SHORT-RUN MONEY DEMAND

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ABSTRACT

The conventional wisdom holds that the short-run demand for money is unstable. This paper challenges the conventional view by finding a stable demand for M1 in U.S. data from 1959 through 1993. The approach follows previous work in interpreting long-run money demand as a cointegrating relation, and it uses Goldfeld's partial-adjustment model to interpret short-run dynamics. The key innovation is the choice of the interest rate in the money demand function. Most previous work uses a short-term market rate, but this paper uses the average return on "near monies"--the savings accounts and money market mutual funds that are close substitutes for M1. This choice helps rationalize the behavior of money demand; in particular, the increase in the volatility of velocity after 1980 is explained by increased volatility in the returns on near monies.

Once, many economists believed that the demand for money was stable and well-understood. The highwater mark for money-demand research was Goldfeld (1973), which explained the long-run demand for M1 with interest rates and output, and captured short-run dynamics with a partial-adjustment model. Since then, other studies have confirmed that long-run money demand is stable (e.g. Hoffman and Rasche, 1991; Stock and Watson, 1993). However, Goldfeld's short-run model broke down in the mid-1970s and efforts to repair it were unsuccessful (Goldfeld and Sichel, 1990). In addition, the velocity of M1 began to fluctuate erratically in the early 1980s. Over the last thirty years, most economists have concluded that the short-run behavior of money demand is unstable and mysterious.

Poole (1970) teaches that the proper role of M1 in monetary policy depends on the stability of short-run money demand. Evidence of instability led the Federal Reserve to de-emphasize M1 targets in 1982 and to stop publishing the targets in 1986. Through most of the 1990s and 2000s, the Fed has essentially ignored the money supply and set interest rates based on output and inflation.

This paper questions today's conventional wisdom about money demand. It argues that there is in fact a stable money demand function that explains short-run as well as long-run movements in velocity. This finding suggests that policymakers should reexamine the role of the money supply in monetary policy.

In deriving a stable money-demand function, I build on ideas from past work. Following Hoffman and Rasche and Stock and Watson, I interpret long-run money demand as a cointegrating relation among real M1, interest rates, and output. To explain short-run deviations from this relation, I return to Goldfeld's partial-adjustment model.

There is one crucial innovation in my approach: the choice of the interest rate in the money demand function. Past studies generally use a short-term market rate, such as the Treasury bill rate or the commercial paper rate. I use instead the average return on "near-monies"--the savings accounts and money market mutual funds that are close substitutes for M1. Short-run fluctuations in money holdings are closely tied to movements in near-money returns.

This paper examines quarterly data for the United States from 1959 through 1993. I end the sample in 1993 because banks introduced "sweep" programs in 1994; as detailed below, this innovation has made official data on M1 unreliable. My sample period is an interesting one because it contains the 1970s and 1980s, when the money-demand function appeared to break down.

Section II of this paper briefly reviews the history of thought on money demand. We see how a once-booming academic literature withered as researchers failed to find a stable money demand function. We also see how the instability of velocity has led the Federal Reserve to stop paying attention to the money supply.

Section III introduces the returns on near monies, defined as money market mutual funds and savings accounts (including money market deposit accounts). These assets are arguably the closest substitutes for M1, as they are included in M2 and have zero maturities. Section III also shows informally how near-money returns can explain the behavior of velocity. The average return on near monies grew smoothly until 1981 and then began to fluctuate, reflecting deregulation and financial innovation. The velocity of M1 followed a strikingly similar path.

Section IV estimates long-run money demand functions. Long-run money demand is stable regardless of whether the interest rate is measured by the return on near monies or a money-market rate (the Treasury-bill rate). However, the deviations of money holdings from their long-run level are smaller with the return on near monies. With this interest rate, there is less variation that must be explained by a model of short-run dynamics.

Section V interprets deviations from long-run money demand with Goldfeld’s partial adjustment model. When the interest rate is the return on near monies, the model yields reasonable parameter estimates, and it is not rejected in favor of a less structured error-correction model. Most important, the deviations of money holdings from the predictions of the model are small. There is little evidence of shifts in the money demand function, even in the short run.

Section VI revisits the history of money-demand research in light of this paper's findings. Section VII discusses policy implications and directions for future research.

II. A BRIEF HISTORY

This section reviews the intertwined histories of research on money demand, shifts in the velocity of M1, and the role of money in Federal Reserve policy.

A. The Money-Demand Literature

A large literature in the 1960s and 70s sought an equation for money demand that fit U.S. data. Goldfeld (1973) declared success: his central finding was "the apparent sturdiness of a quite conventional formulation of the money demand function, however scrutinized." In Goldfeld's specification, the long-run demand for real balances depends on aggregate output and one or more short-term interest rates. Money holdings adjust toward their long-run level at an estimated rate of 20-30% per quarter.

Just three years later, Goldfeld (1976) reported a failure of his specification: the "case of the missing money," in which the money demand equation greatly overpredicted the growth of M1. Further research uncovered another problem: when the sample period was extended to 1979 or later, the estimated adjustment speed of money holdings was close to zero (Goldfeld and Sichel, 1990).

