the square brackets above is a shareholder's marginal utility of a dollar received at the end of period t. Therefore, a dollar of a dividend received in period t can be transformed into $1/P_{t+1}$ units of consumption in period $t+1$, where $U_{c,\,t+1}$ reflects the household's marginal valuation of each additional unit of consumption.

The Financial Intermediary

There is also a representative but competitive financial intermediary, owned by the representative household, that is completely passive in our analysis. It accepts deposits from households, N_t, and receives lump-sum transfers from the government equal to the seigniorage the government receives from money creation, $M_{t+1} - M_t$, then loans these funds out to firms. Therefore, in equilibrium, the supply of loans must equal the demand for loans: $W_t H_t = N_t + (M_{t+1} - M_t)$. Because governments distribute their seigniorage to intermediaries, intermediaries make a profit, which is distributed to households as a lump-sum payment.[11] This dividend payment is given by

$$(3) \quad F_t = R_t(M_{t+1} - M_t).$$

The Monetary Authority

For most of this section, we consider two different operating procedures for the monetary authority. The first is pursuit of an interest rate target, where reserves are supplied to the banking sector in such a way that the interest rate in the economy is constant at $\bar{R}$. Note that money growth, $G_t = M_{t+1}/M_t$, is not constant under this procedure and responds endogenously to support the interest rate target. The second operating procedure that we analyze, money growth, $G_t = \bar{G}$, is constant. In this case, the interest rate R_t is not constant and will respond endogenously to productivity shocks.

Equilibrium

In equilibrium, the labor (4), loan (5), and goods (6) markets must all clear and the CIA constraint (7) must be satisfied.

$$(4) \quad L_t^s = L_t^D = L_t$$

$$(5) \quad n_t + G_t - 1 = w_t L_t^D$$

$$(6) \quad Y_t = \bar{K} + Z_t L_t = C_t$$

$$(7) \quad p_t C_t \le 1 - n_t + w_t L_t,$$

where $w_t = \dfrac{W_t}{M_t}$, $p_t = \dfrac{P_t}{M_t}$, and $n_t = \dfrac{N_t}{M_t}$.[12]

Since this model does not include capital, equation (6) states that the goods market clears when consumption equals output. Equation (7) is the household's CIA constraint which, when combined with (5), states that, in equilibrium, tomorrow's money stock must equal the value of consumption today.

Equilibrium also consists of households maximizing utility[13]

$$(8) \quad A = \frac{w_t}{p_t C_t}$$

and firms maximizing profits

$$(9) \quad \frac{w_t}{p_t} = \frac{Z_t}{R_t}.$$

This last condition says that the equilibrium real wage rate will equal the marginal productivity of labor deflated by the gross nominal

---

[11] Therefore, revenues from money creation are essentially redistributed to households in a lump-sum manner instead of being used by the government to help finance deficit spending. This assumption is made for simplicity and does not affect the results of our analysis.

[12] As long as nominal interest rates are strictly positive, that is, $R > 1$, (7) will be satisfied with equality. All equations with nominal variables are divided by the beginning-of-period money supply so that they are stationary.

[13] There is actually one more equation that is necessary in equilibrium. This is the household's intertemporal first-order condition, which determines its choice of n_t. After simplification, this first-order condition is $E_s(\frac{1}{G_t}) = \beta E_s(\frac{R_t}{G_t G_{t+1}})$. For the sluggish portfolio model, $s = t - 1$, since savings n_t are chosen at time $t - 1$. With fixed capital and independent technology shocks, this implies that savings will be constant, $n_t = \bar{n}$. With flexible portfolios $s = t$, indicating that n_t can be chosen conditional on time t innovations.

interest rate; that is, the real wage equals the after-tax marginal productivity of labor. This equation also gives the demand curve for labor.

Combining (5), (6), (7), and (9) implies the following expression for equilibrium consumption:

$$(10) \qquad C_t = \frac{\bar{K}}{1 - R_t s_t},$$

where $s_t = \dfrac{n_t + G_t - 1}{G_t}$, $R_t = \bar{R}$ for an interest rate peg, and $s_t = \bar{s}$ when money growth rates are pegged.

The variable s_t is interpreted as the share of the money stock held by the intermediary. As the next equation indicates, this share will determine equilibrium labor, and thus output, for the economy. Using (5) and (8) gives the following expression for labor in equilibrium:

$$(11) \qquad L_t = \frac{s_t}{A}.$$

The disadvantage of letting money growth be constant is apparent in (11). With sluggish portfolios and i.i.d. technology shocks, n is constant (see footnote 7). Therefore, when money growth rates are pegged, the share of money in the hands of the intermediary will also be constant, $s_t = \bar{s}$. This implies that with constant money growth, labor will also be constant.

However, with an interest rate peg, money growth is endogenous, so that the share of money held by intermediaries is not constant. The next section analyzes how money growth must respond in order to keep interest rates constant.

IV. Interest Rate Targets versus Money Growth Targets

The Benefit of an Interest Rate Peg

In order to understand how money growth will behave to support an interest rate peg, combine (6), (10), and (11) to obtain the relationship between the share of cash held by intermediaries, s_t, and productivity:

$$(12) \qquad s_t = \frac{Z_t - A\bar{K}\bar{R}}{Z_t \bar{R}}.$$

To keep nominal interest rates constant, the share of cash held by financial intermediaries must increase as productivity rises. Then, from the definition of s_t, money growth must also increase with productivity (since $n_t = \bar{n}$).

Equation (12), however, will hold regardless of whether portfolios are rigid. The only difference between an economy with portfolio rigidities and one without them is how the increase in s_t is achieved. With sluggish portfolios, since savings n are predetermined, the private sector cannot supply the credit necessary to make this occur. Therefore, in order to keep interest rates constant, the monetary authority must step in and supply reserves to the banking system, which lowers the real rate of interest. In appendix 1, we show that with portfolio rigidities, money growth (G_t^{pr}) and savings will be of the following form:

$$\frac{1}{G_t^{pr}} = a + \frac{b}{Z_t},$$

where a, $b > 0$ and $n_t^{pr} = n_{ss}$.

Without portfolio rigidities, private savings are not fixed; that is, they can respond to current economic conditions. This reverses the role of private savings versus government credit creation. When there are no portfolio rigidities (npr), money growth G_t^{npr} is constant, while private savings respond to productivity increases:

$$G_t^{npr} = G_{ss} \text{ and } n_t^{npr} = c - \frac{d}{Z_t},$$

where c, $d > 0$. The relationship between the two economies is $E(n_t^{npr}) = n_{ss}$, $E(\frac{1}{G_t^{pr}}) = \frac{1}{G_{ss}}$.[14]

The important variable governing the economy's behavior is s_t, the share of cash held by financial intermediaries. With an interest rate peg, this share is the same regardless of whether portfolios are sluggish. Therefore, from equation (11) we know that hours worked will also be the same. Since the share of cash held by intermediaries increases with positive productivity shocks, equilibrium labor will respond quickly and efficiently to technology shocks whether or not portfolios are sluggish. The only difference between the two economies is whether the private sector or the government is supplying the

---

[14] With flexible portfolios, there are many possible money growth rules that support an interest rate peg (see footnote 13). Another rule that will support an interest rate peg is i.i.d. money growth shocks.

credit.[15] Without portfolio rigidities, a constant money growth rule can support an interest rate peg. Households are now supplying the intermediary with the savings that the monetary authority supplied when portfolios were rigid.

The advantage of an interest rate peg is that it eliminates the distortion caused by sluggish portfolios. However, it does not eliminate the distortion caused by the CIA constraint, which persists as long as nominal interest rates are positive. With a constant money growth rule, both distortions will be present. Despite this, however, we are in a second-best environment and cannot conclude that an interest rate peg will necessarily dominate a constant money growth rule. The reason is that sometimes two distortions are preferable to one (for example, if one distortion mitigated the other). Indeed, we will show that this occurs to a limited extent: Variable interest rates increase savings, partially mitigating the distortion caused by the CIA constraint.