These findings set off "The Search for a Stable Money Demand Function" (the title of Judd and Scadding, 1982). Researchers explored a plethora of specifications with different measures of the key variables, different functional forms, generalizations of the partial adjustment model, dummy variables for financial innovation, and so on. Yet the search was unsuccessful. When Goldfeld and Sichel surveyed the literature in the 1990 ***Handbook of Monetary Economics***, they reported "recurring bouts of instability in money demand" that remained unexplained.

Since then, researchers have found stable specifications for *long-run* money demand, but research on short-run money demand has made little progress. By the mid-1990s, Goldfeld's partial adjustment model was "largely abandoned" (Hoffman et al., 1995). A few papers estimated non-parsimonious error-correction models (e.g. Baba et al., 1992), but this approach did not catch on. When the ***Handbook of Monetary Economics*** was updated in 2011, no chapter included more than a passing reference to the money-demand literature.

B. Velocity Fluctuations and Fed Policy

Generally, academic research on money demand has not influenced monetary policy immediately. During the late 1970s, researchers were becoming convinced that money demand is unstable, a conclusion that argues against money targeting by the Federal Reserve. Yet it was October 1979 when the Fed began its "monetarist experiment," adopting operating procedures with a central role for M1 targets.

Why did policymakers in 1979 believe that M1 targeting was a reasonable policy? We can see the answer in Figure 1, which presents annual data on the velocity of M1 (that is, the ratio of nominal GDP to M1). Until 1981, velocity followed a smooth upward path. This fact suggested that a steady growth rate for M1 would produce steady growth in nominal GDP, a desirable outcome. Before 1981, the problems that caused the breakdown in Goldfeld's money demand equation were too subtle to show up in the broad behavior of velocity. To the naked eyes of policymakers, money demand looked sufficiently stable to justify money targeting.

Figure 1 also shows why policymakers lost faith in money targeting. In 1982, velocity stopped rising and started to fluctuate erratically. According to Friedman (1988), the relationship between M1 and nominal GDP "utterly fell apart." Historical accounts attribute this instability to shifts in money demand that are "mostly unexplained" (Mankiw, 1997).

This experience led the Federal Reserve to retreat from monetarism in several steps. In 1982, it reversed the 1979 change in operating procedures and de-emphasized its M1 targets. In

1986, it stopped publishing the targets. By the 1990s, policymakers were ignoring money entirely. In his memoir about serving on the Federal Reserve Board, Laurence Meyer (2004) says "we can tell the story about monetary policy without referring to what happens to the money supply."

Because the Fed lost interest in money, it has not adjusted the measurement of M1 to keep up with financial innovation. In particular, the Fed's M1 series does not account for "sweep" programs, in which banks move funds temporarily from demand deposits to money market deposit accounts. Banks began this practice in 1994 for the purpose of circumventing reserve requirements. Swept funds are not included in M1, but they should be: they are shifted back to demand deposits when a depositor wants to use them, so they are just as liquid as demand deposits (Dutkowsky and Cynamon, 2003). Cynamon et al (2012) estimate that the level of M1 in 2010 would have been 43 percent higher if swept funds were included.

The Fed's definition of M1 also ignores media of exchange developed in the information-technology age. These new monies include balances on stored value cards and electronic money such as PayPal accounts. In contrast, M1 *does* include traveler's checks, an archaic instrument that is essentially a paper version of stored value cards.

C. The Role of Interest Rates

The velocity fluctuations of the 1980s are often described as a complete mystery, but this has always been an exaggeration. We can get partway to an explanation for velocity behavior by examining money-market interest rates--the rates typically included in money demand equations. Figure 2 makes this point by comparing the paths of M1 velocity and the Treasury-bill rate (R^{TB}).

Figure 2 shows, first, that the shift in the long-run trend of velocity--from positive through 1981 to slightly negative--coincides with a shift in the trend of the T-bill rate. The natural interpretation is that the downward shift in the interest-rate path raised the quantity of money demanded, and therefore reduced velocity. This interpretation is confirmed by econometric work on long-run money demand, which finds a stable relation among the trends in real balances, output, and the T-bill rate (e.g. Hoffman-Rasche, Stock-Watson, and Ball, 2001).

In addition, the T-bill rate helps explain the short-run fluctuations in velocity after 1981. Velocity fell in 1982-83 (the "velocity shock" of the Volcker era), rose in 1984, fell sharply in 1985-87 (ending the publication of M1 targets), and so on. These velocity shifts are matched almost exactly by changes in the T-bill rate: only in 1990 do the two variables move in opposite directions. Thus, for the period from 1981 to 1993, one can interpret most changes in velocity as movements along a money demand curve caused by interest-rate changes. There is no need to invoke unexplained shifts in the curve.

However, Figure 2 also shows the problem with this story: it does not fit the period before 1981. The T-bill rate fluctuated a lot in the late 1960s and 70s as well as the 80s. If the T-bill rate affects velocity, velocity should have started fluctuating much earlier. Instead, movements in the T-bill rate did not disturb the smooth velocity trend until the early 80s, when something seems to have changed. The experience before 1981 explains why the 80s were surprising: economists were not used to seeing velocity respond to interest-rate movements.

III. THE RETURN ON NEAR MONIES

This section presents my definition of near monies and shows informally how the returns on near monies explain the otherwise-puzzling behavior of velocity.

A. Defining Near Monies and Their Average Return

What interest rates affect money demand? Most studies use market interest rates such as the T-bill rate or the commercial paper rate. In theory, however, the demand for an asset should depend most strongly on the returns on close substitutes for the asset. The demand for M1 should depend on the returns on near monies--highly liquid assets that are close substitutes for M1.