We do know, however, that the Friedman rule of setting the nominal interest rate to zero, $R = 1$, will be unambiguously better than a money growth rule or any other rule that achieves a zero nominal interest rate on average. This is because all distortions in the economy are eliminated when the nominal interest rate is pegged to zero.

Sluggish Portfolios: Constant Money Growth versus Constant Interest Rates

When money growth is constant, equilibrium will still be characterized by equations (10) and (11) above. The difference is that in equation (12), s_t, the share of cash in the hands of financial intermediaries, will be constant, while the nominal interest rate will vary. With constant money growth and sluggish portfolios, this share is also constant, since neither money growth nor private savings can change:

$$(12') \qquad R_t = \frac{Z_t}{\bar{s}Z_t + A\bar{K}}.$$

This equation shows that with constant money growth, interest rates and technology shocks covary positively with one another. A rise in productivity increases loan demand, which in turn increases interest rates, because credit is fixed. Equation (11) tells us that interest rates will increase until equilibrium labor does not change. Labor's inability to respond to technology shocks will prove especially costly. An equivalent way to look at this cost is through the sharp interest rate movements required to ensure that the loan market always clears.

Under an interest rate peg, labor can respond to productivity changes because money growth is procyclical. However, for the same reason, many economists and policymakers believe that an interest rate peg would be counterproductive. They reason that if money growth were procyclical, output (and hence consumption) would also be more variable. They consider this undesirable because, holding everything else constant, consumers prefer a less variable consumption stream.

Yet everything else is not held constant. Allowing labor to respond efficiently to productivity shocks may increase the variability of consumption, but it also increases average consumption. To see this, assume that the average distortion is the same for an interest rate peg as it is for a money growth peg. That is, we assume that $1/\bar{R} = E(1/R_t)$ or, equivalently, that $E(s_t) = \bar{s}$ (from equation [12′]).

From (10) and (12′), the standard deviation of consumption when interest rates are pegged equals

$$(13) \qquad \sigma_R = \frac{\sigma_Z}{A\bar{R}}.$$

From the goods-market-clearing condition, the standard deviation of consumption when money growth is constant equals

$$(14) \qquad \sigma_G = \frac{\bar{s}\sigma_Z}{A}.$$

Since $\bar{s} < 1/\bar{R}$, it is easy to see that consumption is more variable under an interest rate peg.[16] This occurs because money growth is allowed to move with output when interest rates are constant, thus increasing the variability of both output and consumption. Why is an interest rate peg beneficial under these circumstances? Mean consumption will also be higher under an interest rate peg than it is with constant money growth.

---

[15] If all real variables are the same, the real rate of interest will also be the same. Since nominal interest rates are the same by assumption, the expected rate of inflation is also the same for an economy with and without portfolio rigidities. Yet with portfolio rigidities, money growth increases with productivity shocks. However, this increase leads to a one-time rise in the price level and does not affect "expected" inflation, since with portfolio rigidities, the expectation is formed prior to realization of the productivity shock.

[16] From (12), we know that $\bar{s} = 1/\bar{R} - AKE(1/Z_t)$. This implies that $\bar{s} < 1/\bar{R}$.

From equation (6), the goods-market-clearing condition, we obtain

$$(15)\quad E_tC_t^R - E_tC_t^G = \text{cov}(L_t^R, Z_t).$$

Average consumption is higher under an interest rate peg precisely because labor responds optimally to technology shocks. Therefore, the same economic force that increases output's variability when interest rates are pegged also increases average consumption. With constant money growth, however, labor supply is constant. Variable labor is preferred because it allows workers to truncate the effect of bad shocks by working less and to accentuate the effect of good shocks by working more.

Despite increased variability in consumption, households would gladly trade off this extra variability for the extra consumption it provides on average. Using (13) we have

$$(16)\quad EU^R - EU^G = \ln\left(\frac{1}{\bar{R}}\right) - E\ln\left(\frac{1}{R_t}\right) > 0.^{17}$$

This expression is positive, since utility is concave and, by assumption, $E(1/R_t) = 1/\bar{R}$. Recalling that $1/R_t = (1 - \tau_t)$, this expression is the general equilibrium equivalent of the result that a constant tax rate is preferred to a variable one.

To compare an interest rate peg with a constant money growth rule, something must be held constant across the two regimes. The analysis above assumes that the average distortion is the same for both economies. An alternative variable that could be held constant across both regimes is the amount of seigniorage collected under each. Although $1 - 1/R$ measures the distortion in the economy, the effective rate at which taxes are collected is $1 - 1/G$.[18] These two differ because, even if inflation is zero, there still exists the distortion caused by workers' inability or unwillingness to obtain direct payment in real goods after production. Therefore, an alternative way to compare constant money growth rates and constant interest rates is to choose money growth so that $\frac{1}{\bar{G}} = \frac{1}{\beta E(R_{t-1})} = E(\frac{1}{G_t}) = \frac{1}{\beta \bar{R}}\cdot$ This is equivalent to setting interest rates in the two economies to be equal on average. In appendix 2, we show that for any two policies in which average seigniorage is the same, a constant interest rate will be preferred to a variable one.[19] As a special case, this implies that an interest rate rule is preferred to a constant money growth rule.

The intuition about the advantages and disadvantages of a constant money growth rule versus a constant interest rate rule is this: The cost of a money growth rule is that with sluggish portfolios, it greatly increases interest rate variability and thus the variability of the equivalent wage tax. However, there is also a benefit to having a constant money growth rate, that is, letting interest rates be variable: Since interest rates are the same on average, the inverses of the interest rates are not the same; in particular, $1/\bar{R} > E(1/R_t)$. Therefore, to obtain equal revenue, the average distortion is greater with an interest rate peg. Variable interest rates help mitigate the distortion caused by the CIA constraint, because they increase savings. From equation (12), we derive $E(s_t) > \bar{s}$ or $n^G > n^R$. This increase in savings spills over into the labor market, implying more employment, thus mitigating the distortion caused by the CIA constraint. Unless this distortion is extremely large ($R > 2$), the gains from reducing it are less than the potential gains from stabilizing interest rates and hence wage taxes.

V. Interest Rate Rules and Government Spending Shocks

Up to this point, our analysis has assumed that all shocks to the economy are productivity shocks. Poole's original study suggested that an interest rate rule is preferred when money demand shocks are more numerous than IS shocks, while a money growth rule is preferred when IS shocks are more numerous. The meaning of IS and LM shocks is ambiguous in general equilibrium models. Nonetheless, one might expect an interest rate rule to be desirable, because we assume that all shocks to the economy are supply shocks.

---

[17] Since $E(s_t) = \bar{s}$, equilibrium labor is the same on average. Therefore, given the assumption that utility is linear in leisure, we are simply left with the difference in the utility from consumption, which from (13) simplifies to (16).

[18] We define seigniorage for the two policies in terms of how many labor units the government can hire with the revenue. This is because we think of the government as using seigniorage to hire labor in order to produce a public good. Therefore, seigniorage (in labor units) equals $(M_{t+1} - M_t)/W_t = (G_t - 1)/(A*p_t*C_t) = (G_t - 1)/(A*G_t)$. If government production is not subject to the same high-frequency technology shocks as the private sector, the average amount of public goods produced will be the same for any two policies where $E(1/G_t)$ is the same for both policies. For simplicity, however, the actual model in the text continues to assume that these revenues are given right back to the households as a lump-sum transfer. That is, the government robs Peter to pay Peter.