In defining near monies, a natural starting point is the set of assets included in M2 but not M1. These assets are savings deposits, which include both traditional savings accounts and money market deposit accounts; time deposits; and retail money market mutual funds. The Federal Reserve puts these items in M2 because it considers them close substitutes for M1.

We can refine the definition of near monies by looking within the non-M1 part of M2. All assets in this category have zero maturity--they can be liquidated almost immediately--except for time deposits. Time deposits are less liquid than zero-maturity assets, and hence less perfect substitutes for M1. This fact has led some researchers to de-emphasize the M2 aggregate in favor of M2 less time deposits--"zero maturity money," or MZM (Motley, 1988; Carlson and Byrne, 1992). In the same spirit, I exclude time deposits from my definition of near monies. Near monies are defined as the non-M1 components of MZM, or equivalently the non-M1 components of M2 except time deposits.[1]

With this definition, the components of near monies are savings accounts and money market mutual funds. The Federal Reserve maintains quarterly series on the quantities of these assets and their returns. For each quarter, I measure the overall return on near monies with an average of the returns on savings

[1] Carlson and Byrne's definition of MZM includes an additional asset that is not part of M2: institutional money market funds. To be conservative, I exclude these funds from my definition of near monies.

accounts and money market funds, weighted by the shares of each asset in total near money. As we will see, these shares change greatly over time; nonetheless, the series that I construct is a consistent measure of the average return on close substitutes for M1.[2]

The opportunity cost of holding M1 rather than a near money is the difference between these assets' returns. The returns on M1 are zero before 1973 but slightly positive thereafter, because some demand deposits pay interest. In the analysis below, I assume that money demand depends on the average return on near monies (R^{NM}) minus the average return on M1 (R^{M1}). The results are similar when I do not subtract the return on M1.

B. Near-Money Returns and Velocity

Figure 3 compares the paths of velocity and of the opportunity cost of holding M1, which I denote $R^{OP} = R^{NM} - R^{M1}$. In contrast to the Treasury bill rate, R^{OP} can explain velocity behavior both before and after 1981. After 1981, R^{OP} fluctuates along with the T-bill rate. Before 1981, it follows the upward trend of the T-bill rate, but its path is smoother. This pattern--a steady rise through 1981 and then fluctuations--matches the behavior of velocity. Thus the increase in the volatility of velocity can be explained by increased volatility

[2] Data series for returns on the different components of M2 were first developed at the Federal Reserve Bank of Richmond (see Hetzel, 1989).

in R^{OP}.

What accounts for the behavior of R^{OP}? To help answer this question, Figure 4 presents R^{NM} and R^{M1}, the returns on near monies and on M1. The Figure also shows the two interest rates that determine R^{NM}, the rates on savings accounts and on money market funds. Finally, the Figure shows the share of money market funds in total near money, which determines how the two interest rates are weighted.

The story behind Figure 4 is a familiar one. Before 1979, near monies were almost entirely savings accounts. The Fed's Regulation Q placed ceilings on the interest rates that these accounts could pay. Over the 1960s and 70s, market interest rates trended upward, and the ceilings on savings rates were increased periodically to keep up. But Regulation Q prevented savings rates from responding to short-run fluctuations in market rates.

The nature of near monies changed rapidly in the late 1970s and early 80s. Money market mutual funds were invented in 1971 and took off between 1978 and 1982, growing from 1 percent of near monies to 34 percent. Money market funds gained popularity because their interest rates followed the Treasury-bill rate, which was rising rapidly.

Fearing disintermediation, Congress sought to keep savings accounts competitive with money market funds. Starting with the Monetary Control Act of 1980, Regulation Q was phased out. A key step was the Garn-St. Germain Act of 1982, which authorized money market deposit accounts, a new kind of savings account that was "directly equivalent to and competitive with money market mutual funds." As we see in Figure 4, this action partly reversed the rise of money market funds. Finally, in 1986, interest rate ceilings were eliminated for all types of savings accounts.

In sum, from 1979 to 1986, two changes influenced the returns on near monies. The first was the growth of money market mutual funds, whose interest rates follow market rates closely. The second was deregulation, which made savings-account rates more responsive to market rates than they were before. Together, these changes explain the volatility of near-money returns after 1981.

Figures 3 and 4 tell us that deregulation and financial innovation were the underlying causes of the post-1981 instability in velocity. Many past researchers point to the same factors (e.g. Goldfeld and Sichel, 1990). However, past authors usually suggest that deregulation and innovation caused a breakdown in the money demand function. In contrast, I interpret these developments as causing changes in the behavior of interest rates, and hence movements along a stable money demand curve.

IV. DEVIATIONS FROM LONG-RUN MONEY DEMAND

This section estimates a long-run money demand equation. I confirm previous findings that such an equation is stable in the sense that real balances, income, and an interest rate are cointegrated. This result holds regardless of whether the interest rate is the T-bill rate or the return on near moneys. As discussed by Hoffman et al. (1995), the choice of an interest rate is not critical for studies of long-run money demand, because most interest rates have similar long-run trends.

After estimating long-run money demand, I examine short-run departures from this relation. Here, the choice of an interest rate matters greatly. The deviations of money holdings from their long run level are smaller when the interest rate is the return on near monies.