[19] Actually, an interest rate target will be preferred only if $\bar{R} < 2$. That is, the nominal interest rate must be less than 100 percent annually.

To analyze the effect of demand shocks, we introduce government spending shocks into our framework.[20] The question now is whether a benevolent monetary authority should accommodate government spending shocks to support an interest rate peg. The answer is yes.

Government spending that is financed with lump-sum taxes can be introduced quite simply by redefining output and consumption as follows:

$$y_t = (\bar{K} + e_{ss}) + \bar{Z}L_t$$

$$C_t = K_t + \bar{Z}L_t,$$

where $K_t = (\bar{K} + e_{ss}) - e_t$.

The only difference in the definition of consumption is that K is no longer constant but can vary randomly over time. In particular, we assume that K_t is i.i.d. over time, which corresponds to the assumption that government spending shocks are i.i.d. A large value of K is equivalent to government spending below its mean ($e_t < e_{ss}$), while small values of K represent government spending shocks above its mean ($e_t > e_{ss}$).

The first-order conditions are the same as before, except that in equations (10)–(12), Z_t is assumed to be constant while K is allowed to vary:

$$(17) \quad C_t = \frac{K_t}{1 - R_t s_t},$$

where $s_t = \dfrac{n_t + G_t - 1}{G_t}$, $R_t = \bar{R}$ for an interest rate peg, and $s_t = \bar{s}$ when money growth rates are pegged.

$$(18) \quad L_t = \frac{s_t}{A}$$

$$(19) \quad R_t = \frac{\bar{Z}}{\bar{s}\bar{Z} + AK_t} \text{ (money growth rule)}$$

$$(19') \quad s_t = \frac{\bar{Z} - A\bar{R}K_t}{\bar{Z}\bar{R}} \text{ (interest rate rule).}$$

With a money growth rule, interest rates increase to clear the loan market so that equilibrium labor is constant once again. When interest rates are pegged, however, labor will increase with positive government spending shocks (K is small). This increase is brought about as the money supply increases in order to keep the interest rate from rising. An interest rate peg will still undo the distortion caused by sluggish portfolio adjustments.

To understand the dynamics of the model, it is useful to look at the labor market again. The demand curve for labor, given by equation (9), is completely elastic at the marginal productivity of labor deflated by the nominal interest rate, $\bar{Z}/R_t$. Labor supply is obtained by combining (8) and (6). For a money growth peg, labor supply equals

$$(20) \quad L_t^s = \frac{1}{A\bar{s}}\left(\frac{w_t}{p_t}\right) - \frac{K_t}{\bar{s}}.$$

A positive shock to government spending (small K) has the immediate impact of reducing today's private consumption relative to tomorrow's. As the marginal utility of consumption rises, workers want to increase the number of hours worked in order to boost their consumption. Thus, labor supply (20) shifts outward. This increases firms' demand for both labor and loans. In order to clear the loan market, interest rates are driven up, thereby shifting labor demand (9) down. In equilibrium, the nominal interest rate increases until the real wage in (20) declines, so that equilibrium labor does not change.

Therefore, with a money growth rule, output (private consumption plus government spending) is constant, implying that private consumption is crowded out completely. With an interest rate peg, however, money growth increases in order to prevent the nominal rate from rising (19′), thereby allowing both labor and output to increase. Combining (2) and (19), private consumption is constant ($C_t^R = \frac{\bar{Z}}{A\bar{R}}$), so that equilibrium output rises by the amount of the increase in government spending.

If we choose an interest rate target such that $Es_t = \bar{s}$, it is easy to see that mean consumption is the same with either operating target. But an interest rate target is preferred, since private consumption is less variable (that is, constant). However, equation (16) will still hold, implying that an interest rate target will be preferred to any other rule where $1/\bar{R} = E(1/R_t)$. As with productivity shocks, seigniorage is higher for a money growth peg if $1/\bar{R} = E(1/R_t)$. However, as appendix 2 makes clear, if $1/\bar{G} = E\left(1/G_t\right)$, an interest rate rule will be preferred to a money growth peg.

---

[20] In some ways, it is misleading to call government spending shocks "demand shocks," since they act like a drain on resources.

VI. Extensions

The foregoing analysis illustrates an important implication of an interest rate target: It completely eliminates the distortion caused by households' inability to readjust portfolio holdings quickly following either technology or government spending shocks. But there is nothing special about these shocks. The result of this analysis would be true for any type of shock, including preference shocks. For example, the same arguments would apply if *A* or even β were allowed to vary over time.

We also assume that these shocks are i.i.d. over time. In an earlier paper (Carlstrom and Fuerst [1995]), we show that this assumption is also unnecessary. Under a money growth rule, consumption and labor will depend on last period's shocks and not on today's innovations. In contrast, an interest rate rule will once again allow labor and consumption to respond to today's information. As before, this option value will be welfare-improving.

The other assumption used in our model—that portfolios are rigid for exactly one period—is also nonessential. Suppose that households adjust their portfolios slowly because of convex adjustment costs, as in Christiano and Eichenbaum (1992). Equation (12′) will still determine the share of cash held by intermediaries. Therefore, labor and output will also be the same. The only difference will be how fast money must grow in response to various shocks in order to support the interest rate target. Besides allowing the economy to respond efficiently to current shocks, the interest rate rule also has the advantage of enabling households to avoid the costs associated with adjusting their nominal portfolio holdings.

Yet monetary authorities typically do not keep interest rates constant over the course of a business cycle. One reason often given is that procyclical money growth may make output more variable, but it has already been refuted in this paper: It is efficient to allow the economy to respond to shocks, although output variability increases. A second reason is fear of the long-run inflationary consequences of an interest rate peg. In the model presented here, long-term inflation is pinned down by the nominal interest rate, but short-term inflation can be quite variable under an interest rate peg. The long-run inflation rate will be pinned down by Fisher's equation. The real federal funds rate has averaged approximately 2 percent per year since the beginning of the century; thus, if one wants inflation to average zero over time, one should choose a funds rate peg of 2 percent. Similarly, if one wants inflation to average 3 percent, the nominal interest rate peg should be 5 percent. As for increased short-run inflation variability, it is far from clear why this is costly.[21]

According to one argument, there are costs to changing prices, so stable prices would be beneficial. If these costs result simply from having to reprogram price scanners and change price tags on products, it is uncertain that prices will change more frequently with variable inflation, given that inflation is positive. In addition, similar savings are associated with an interest rate target, since it has the advantage of allowing households to avoid the costs associated with adjusting their nominal portfolio holdings.

VII. Conclusions

This paper explores some of the benefits of interest rate targeting. An interest rate peg is desirable because such a policy eliminates any distortion caused by sluggish portfolios. That is, an interest rate peg allows labor—and thus output and consumption—to respond optimally to economic shocks. An equivalent way to think about the benefits of an interest rate peg is that it minimizes the "inflation tax" distortion. Nominal interest rates are a tax on non-interest-bearing assets and mimic the effect of wage taxes. With sluggish portfolios and constant money growth, interest rates can be quite variable. Eliminating this variability is welfare-improving.

Our analysis also suggests that, in order to achieve an interest rate peg, money growth should be procyclical. This implies that the variability of output will also be higher when interest rates are pegged. Despite popular wisdom to the contrary, this increase in variability is optimal. With productivity shocks, this is so because mean consumption is higher. With government spending shocks, it is so because, although output is more variable, private consumption is less variable.

---

[21] It is obvious why increased inflation uncertainty would be costly. However, inflation would not be more uncertain, since money growth, and hence inflation, would respond to publicly observed shocks. If nominal wage contracts had been made prior to these shocks, this variability would have real costs.

Appendix 1

Portfolio Rigidities and an Interest Rate Rule

With portfolio rigidities, money growth (G_t^{pr}) and savings will be of the form

$$\frac{1}{G_t^{pr}} = a + \frac{b}{Z_t},$$

where a, $b > 0$ and $n_t^{pr} = n_{ss}$.

Given that money growth is of this form, using the first-order condition for n_t (footnote 13), we obtain

$$E_{t-1}\left(\frac{1}{G_{t+1}}\right) = E_{t-1}\left(a + \frac{b}{Z_{t+1}}\right) = \frac{1}{\beta\bar{R}}.$$

This expression uses the assumption that technology shocks are i.i.d. Taking a second-order approximation, we obtain

$$\text{(A1)}\quad a + \frac{b}{\bar{Z}} + \frac{b}{2}\sigma_Z^2 = \frac{1}{\beta\bar{R}},$$

where $\bar{Z}$ and σ_Z^2 are the mean and variance of Z_t, respectively.

From equation (15), the definition of s_t, and our assumed form for money growth, we obtain

$$\text{(A2)}\quad 1 + (n_{ss} - 1)a + \frac{(n_{ss} - 1)b}{Z_t} = \frac{1}{\bar{R}} - \frac{A\bar{K}}{Z_t}.$$

Using the method of undetermined coefficients, we have

$$a = \frac{(\bar{R} - 1)}{\beta\bar{R}\,[(\bar{R} - 1) + \bar{R}A\bar{K}\,(1 + \sigma_Z^2)]}$$

$$b = \frac{AK}{\beta[(\bar{R} - 1) + \bar{R}A\bar{K}\,(1 + \sigma_Z^2)]}$$

$$n_{ss} = 1 + \beta(1 - \bar{R}) - \beta\bar{R}A\bar{K}\,(1 + \sigma_Z^2).$$

No Portfolio Rigidities and an Interest Rate Rule

If portfolios are not fixed, we assume that money growth and savings have the following form:

$$G_t^{npr} = G_{ss} \text{ and } n_t^{npr} = c - \frac{d}{Z_t},$$

where c, $d > 0$, $E(n_t^{npr}) = n_{ss}$, and $E\left(\frac{1}{G_t^{pr}}\right) = \frac{1}{G_{ss}}$.

From footnote 13, we obtain

$$\text{(A3)}\quad \frac{1}{G_{ss}} = \frac{1}{\beta\bar{R}}.$$

Using the definitions of n_t, s_t, and equation (12) yields

$$\text{(A4)}\quad 1 + \frac{(c - 1)}{G_{ss}} - \frac{d}{G_{ss}}\left(\frac{1}{Z_t}\right) = \frac{1}{\bar{R}} - \frac{A\bar{K}}{Z_t}.$$

Using the method of undetermined coefficients, we have

$$c = 1 + \beta(1 + \bar{R})$$

$$d = -\beta\bar{R}A\bar{K}$$

$$G_{ss} = \beta\bar{R}.$$

Therefore, $E(n_t^{npr}) = n_{ss}$, and $E\left(\frac{1}{G_t^{pr}}\right) = \frac{1}{G_{ss}}$, as the text of this paper asserts.

Appendix 2

The Desirability of an Interest Rate Peg

This appendix shows that if seigniorage is on average equal, interest rate rules will dominate a money growth rule. Equal revenues imply

$$E\left(\frac{1}{G_t^R}\right) = \frac{1}{G_{ss}}, \text{ or } E(R_t) = \bar{R}.$$

Money Growth Rule:

$$\bar{s} = \frac{1}{R_t} - \frac{AK}{Z_t}$$

$$\bar{s} \approx \frac{1}{\bar{R}} + \frac{\sigma_{Rr}^2}{\bar{R}^3} - \frac{AK}{\bar{Z}} - \left(\frac{AK}{\bar{Z}^3}\right)\sigma_Z^2 .$$

Interest Rate Peg:

$$s_t = \frac{1}{\bar{R}} - \frac{AK}{Z_t}$$

$$E(s_t) \approx \frac{1}{\bar{R}} - \frac{AK}{\bar{Z}} - \left(\frac{AK}{\bar{Z}^3}\right)\sigma_Z^2 .$$

We know that consumption is equal to

$$C_t^R = \frac{Z_t}{A\bar{R}}$$

$$C_t^G = \frac{Z_t}{AR_t}$$

and labor is $L_t = \frac{s_t}{A}$.

The difference in utility is therefore

$$EU_t^R - EU_t^G = E\ln(R_t) - \ln(\bar{R}) + \bar{s} - E(s_t)$$

$$\approx \frac{1}{\bar{R}^3} - \left(\frac{1}{2\bar{R}^2}\right)\sigma_R^2 > 0.$$

If $\bar{R} < 2$, that is, if the nominal interest rate is less than 100 percent, then an interest rate peg is preferred to a money growth peg. Actually, a stronger result holds. Nothing in the proof assumes that money growth is constant. The proof compares an interest rate peg to a policy where the interest rate varies (with average revenues in labor units equal). An interest rate peg will be preferred to any other policy unless the distortion caused by the CIA constraint is extremely large.

References

Barro, R.J. "On the Determination of the Public Debt," *Journal of Political Economy,* vol. 87, no. 5, part 1 (October 1979), pp. 940–71.

Carlstrom, C.T., and T.S. Fuerst. "Interest Rate Rules vs. Money Growth Rules: A Welfare Comparison in a Cash-in-Advance Economy," *Journal of Monetary Economics,* vol. 36, no. 2 (November 1995), pp. 247–67.

Christiano, L. "Modeling the Liquidity Effect of a Monetary Shock," Federal Reserve Bank of Minneapolis, *Quarterly Review,* vol. 15, no. 1 (Winter 1991), pp. 3–34.

____________, and M. Eichenbaum. "Liquidity Effects and the Monetary Transmission Mechanism," *American Economic Review,* vol. 82, no. 2 (May 1992), pp. 346–53.

____________, ____________, and C. Evans. "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," *Review of Economics and Statistics,* vol. 78, no. 15 (February 1996), pp. 16–38.

Fuerst, T.S. "Liquidity, Loanable Funds, and Real Activity," *Journal of Monetary Economics,* vol. 21, no. 1 (February 1992), pp. 3–24.

Hansen, G.D. "Indivisible Labor and the Business Cycle," *Journal of Monetary Economics,* vol. 16, no. 3 (November 1985), pp. 309–27.

Lucas, R.E., Jr. "Liquidity and Interest Rates," *Journal of Economic Theory,* vol. 50, no. 2 (April 1990), pp. 237–64.

Poole, W. "Optimal Choice of the Monetary Policy Instrument in a Simple Stochastic Macro Model," *Quarterly Journal of Economics,* vol. 84, no. 2 (May 1970), pp. 197–216.

Rogerson, R. "Indivisible Labor, Lotteries, and Equilibrium," *Journal of Monetary Economics,* vol. 21, no. 1 (January 1988), pp. 3–16.

Sandmo, A. "A Note on the Structure of Optimal Taxation," *American Economic Review,* vol. 64, no. 4 (September 1974), pp. 701–06.

MZM: A Monetary Aggregate for the 1990s?

by John B. Carlson and Benjamin D. Keen

John B. Carlson is an economist at the Federal Reserve Bank of Cleveland, and Benjamin D. Keen is a graduate student of economics at the University of Virginia. The authors thank Thomas Hall, Robert Hetzel, Dennis Hoffman, Robert Rasche, and E.J. Stevens for helpful comments and suggestions.

Introduction

The Humphrey–Hawkins Act of 1978 requires the Federal Open Market Committee (FOMC) to specify annual growth ranges for money and credit early each year. These ranges are reconsidered at midyear, and preliminary ranges are specified for the upcoming calendar year. In the past, financial market participants paid close attention to the announcement of the monetary aggregate growth ranges in order to assess the intentions of the FOMC, the policymaking arm of the Federal Reserve System. Large deviations from range midpoints were often associated with policy actions designed to bring money growth back to its intended path.