A. Long-Run Equations

Following Stock and Watson (1993) and Ball (2001), I estimate money demand functions of the form

$$(1) \qquad m - p = \alpha + \theta_y y + \theta_R R + \varepsilon ,$$

where m is the log of M1, p is the log of the GDP deflator, y is the log of real GDP, R is the level of an interest rate, and ε is an error term. θ_y is the long-run income elasticity of money demand and θ_R is the interest-rate semi-elasticity.

I first consider equation (1) with the Treasury-bill rate, R^{TB}, as the interest rate. For the period 1959Q2 through 1993Q4, the Johansen test with two or four lags rejects non-cointegration among m-p, y, and R^{TB} at the one percent level. Thus we can interpret (1) as a cointegrating relation and ε as a stationary error term.

Because (1) is a cointegrating relation, one can estimate its parameters with Stock and Watson's (1993) dynamic OLS estimator (DOLS). Table I presents the results: the income elasticity θ_y is 0.53, and the interest rate semi-elasticity θ_R is -0.40. These estimates are close to those of Ball (2001) and Dutkowsky and Cynamon (2001).

I now replace the T-bill rate in equation (1) with R^{OP}, the difference between the return on near monies (R^{NM}) and the return on M1 (R^{M1}). The Johansen test rejects non-cointegration of m-p, y, and R^{OP} at the one percent level with two lags and at the five percent level with four lags. The DOLS estimate of θ_y is 0.47, and the estimate of θ_R is -0.82. (The results are similar if I use R^{NM} as the interest rate without subtracting R^{M1}.)

Notice that the interest-rate coefficient when $R=R^{OP}$ is roughly twice as large as the coefficient when $R=R^{TB}$. This result reflects the fact that long-run movements in R^{OP} are smaller than movements in R^{TB}. For example, R^{OP} rises by 4.5 percentage points from 1960 to 1981, while R^{TB} rises by 11.1 points. With R^{OP}, a given change in real balances is explained by a smaller change in the interest rate, implying a larger coefficient.

B. Deviations from the Long-Run Equation

The results so far do not tell us whether a money demand function can explain quarter-to-quarter or year-to-year movements in real balances. These movements might be predicted by the long-run equation (1), or they might be deviations from this equation. In the latter case, we need an additional model of short-run dynamics to understand the data.

To see how much equation (1) explains, I examine the path of real balances that it implies, given the paths of output and interest rates. This path is given by

$$(2) \qquad (m-p)^* = \alpha' + \theta_y' y + \theta_R' R ,$$

where ′ denotes an estimate. θ_y' and θ_R' are DOLS estimates, and α' is the mean of $(m-p)-\theta_y' y-\theta_R' R$. The quantity $(m-p)^*$ is an estimate of the long-run equilibrium level of real balances. To interpret the results, I also compute "equilibrium velocity," defined as $v^* \equiv y-(m-p)^*$. I compare v^* to the actual path of velocity v.

Figure 5 presents the results. The top panel compares v to v^* when the interest rate is R^{TB}, and the bottom panel does the same for R^{OP}. The levels of v and v^* are usually closer in the second case. The average value of $(v-v^*)^2$ is 3.6×10^{-3} for R^{TB} and 1.4×10^{-3} for R^{OP}. Thus the use of R^{OP} reduces the apparent size of short-run velocity fluctuations around the equilibrium level.

The choice of interest rate makes the greatest difference for the period before 1981. For this subsample, the average value of $(v-v^*)^2$ is more than three times larger with R^{TB} than with R^{OP}.

As shown above in Figures 2-3, R^{TB} fluctuated substantially before 1981. The swings in R^{TB} imply corresponding swings in equilibrium velocity, but the actual path of velocity was smooth. R^{OP} grew more smoothly than R^{TB}, and thus produces a v^* path that more closely matches v.

The results for R^{OP} suggest again that money demand is not very mysterious. The increased volatility of velocity after 1980 corresponds to increased volatility in v^*. Indeed, the "velocity shock" of 1981-82, the episode that discredited money targeting, is ***over***-explained by the long-run money demand function. Given the sharp fall in R^{OP} over 1981-82, v^* falls even more than v. Overall, the long-run equation explains much of the velocity behavior that has puzzled researchers.

V. A PARTIAL ADJUSTMENT MODEL

The previous section shows that a long-run money demand equation explains much of the behavior of velocity over 1959-1993. Here I go a step farther and explore deviations from the long-run relation. It turns out that Goldfeld's (1973) partial adjustment model explains most of these deviations. Once again, the choice of an interest rate is crucial for the results.

A. The Behavior of Nominal Money

To motivate the partial-adjustment model, I first examine the data from a new angle. Figure 6 shows the path of nominal money, m. It also shows the path of money implied by the long-run money demand function with $R=R^{OP}$. This path is $m^* = (m-p)^* + p$, where $(m-p)^*$ is given by equation (2). Note that the deviations of actual from equilibrium money, $m-m^*$, are the same as the velocity deviations $v-v^*$ examined above. However, comparing m and m^* provides intuition about the behavior of short-run money demand.

Specifically, in Figure 6, actual money m appears to be a smoothed version of equilibrium money m^*. The two variables follow the same upward trend, but m fluctuates less: the variance of the change in m is $1.1x10^{-4}$, compared to $4.0x10^{-4}$ for the change in m^*. Thus the differences between actual and equilibrium money do ***not*** appear to reflect short-run shifts in money demand, which would cause m to fluctuate around m^*. Instead, there seems to be some stickiness in m. Partial-adjustment models are designed to explain such behavior.

B. The Model

I assume that money holdings differ from m^*, the long-run equilibrium level, for two reasons. First, there are transitory shocks to desired money holdings arising from shifts in tastes or technology. Desired money holdings are $m^*+\eta$, where η follows a stationary process with zero mean.

Second, actual money holdings do not adjust fully to the desired level. Current m depends partly on $m^*+\eta$ and partly on lagged m:

(3) $$m = k + \mu(m^{*}+\eta) + (1-\mu)m_{-1}\ , \quad k>0,\ 0<\mu<1\ .$$

Equation (3) is optimal if agents suffer quadratic losses from changes in m and from deviations of m from $m^{*}+\eta$. The parameter μ is the speed of adjustment of money holdings. The constant k arises because m^{*} has a positive trend (see Nickell, 1985).

To estimate this model, I assume that the shock η follows an AR-2 process: $\eta = \rho_1\eta_{-1}+\rho_2\eta_{-2}+\nu$. Quasi-differencing equation (3) leads to

(4) $$m = k(1-\rho_1-\rho_2) + (1-\mu+\rho_1)m_{-1} + (\mu\rho_1-\rho_1+\rho_2)m_{-2}$$
$$- (1-\mu)\rho_2 m_{-3} + \mu(m^{*} - \rho_1 m^{*}_{-1} - \rho_2 m^{*}_{-2}) + \mu\nu\ .$$

There are four parameters of short-run money demand: μ, k, ρ_1, and ρ_2.

Following Duca (2000), I estimate equation (4) with both one-step and two-step methods. In the two-step case, I use the series for m^{*} constructed from the DOLS regression and estimate the parameters of (4) by non-linear least squares.[3] In the one-step case, I use the long-run money demand function to write m^{*} in terms of p, y, and R. Then I jointly estimate the parameters of (4) and the parameters of long-run money demand (except the constants k and α, which are not separately identified).

Table II presents the results. In the two-step case, the

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[3] DOLS estimates of long-run parameters are super-consistent. Thus these parameters can be treated as known in the second-step regression (there is no generated-regressor problem).

estimate of the adjustment parameter μ is 0.20. Thus money holdings adjust 20% toward the optimal level in one quarter and 59% in a year. This adjustment speed is close to estimates from the heyday of partial adjustment models (e.g. Goldfeld, 1973). The transitory money demand shocks have substantial serial correlation (ρ_1=0.54 and ρ_2=0.21).

The one-step procedure produces similar estimates of the short-run parameters. In addition, the long-run income and interest-rate coefficients are close to the DOLS estimates in Table I.

Once again, the use of R^{OP} is important for the results. When the model is estimated with R^{TB} as the interest rate, the adjustment speed is only 0.08. This result reflects the fact that R^{TB} fluctuates before 1980 but velocity is steady, which suggests very slow adjustment.

C. Another Look at Velocity Fluctuations

To evaluate the model's fit, note first that the variance of $\mu\eta$, the error in the partial adjustment equation (3), is $1.7\text{x}10^{-4}$ (for the two-step estimates). This is only 12% of the variance of $m-m^*$, the deviation of money from its long-run equilibrium. Thus slow adjustment rather than unexplained shocks to money demand explain most of $m-m^*$.

Figure 7 compares the path of velocity to the path predicted by the model. The predicted path is derived from the partial-adjustment equation (3) with the η's set to zero and the parameters given by two-step estimates. For the first observation (1959Q2), I use the actual value of lagged m in (3); for the other observations, I use the predicted m from the previous period. Given the initial m_{-1} and the series for m^*, the predicted path shows how velocity would have evolved if there were no shocks to desired money holdings and m adjusted to m^* at the estimated rate. The Figure shows that predicted and actual velocity are usually close to one another.

Figure 7 helps us understand some famous historical episodes, notably the fall in velocity in 1981-82. Recall from Figure 5 that the long-run money demand equation predicts a larger velocity fall than the one that actually occurred. In contrast, the predicted velocity path in Figure 7 matches the actual path almost perfectly over 1981-82. Slow adjustment explains why actual velocity fell less than equilibrium velocity when interest rates fell.

The partial adjustment model also helps explain other episodes. The sharp fall in velocity over 1985-87 is mostly predicted by the model. The model does not fully resolve the "missing money" puzzle of the late 1970s: actual velocity drifts above predicted velocity during that period. However, one can interpret this episode as a moderate-sized, transitory shock to money demand, not a breakdown of the money-demand relation.

D. Partial Adjustment vs. Error Correction

After Goldfeld's partial adjustment model broke down, efforts to repair it were unsuccessful, and by 1990 the model was "largely abandoned" (Hoffman et al., 1995). Since then, the few researchers who have studied short-run money demand have estimated error-correction models (e.g. Baba et al., 1992; Duca, 2000). These models impose few theoretical restrictions: they assume that money eventually moves toward its equilibrium level, but they allow arbitrary effects of many variables on money growth.

This paper aims to revive the partial adjustment model. Thus it is natural to ask whether the model's assumptions fit the data. The partial adjustment model is a special case of an error-correction model: it includes the same variables, but it imposes restrictions across the coefficients. Here I test these restrictions.