In recent years, however, the reliability of various money measures as useful indicators on which to base policy has become seriously compromised. Consequently, the role of money in policy decisions has greatly diminished. In July 1993, Federal Reserve Chairman Alan Greenspan reported that "... at least for the time being, M2 has been downgraded as a reliable indicator of financial conditions in the economy, and no single variable has yet been identified to take its place."[1]

The breakdown of M2 as a monetary policy guide may sound familiar to those who have followed policy closely over the past two decades.[2] In the 1980s, the relationship between M1 and the economy became questionable.[3] As evidence grew that the aggregate had become an unreliable indicator, policymakers turned their attention to M2, which appeared to be immune to the effects that had undermined M1.

Recently, in response to the M2 breakdown, some analysts have been monitoring MZM, a measure of money that includes assets redeemable at par on demand. Interestingly, the relationship between MZM and economic activity appears to have stabilized in recent years, suggesting that the aggregate has a potential role

[1] See *1993 Monetary Policy Objectives: Summary Report of the Federal Reserve Board*, July 20, 1993, p. 8.

[2] For a complete analysis of the breakdown of M2, see Miyao (1996).

[3] Although Hoffman and Rasche (1991) present evidence that M1 continued to have a stable long-run relationship with interest rates and income throughout this period, no short-run relationship was found to be sufficiently reliable for policy. Lucas (1994) also presents some evidence of a stable M1 demand relationship using annual data from 1900 to 1985.

BOX 1

Measures of Money

M1 = Currency
\+ Demand deposits
\+ Other checkable deposits
\+ Traveler's checks

M2 = M1
\+ Savings deposits (including MMDAs)
\+ Small time deposits
\+ Retail MMMFs

MZM = M2
\+ Institutional MMMFs
– Small time deposits

M3 = M2
\+ Large time deposits
\+ Institutional MMMFs
\+ Eurodollars
\+ RPs

for policy. This article describes MZM, discusses its relationship with economic activity, and presents evidence that it has maintained a stable relationship with nominal GDP and interest rates. Some implications for MZM's usefulness as a policy guide are also briefly discussed.

I. What Is MZM?

Poole (1991) first coined the term MZM when he proposed a measure of money encompassing all of the monetary instruments with zero maturity. He based this distinction on Friedman and Schwartz's (1970) principle that money is a "temporary abode of purchasing power." Assets included in MZM are essentially redeemable at par on demand, comprising both instruments that are directly transferable to third parties and those that are not (see box 1). This concept excludes all securities, which are subject to risk of capital loss, and time deposits, which carry penalties for early withdrawal. Motley (1988) had earlier proposed such a measure, but called it nonterm M3.

On the spectrum of monetary aggregates, MZM is broader than M1 but essentially narrower than M2. Like M2, it encompasses M1, savings deposits (including money market deposit accounts [MMDAs]), and retail money market mutual funds (MMMFs). It does not, however, include small time deposits (such as retail certificates of deposit), which are in M2. On the other hand, MZM does cover institutional MMMFs, while M2 does not.[4] In sum, MZM includes all types of financial instruments that are, or can be easily converted into, transaction balances without penalty or risk of capital loss. The MZM measure that we use in this paper does not include overnight wholesale repurchase agreements (RPs) or overnight eurodollars, components of the originally proposed measure.[5]

II. Why MZM?

One of the basic motives for holding monetary assets is uncertainty. Inventory-theoretic models of money demand such as those of Baumol (1952), Tobin (1958), and Miller and Orr (1966) stress the uncertainties related to cash flow. Earlier, Keynes (1936) had noted the importance of uncertainty regarding future interest rates as a determinant of money balances. In proposing the nonterm distinction for a money measure, Motley states that "if there were no uncertainty about future rates of interest, the present and all future values of securities also would be known, and hence an investor would have no incentive to hold money." Holding money is thus a hedge against potential capital losses if an unanticipated need for liquidity occurs. The demand for money arises because wealth holders cannot anticipate their transaction needs in the face of uncertainty.

Motley also discusses the importance of transaction costs in exchanging non-money assets for money. These costs include not only brokerage fees, but also the implicit costs associated with inconvenience, sometimes called *shoe-leather* costs. Uncertainty about the future need for liquid funds thus creates incentives apart from interest rate uncertainty. The consequences of such behavior are captured in the inventory-theoretic models of money demand. Whether predicated on transaction costs or on interest rate uncertainty, money demand models generally indicate that the amount of money demanded varies directly with income and inversely with the opportunity cost of money.

To link the MZM measure to its theoretical conception, Motley (1988, p. 39) argues that "each of the motives for holding wealth in the form of 'money' is more closely related to

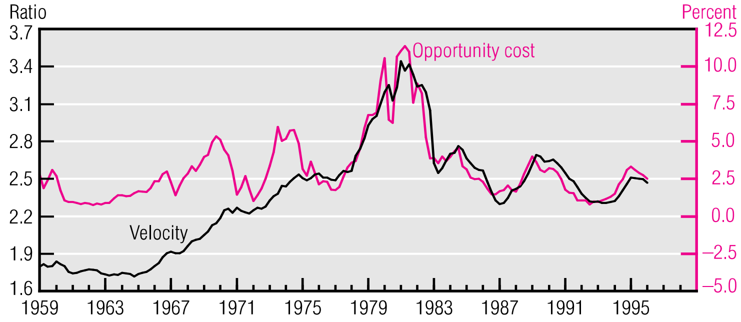
---

[4] Retail money funds are those with minimum initial investments under $50,000; institutional money funds have a required minimum initial investment of $50,000.

[5] Technically, these are both term instruments, albeit of short duration. Whitesell and Collins (1996) find little evidence of substitution between these instruments and demand deposits in recent years. Data on overnight RPs and eurodollars are no longer available.

FIGURE 1

MZM Velocity and Opportunity Cost



SOURCES: Board of Governors of the Federal Reserve System; and U.S. Department of Commerce, Bureau of Economic Analysis.

BOX 2

Calculation of MZM's Rate of Return

$$RMZM = (1/MZM) \times [OCD \times ROCD + SAV \times RSAV + (RMF + IMF) \times RR\&IMF]$$

RMZM = Rate of return on MZM deposits
MZM = MZM
OCD = Other checkable deposits
ROCD = Rate of return on other checkable deposits
SAV = Savings deposits
RSAV = Rate of return on savings deposits
RMF = Retail MMMFs
IMF = Institutional MMMFs
RR&IMF = Rate of return on retail and institutional MMMFs

money's being a nonterm asset, that gives more or less immediate command over goods and services, than to its being the medium of exchange. All are motives for holding liquid assets in general, and not only assets that are a means of exchange." Thus, the zero-maturity criterion for selecting assets to be included in a measure of money has its basis in principle.

III. The Demand for MZM

Developing theoretical underpinnings for money demand is one thing; finding a stable empirical relationship is another. Estimated money demand relationships are notoriously unstable. The literature is replete with examples of estimated models that fail the test of time. Most fall victim to the effects of financial innovation, if not of regulation and deregulation. Financial innovation, for example, can lead to the development of new instruments like MMMFs, first introduced in the mid-1970s. Generally, such instruments are not included in the official money measures until an empirical basis becomes well established. MMMFs were first included in the 1980 redefinition of M2.

Structural change in the demand for an aggregate is usually evident in the time series of its velocity, especially in relation to interest rates. Figure 1 illustrates MZM velocity in relation to its opportunity cost (the difference between a market yield and the yield on MZM). In principle, MZM opportunity cost is a measure of the forgone income from holding MZM. It is calculated here as the difference between the three-month Treasury bill rate and the share-weighted average of yields paid on MZM components (see box 2).[6]

The movements in MZM velocity can be separated into two distinct periods. Prior to 1975, velocity seemed to trend continually upward with little regard for changes in the aggregate's opportunity cost. Since then, however, velocity appears to be relatively trendless in the long run, but varies systematically with changes in opportunity cost in the short run.

Poole argues that the upward trend in MZM velocity before 1975 is the likely result of financial regulations, especially Regulation Q, which placed ceilings on interest rates paid by depositories. We find this argument compelling. During periods of high and rising market interest rates, such ceilings create strong incentives for deposit holders to economize on their cash balances.[7]

Although interest rate ceilings were not totally eliminated until the early 1980s, they were often rendered ineffective by revisions of Regulation Q that started in the mid-1970s. For example, ceilings were sometimes raised once

■ [6] Ideally, the opportunity cost measure would include all returns to holding deposits (such as gifts for opening an account and service credits) and subtract service charges. These data are not available, which may explain why some empirical specifications fail.

■ [7] It is interesting to note that MZM velocity appears to ratchet up. When the aggregate's opportunity cost rises, its velocity also rises, but when opportunity cost falls, velocity does not. This is reminiscent of the experience of M1 in the 1970s. Porter, Simpson, and Mauskopf (1979) argue that this pattern reflected incentives for adopting cash management technology. Specifically, when interest rates breached old thresholds, balance holders adopted techniques that allowed them to economize on their M1 holdings. These techniques reduced the need to hold M1 even when interest rates fell.

they became effective. Moreover, depositories were periodically allowed to introduce new accounts whose interest rates were tied to those paid on U.S. Treasury bills. Finally, MMMFs, first introduced in 1973, provided balance holders with a zero-maturity instrument that effectively yielded a market rate. These instruments appeared to serve as a refuge from regulated yields. Because MMMFs attracted at least part of the depository outflows related to effective interest rate ceilings, such substitutions were internalized in the MZM aggregate.[8]

IV. An MZM Demand Specification

We consider a specification of MZM demand similar to that proposed by Moore, Porter, and Small (1990; hereafter MPS) for the M2 demand model. They apply methods developed by Engle and Granger (1987) that distinguish long-run and short-run determinants. Our long-run relation follows the form

$$(1) \qquad M_t = AY_t S_t^{\gamma},$$

where M is the measure of money, A is the scale parameter, Y is nominal GDP, and S is equal to one plus the opportunity cost of money.[9] Note the implicit constraint that the elasticity of M with respect to Y is equal to one.[10] The parameter γ is the elasticity of opportunity cost. An implication of all money demand theories, of course, is that the sign of γ is negative.

Equation (1) can be rewritten as

$$(2) \qquad Y_t/M_t = V_t = A^{-1}S_t^{-\gamma},$$

where V is the income velocity of money. Thus, the long-run relation embeds the simple relationship between MZM velocity and opportunity cost evident in figure 1.

Because the model is estimated in log form, we rewrite the long-run relations as

$$(1') \qquad m_t = \alpha + y_t + \gamma s_t + e_t \text{, or}$$

$$(2') \qquad v_t = -\alpha - \gamma s_t - e_t,$$

where lower-case variables denote the natural log. The variable e is introduced to account for any potential deviation between the actual level and long-run equilibrium.

Estimation of (1′) or (2′) requires careful analysis. It is widely known that most aggregate economic time series are nonstationary in levels. In such variables, there is no tendency to systematically return to a unique level or trend over time. Moreover, when these variables exhibit drift, standard regression analysis can yield spurious relationships. Table 1 presents evidence that natural logarithms of MZM velocity and opportunity cost are nonstationary both in the whole sample period and after 1974.

Methods developed by Engle and Granger (1987) and Johansen (1988) allow us to examine whether equilibrium relationships exist between two or more nonstationary variables. Such variables are said to be cointegrated if some linear combination of them is stationary. Thus, cointegration implies a long-run relationship between variables, and we can obtain estimated long-run elasticities from the cointegrating vector. However, cointegration between two or more variables requires that each be stationary in a differenced form. The evidence presented in table 1 tends to confirm that the first differences of MZM velocity and opportunity cost are stationary.[11]

To test if MZM velocity and opportunity cost are cointegrated, we estimate a chi-squared statistic proposed by Johansen (1988).[12] Specifically, this approach tests the hypothesis that there are, *at most, r* cointegrating vectors. The results presented in table 2 are mixed. These tests fail to reject the hypothesis that there is no cointegrating vector involving MZM velocity and opportunity cost over the whole sample. Since 1974, however, evidence supports the hypothesis that there is one cointegrating vector. Thus, a stable equilibrium relationship linking MZM velocity and opportunity cost appears to have

---

[8] The existence of reserve requirements has given banks an incentive to “sweep” transaction balances into nonreservable and usually nonmaturing assets like MMDAs. Thus, this form of regulation avoidance is also internalized in the zero-maturity measure.

[9] The units are not in percentage terms. Hence, a 3 percent rate for opportunity cost would appear as 1.03. We found that this specification is more robust than the simple log of opportunity cost. Since the model is estimated in log form, this variable approximates a semilog form for opportunity cost. MPS include the log of opportunity cost in their model, but use a linear approximation when the value is small.

[10] Although the Baumol (1952) model of money demand indicates an income elasticity of 0.5, it assumes that money bears no interest. MZM largely comprises interest-bearing components.

[11] Unlike the whole-period findings, these test results are not uniformly concordant. The augmented Dickey–Fuller test for stationarity in the first difference of MZM is not significant at the 10 percent level, but the Phillips–Perron test is significant at the 5 percent level.

[12] For any *n* variables there may be *n* cointegrating vectors. We are concerned here with finding one cointegrating vector for two variables.

TABLE 1

Stationarity Test Results

Sample: 1961:IQ to 1994:IVQ

		Test Statistics			Critical Value	
Variable		v_t	s_t	m_t	10%	5%
Lag truncation:		(8)	(11)	(11)		
Constant, no trend						
Dickey–Fuller	t_α	−1.92	−2.13	0.59	−2.58	−2.89
Phillips–Perron	t_α	−1.72	−2.52	0.34	−2.58	−2.89
	z_α	−3.77	−11.9	0.17	−11.1	−13.8
Constant, trend						
Dickey–Fuller	t_α	−1.28	−2.04	−1.86	−3.15	−3.45
Phillips–Perron	t_α	−1.26	−2.47	−1.84	−3.15	−3.45
	z_α	−3.62	−11.7	−5.96	−17.6	−20.8

Variable (1st diff.)		Δv_t	Δs_t	Δm_t	10%	5%
Lag truncation:		(8)	(11)	(11)		
Constant, no trend						
Dickey–Fuller	t_α	−3.34	−3.64	−3.31	−2.58	−2.89
Phillips–Perron	t_α	−7.15	−9.90	−6.73	−2.58	−2.89
	z_α	−76.9	−101.7	−68.8	−11.1	−13.8
Constant, trend						
Dickey–Fuller	t_α	−3.68	−3.66	−3.38	−3.15	−3.45
Phillips–Perron	t_α	−7.11	−9.86	−6.68	−3.15	−3.45
	z_α	−75.1	−100.7	−68.1	−17.6	−20.8