To see the relation between partial-adjustment and error-correction models, rearrange equation (4) to obtain

$$\Delta m = k(1-\rho_1-\rho_2) + \mu(1-\rho_1-\rho_2)(m^*_{-1}-m_{-1}) + (\rho_1-\mu\rho_1-\mu\rho_2)\Delta m_{-1} + (1-\mu)\rho_2\Delta m_{-2} + \mu\Delta m^* + \mu\rho_2\Delta m^*_{-1} + \mu\nu \ . \quad (5)$$

Using the definition of m^*, this becomes

$$\Delta m = k(1-\rho_1-\rho_2) + \mu(1-\rho_1-\rho_2)(m^*_{-1}-m_{-1}) + (\rho_1-\mu\rho_1-\mu\rho_2)\Delta m_{-1} + (1-\mu)\rho_2\Delta m_{-2} + \mu\Delta p \quad (6)$$

$$+ \mu\rho_2\Delta p_{-1} + \mu\theta_y'\Delta y + \mu\rho_2\theta_y'\Delta y_{-1} + \mu\theta_R'\Delta R$$
$$+ \mu\rho_2\theta_R'\Delta R_{-1} + \mu\nu \ .$$

Equation (6) is an error-correction model: the change in m depends on an error-correction term ($m^*_{-1}-m_{-1}$), lags of the change in m, and current and lagged changes in p, y, and R. However, once θ_y' and θ_R' are set at DOLS estimates, the ten coefficients in (6) are determined by only four parameters (k, μ, ρ_1, and ρ_2). Thus the partial adjustment model places six restrictions on the error-correction model.

A test of the partial adjustment model based on sums of squared residuals yields an F statistic of 0.7, with a p-value above 0.5. Thus the partial adjustment model fits the data. We need not accept the lack of parsimony in error-correction models.

Once again, the choice of an interest rate is crucial to the results. I have also tested the partial adjustment model when the interest rate is the Treasury bill rate rather than R^{OP}. In this case, the F statistic is 7.6 ($p<0.01$), so the model is rejected.

VI. REVISITING THE 1970S LITERATURE

As a final exercise, I revisit the history of money-demand research--in particular, the apparent breakdown of Goldfeld's model in the 1970s. This paper has shown that the model fits the data from 1959 through 1993 if we measure the interest rate with R^{OP}. Does this result mean that the problems encountered by

Goldfeld and other researchers were due solely to inappropriate choices of interest rates? If R^{OP} had been the standard interest rate in money-demand equations, would money demand have appeared well-behaved in the 1970s?

To address these questions, I estimate this paper's money demand equation, (4), for three sample periods that end in the 1970s. Specifically, all the samples begin in 1959Q2, and they end in 1973Q2, 1976Q2, and 1979Q3. These end dates match the ends of samples in three Goldfeld papers: the 1973 paper that reports stable money demand; the missing money paper of 1976; and the Goldfeld-Sichel Handbook chapter from 1990. For each sample, I measure the interest rate with R^{OP} and use both one-step and two-step methods to estimate the model.

Table 3 presents the results, which reveal instability reminiscent of the 1970s literature. For the sample ending in 1973Q2, the one-step estimates are broadly believable. However, for the longer sample periods--which add 12 or 25 quarters--the one-step estimates go haywire. The adjustment speed μ is close to zero, and the output and interest-rate coefficients are essentially not identified: the point estimates are huge but the standard errors are even larger.

Making matters worse, the two-step estimates differ greatly from the one-step estimates. The two-step estimates are within the reasonable range when the sample ends in either 1973Q2 or

1976Q2 (although the longer sample produces a much larger interest-rate coefficient and a much smaller adjustment speed). When the sample ends in 1979Q3, the income and interest-rate coefficients are statistically insignificant. Overall, the results are non-robust across estimation procedures as well as sample periods.

Viewed in isolation, these results confirm the conventional wisdom that the money demand function broke down in the 1970s--even if the interest rate is measured by R^{OP}. Yet we have seen that data from 1959 through 1993 produce a stable money demand equation with only modest residuals in the 1970s. Looking back from 1993, there is no sign of a major breakdown in money demand. Instead, I interpret Table 3 as showing that samples ending in the 1970s contain too little information to estimate money demand reliably.

This interpretation is suggested by Stock and Watson's (1993) study of long-run money demand. These authors point out the fact that output and interest rates have similar upward trends before 1982. As a result of this collinearity, Stock and Watson's data (which end in 1986) "contain quite limited information about long-run money demand." Stock and Watson find that different estimation techniques produce different results, as I do in Table III. Generally, Stock and Watson's estimates of money-demand parameters are highly imprecise. In some cases the asymptotic standard errors are small, but Monte Carlo experiments discredit these standard errors.

Ball (2001) estimates long-run money demand with the same methods as Stock and Watson, but extends the sample period into the 1990s. With a longer sample, Ball obtains reasonable and precise estimates of long-run money demand parameters. The extra observations are important because they cover a period in the late 1980s and early 90s when interest rates fell, breaking the collinearity between interest rates and output. The same observations are the reason that this paper can pin down money demand with data through 1993, but not data ending in the 1970s.