Sample: 1975:IQ to 1994:IVQ

		Test Statistics			Critical Value	
Variable		v_t	s_t	m_t	10%	5%
Lag truncation:		(8)	(7)	(1)		
Constant, no trend						
Dickey–Fuller	t_α	−1.54	−1.80	−0.93	−2.59	−2.91
Phillips–Perron	t_α	−1.65	−2.18	−1.04	−2.59	−2.91
	z_α	−5.59	−6.91	−0.55	−10.9	−13.6
Constant, trend						
Dickey–Fuller	t_α	−2.54	−2.69	−1.81	−3.16	−3.46
Phillips–Perron	t_α	−2.09	−2.18	−1.23	−3.16	−3.46
	z_α	−7.58	−8.95	−4.10	−17.2	−20.4

Variable (1st diff.)		Δv_t	Δs_t	Δm_t	10%	5%
Lag truncation:		(8)	(11)	(11)		
Constant, no trend						
Dickey–Fuller	t_α	−2.69	−2.66	−2.46	−2.59	−2.91
Phillips–Perron	t_α	−5.28	−7.93	−5.37	−2.59	−2.91
	z_α	−41.5	−67.4	−42.7	−10.9	−13.6
Constant, trend						
Dickey–Fuller	t_α	−2.68	−2.69	−2.47	−3.16	−3.46
Phillips–Perron	t_α	−5.27	−7.93	−5.37	−3.16	−3.46
	z_α	−41.9	−67.0	−43.2	−17.2	−20.4

NOTE: Regressions are of the form $\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 t + \sum_{j=1}^{n} \gamma j \Delta y_{t-j} + \varepsilon_t$, except when the trend is omitted. The test statistics are for H_0: $\alpha_1 = 0$. Thus, when the test statistic exceeds the critical value, we cannot reject the hypothesis that the series is nonstationary. Lag length is determined by the highest significant lag order from the autocorrelation or partial autocorrelation function. Critical values are interpolated from tables 4.1 and 4.2 in Banerjee et al. (1993).
SOURCE: Authors' calculations.

TABLE 2

Cointegration Test Results

	Johansen Trace Test Statistics	
5% Critical Values Trace Test	17.84 $r = 0$	8.08 $r = 1$
1961:IQ–1994:IVQ	13.88	2.92
1975:IQ–1994:IVQ	20.62	5.14

NOTE: If the test statistic is greater than the critical value, we can reject the hypothesis that there are, at most, *r* cointegrating vectors. The results are based on four lag specifications.
SOURCE: Authors' calculations.

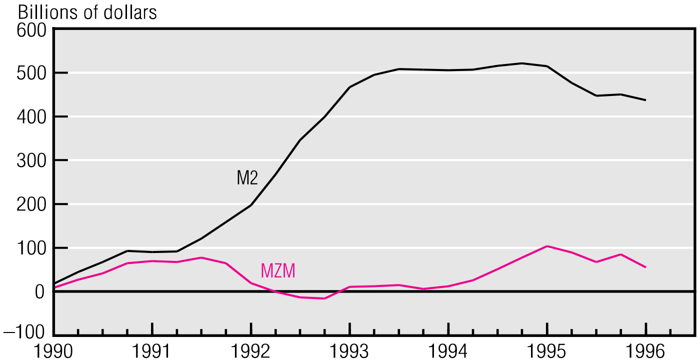
emerged beginning in 1975. It is important to note that this latter period includes extensive deregulation of depositories, an acceleration in financial innovation, a substantial disinflation, and three relatively unique business cycles.

V. An Error-Correction Specification

One implication of the cointegration test results is that e_t in equations (1′) and (2′) has been stationary since 1974. Stationarity in e_t allows us to obtain consistent estimates of the parameters of the long-run relationship over the latter period. One estimation procedure is to embed e_{t-1} in a short-run relation that describes the adjustment path to equilibrium. This relation is commonly called the error-correction process. We propose a streamlined version of the MPS specification:

FIGURE 2

MZM and M2 Prediction Errors



SOURCES: Board of Governors of the Federal Reserve System; and authors' calculations.

BOX 3

Regression Results

$$\begin{array}{l} \Delta m_t = -0.095 - \underset{(3.35)}{0.132}\,(m_{t-1} - y_{t-1}) - \underset{(3.26)}{0.572}\; s_{t-1} + \underset{(5.55)}{0.248}\;\Delta m_{t-1} \\ \text{(2.97)} \\[1em] \quad -\underset{(3.60)}{0.438}\;\Delta s_t - \underset{(4.70)}{0.742}\;\Delta s_{t-1} - \underset{(10.51)}{0.114}\, D831_t + \varepsilon_t \end{array}$$

NOTE: Adj. $R^2 = 0.83$, $SSE = 0.0098$, Box–Ljung statistic $Q(12) = 18.35$, $F_{1,72} = 3.20$ (test on restriction: $m_t - y_t = 0$), and estimation period = 1975:IQ to 1994:IVQ.
SOURCE: Authors' calculations.

$$(3)\qquad \Delta m_t = \beta_0 + \beta_1 e_{t-1} + \beta_2 \Delta m_{t-1} + \beta_{30}\Delta s_t + \beta_{31}\Delta s_{t-1} + \beta_4 D831 + \varepsilon_t,$$

where Δ denotes the first difference of a variable, e_{t-1} is the deviation of money from its long-run equilibrium value in the prior period, ε is white noise, and *D831* is a qualitative variable that equals zero in all quarters except 1983:IQ, when it equals one. We include the final variable to account for transitory effects related to the introduction of MMDAs.

Solving for e_t in (1′) and substituting into (3) yields a form that allows the parameters to be estimated jointly:

$$(3')\qquad \Delta m_t = \beta_0 - \beta_1\alpha + \beta_1(m_{t-1} - y_{t-1}) - \beta_1\gamma s_{t-1} + \beta_2\Delta m_{t-1} + \beta_{30}\Delta s_t + \beta_{31}\Delta s_{t-1} + \beta_4 D831 + \varepsilon_t.$$

From this form, the long-run opportunity cost elasticity, γ, can be easily recovered. Equation (3′) is estimated using ordinary least squares, with the results presented in box 3.

It is most interesting to note that the long-run opportunity cost elasticity of MZM is –4.33, an unusually high estimate. A one-percentage-point increase in MZM opportunity cost from its current level would reduce equilibrium MZM demanded by more than 4 percent. This indicates that the lion's share of MZM variation (and the variation in its velocity) reflects a systematic effect due to interest rates. To verify that the velocity specification is appropriate, we test the restriction that the income elasticity equals one. This test fails to reject a unitary income elasticity at the 5 percent significance level. In sum, MZM demand since 1974 is relatively well explained by the few variables included in our framework.

VI. MZM in the 1990s

It is widely held that the demise of M2 as a reliable policy guide resulted largely from the proliferation of mutual funds in capital market instruments, particularly bond funds (see Duca [1995], Darin and Hetzel [1994], Collins and Edwards [1994], and Orphanides, Reid, and Small [1994]). This view is summarized succinctly by Darin and Hetzel (p. 39): "In the early 1990s, the combination of 1) low rates of return on bank deposits relative to capital market instruments and 2) the decreased cost of operating bond and stock mutual funds diminished the public's demand for saving in the form of bank deposits." The historical relationship between M2 and economic activity broke down as depositors redirected these savings flows from bank deposits to stock and bond mutual funds. This unraveling is evident in the cumulative out-of-sample projection errors of a version of the MPS model specification (see figure 2).

To investigate the robustness of the MZM specification during the proliferation of bond and equity funds, we estimate the model through 1989 and use out-of-sample simulations to 1996:IQ.[13] This simulation reveals no significant cumulative error. Indeed, more than five years after the sample period, MZM is essentially

---

[13] Because we are examining only the robustness of parameters, we use actual values for exogenous variables. However, the simulation is dynamic. Hence, values of MZM are model projections during the simulation period.

on track. It appears that the rapid growth of mutual funds came largely at the expense of small time deposits, and that the zero-maturity distinction is an important and durable dividing line for aggregating monetary assets.

MZM also fares well when compared to the narrower aggregates. One factor that has recently been depressing growth in the narrow aggregates is the widespread emergence of sweep accounts. Banks are initiating these programs to economize on their reserves, which earn no return. These arrangements “sweep” excess household checkable deposits, which are reservable, into MMDAs (also of zero maturity), which are not reservable, thereby reducing a bank’s required reserves. Over the past few months, depository institutions have stepped up their efforts to initiate sweep programs, leading to sharp declines in checkable deposits and total reserves and thereby depressing both M1 and the monetary base. Because there is little or no reason to believe that the development of sweep accounts has had any measurable impact on aggregate economic activity, the related weakness in the narrow money measures is misleading. Since MZM includes MMDAs, the effects of the sweep program are internalized. Thus, MZM’s relationship to economic activity is unaffected.

VII. MZM as a Policy Guide

The estimated interest sensitivity of MZM demand has implications for the aggregate’s usefulness as a policy guide. For example, normal interest rate fluctuations over a business cycle may imply relatively sharp movements in the level of MZM demanded. When choosing monetary targets, policymakers typically attempt to project changes in money growth due to demand and set target ranges to accommodate such growth. Because interest rate changes are largely induced by unforeseen circumstances, it would be difficult, if not impossible, to anticipate the appropriate growth rate for MZM in the year ahead. Thus, the aggregate does not seem well suited to being a monetary target, particularly when real shocks to the economy result in desired changes in equilibrium interest rates.

Nevertheless, policymakers may find it useful to monitor MZM. Specifically, MZM could play an important *complementary* role in assessing the indicator properties of the other monetary aggregates, especially M2. Because MZM was immune to the effects of mutual fund development while M2 was not, we can reasonably infer that M2 weakness was largely a portfolio phenomenon—reflecting the substitution of mutual funds for time deposits—and not a signal of inherent weakness in the economy. Monitoring MZM thus allows us to gain some insight into potential problems associated with M2. Moreover, given the widespread implementation of sweep accounts, narrower aggregates such as M1 have become less reliable.

VIII. Conclusion

Deregulation and financial innovation have wreaked havoc on the relationship of traditionally defined money measures with economic activity and interest rates. Surprisingly, perhaps, we have found that an alternative measure of money, MZM, has endured these events quite well. Over the last 20 years, the aggregate has exhibited a stable relationship with nominal GDP and with its own opportunity cost.

Our estimated model of MZM demand is based on the framework proposed by MPS to estimate M2 demand. Out-of-sample predictions in the 1990s reveal that the MZM demand relationship is immune to innovations in the mutual fund industry that led to the demise of M2. In addition, because MZM includes MMDAs, it has not been affected by the advent of sweep accounts, which continue to confound the interpretation of narrower money measures such as M1 and the monetary base.

The relative stability of MZM demand tends to confirm Motley’s (1988) and Poole’s (1991) conjecture that zero maturity is an important theoretical distinction for determining which assets should be included in a measure of money. Interestingly, Poole invoked the “temporary abode of purchasing power” principle advocated by Milton Friedman, while Motley drew on the notion of “liquidity preference” proposed by Keynes. Nonetheless, both argue that zero-maturity instruments tend to be better insulated from the effects of deregulation and financial innovation.

We find that MZM demand is quite sensitive to changes in opportunity cost. This complicates MZM’s usefulness for policy purposes because policymakers may choose to accommodate such changes in demand. The upshot is that MZM is not particularly well suited to being an intermediate target. Nevertheless, it could play a complementary role in monitoring the other monetary aggregates.

Finally, we would like to acknowledge our own reservations about making too much out of empirical relationships estimated over spans of 20 years or less. Clearly, experience has shown that many macroeconomic relationships hold up well for such periods, only to break down miserably once they are taken seriously. What is different about our model of MZM demand is that it has endured a period of tumultuous change that laid waste to most other measures of the money supply.

References

Banerjee, A., et al. *Cointegration, Error-Correction, and the Econometric Analysis of Nonstationary Data.* New York: Oxford University Press, 1993.

Baumol, W.J. "The Transactions Demand for Cash: An Inventory Theoretic Approach," *Quarterly Journal of Economics,* vol. 66 (November 1952), pp. 545–56.

Collins, S., and C.L. Edwards. "An Alternative Monetary Aggregate: M2 Plus Household Holdings of Bond and Equity Mutual Funds," Federal Reserve Bank of St. Louis, *Review,* vol. 76 (November/December 1994), pp. 7–30.

Darin, R., and R.L. Hetzel. "A Shift-Adjusted M2 Indicator for Monetary Policy," Federal Reserve Bank of Richmond, *Economic Quarterly,* vol. 80, no. 3 (Summer 1994), pp. 25–47.

Duca, J.V. "Should Bond Funds Be Added to M2?" *Journal of Banking and Finance,* vol. 19, no. 1 (April 1995), pp. 131–52.

Engle, R.F., and C.W.J. Granger. "Cointegration and Error Correction: Representation, Estimation, and Testing," *Econometrica,* vol. 55, no. 2 (March 1987), pp. 251–76.

Friedman, M., and A. Schwartz. *Monetary Statistics of the United States: Estimates, Sources, and Methods.* New York: National Bureau of Economic Research, 1970.

Hoffman, D.L., and R.H. Rasche. "Long-run Income and Interest Elasticities of Money Demand in the United States," *Review of Economics and Statistics,* vol. 73, no. 4 (November 1991), pp. 665–74.

Johansen, S. "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control,* vol. 12, nos. 2/3 (June/September 1988), pp. 213–54.

Keynes, J.M. *The General Theory of Employment, Interest, and Money.* New York: Harcourt, Brace, and World, 1936.

Lucas, R.E., Jr. "On the Welfare Cost of Inflation," Center for Economic Policy Research, Publication No. 394, February 1994.

Miller, M.H., and D. Orr. "A Model of the Demand for Money by Firms," *Quarterly Journal of Economics,* vol. 80 (August 1966), pp. 413–35.

Miyao, R. "Does a Cointegrating M2 Demand Relation Really Exist in the United States?" *Journal of Money, Credit, and Banking,* vol. 28, no. 3 (August 1996), pp. 365–80.

Moore, G.R., R.D. Porter, and D.H. Small. "Modeling the Disaggregated Demands for M2 and M1: The U.S. Experience in the 1980s," in P. Hooper et al., eds., *Financial Sectors in Open Economies: Empirical Analysis and Policy Issues.* Washington, D.C.: Board of Governors of the Federal Reserve System, 1990, pp. 21–105.

Motley, B. "Should M2 Be Redefined?" Federal Reserve Bank of San Francisco, *Economic Review,* Winter 1988, pp. 33–51.

Orphanides, A., B. Reid, and D.H. Small. "The Empirical Properties of a Monetary Aggregate that Adds Bond and Stock Funds to M2," Federal Reserve Bank of St. Louis, *Review,* vol. 76, no. 6 (November/December 1994), pp. 31–51.

Poole, W. Statement before the Subcommittee on Domestic Monetary Policy of the Committee on Banking, Finance, and Urban Affairs, U.S. House of Representatives, November 6, 1991.

Porter, R.D., T.D. Simpson, and E. Mauskopf. "Financial Innovation and the Monetary Aggregates," *Brookings Papers on Economic Activity,* vol. 1, no. 79 (1979), pp. 213–29.

Tobin, J. "Liquidity Preference as a Behavior Towards Risk," *Review of Economic Studies,* vol. 25 (1958), pp. 65–6.

Whitesell, W.C., and S. Collins. "A Minor Redefinition of M2," Board of Governors of the Federal Reserve System, *Finance and Economics Discussion Series,* No. 96-7, February 1996.