In sum, the data through 1993 point to a stable money demand function, but it was not possible for researchers in the 1970s or early 80s to discover this relation. Ironically, the negative results of studies in the 70s and 80s led many economists to despair of finding a stable money demand function. By the time enough data accumulated to estimate money demand, research on the subject had largely died out.

VII. CONCLUSION

This paper estimates a long-run money demand function and interprets deviations from this relation with a partial adjustment model. The interest rate in the money demand function is the average return on near monies--savings accounts and money market mutual funds. The model explains most of the behavior of M1 from 1960 through 1993. The money demand function does not break down in the 1970s, and the volatility of velocity after 1980 is explained by volatility in the return on near monies.

Future research should extend this paper’s analysis from 1993 to the present. This will require adjustment of the M1 data to account for financial innovation, especially the sweep programs that banks introduced in 1994. The Federal Reserve does not report balances in sweep accounts, but Dutkowsky and Cynamon (2003) show how to estimate them from flows into the accounts.

Future research should also address the role of money in monetary policy. Today most economists believe that central banks should set interest rates with little regard to monetary aggregates (except possibly at the zero bound on interest rates). This consensus, however, is based on the view that money demand is unstable. My finding that M1 demand is well-behaved suggests that we should reopen the policy question.

Understanding money demand may also be useful when a central bank “unwinds” a policy of zero interest rates and quantitative easing (as the Federal Reserve will presumably do at some point). The money demand function can tell the central bank how much it must shrink the money supply to raise interest rates above zero. This information, along with the money multiplier, determines how much the central bank must reduce the monetary base.

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Figure 1

M1 Velocity

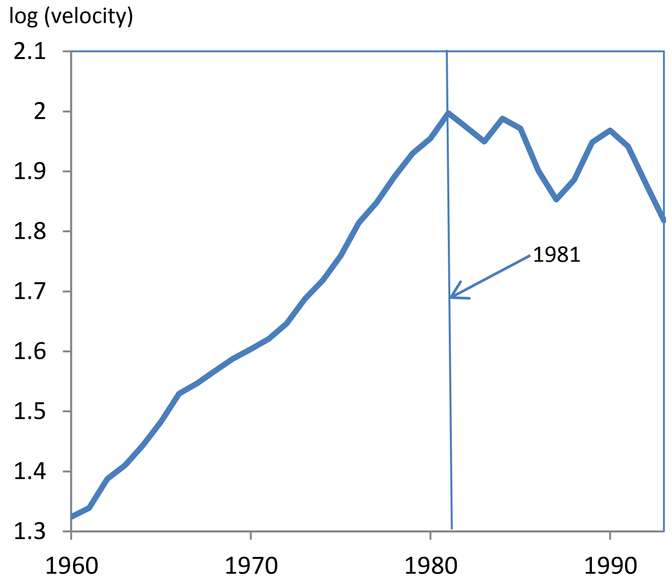


Figure 2

Velocity and the Treasury-Bill Rate

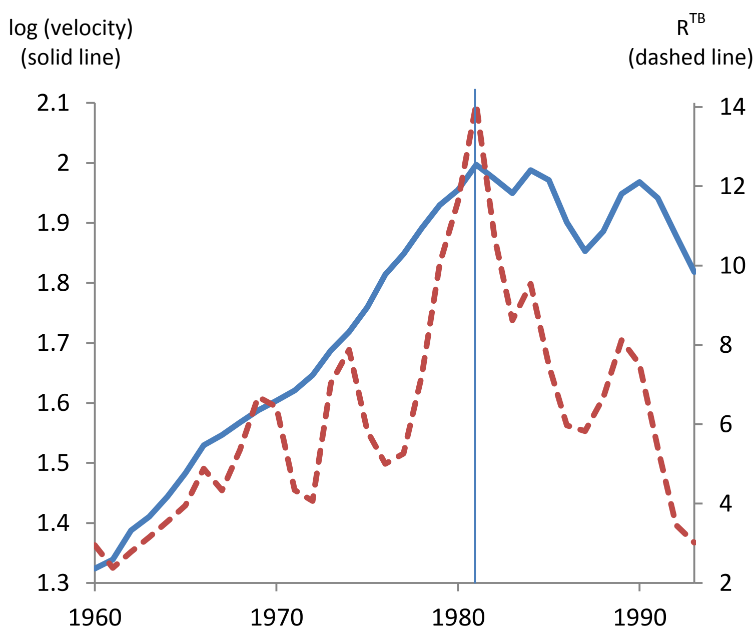


Figure 3

Velocity and the Cost of Holding M1 (R^{OP})
($R^{OP} = R^{NM} - R^{M1}$)

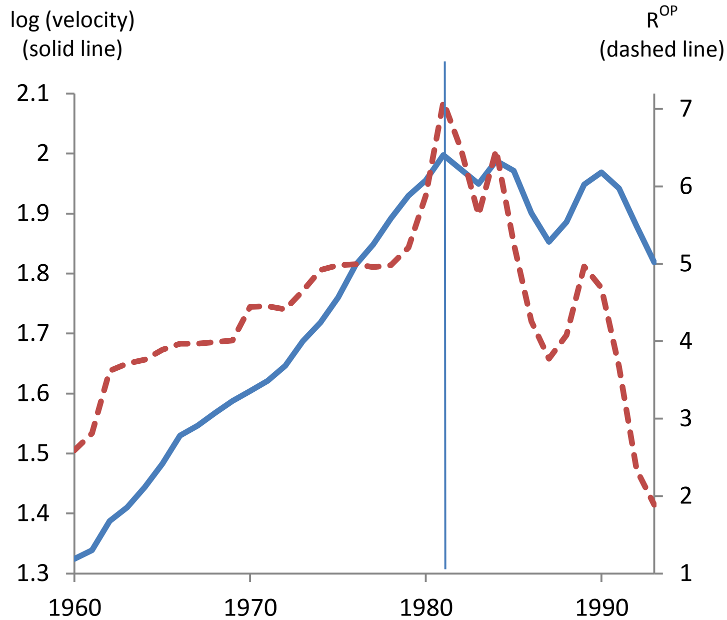
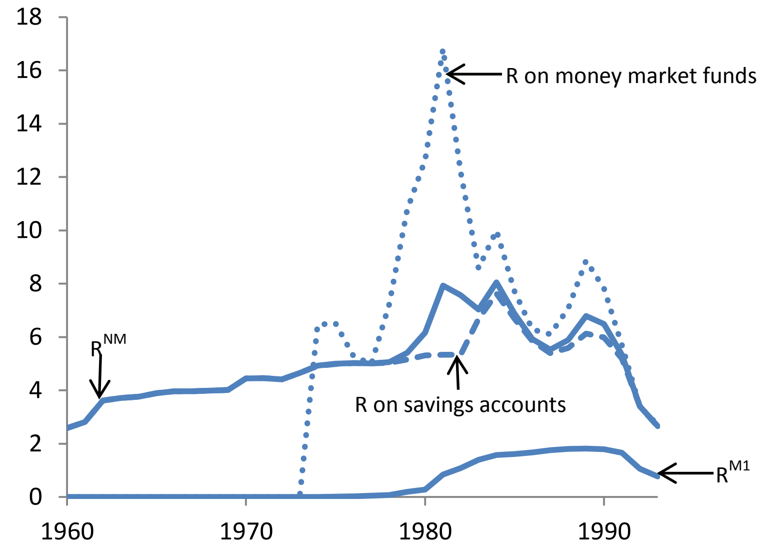


Figure 4

Individual Interest Rates



Money Market Funds as a Share of Near Monies

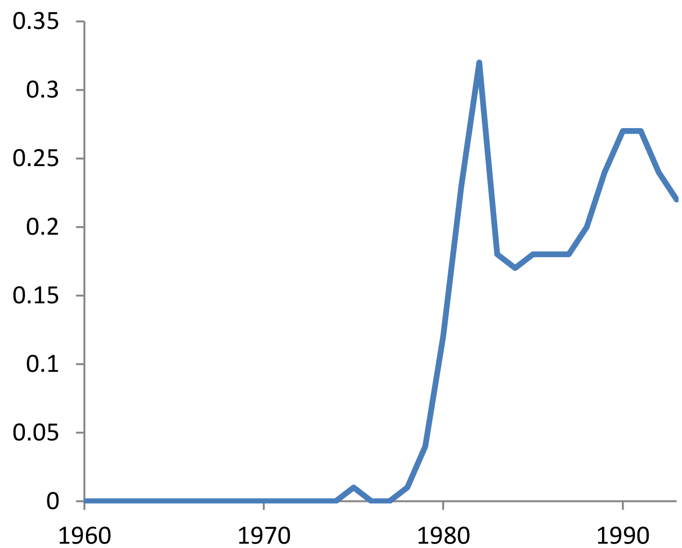
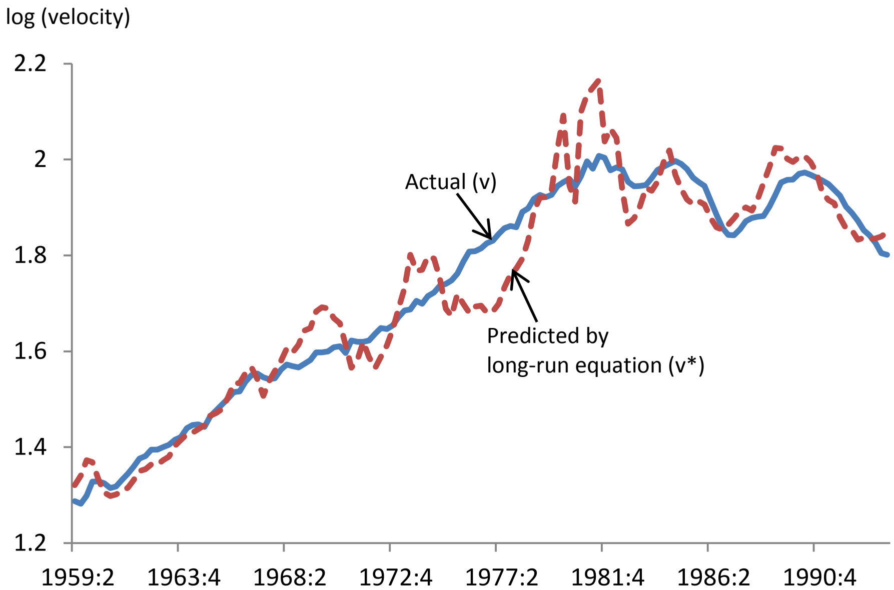


Figure 5

Velocity Fluctuations and Long-Run Money Demand

$R = R^{TB}$



$R = R^{OP}$

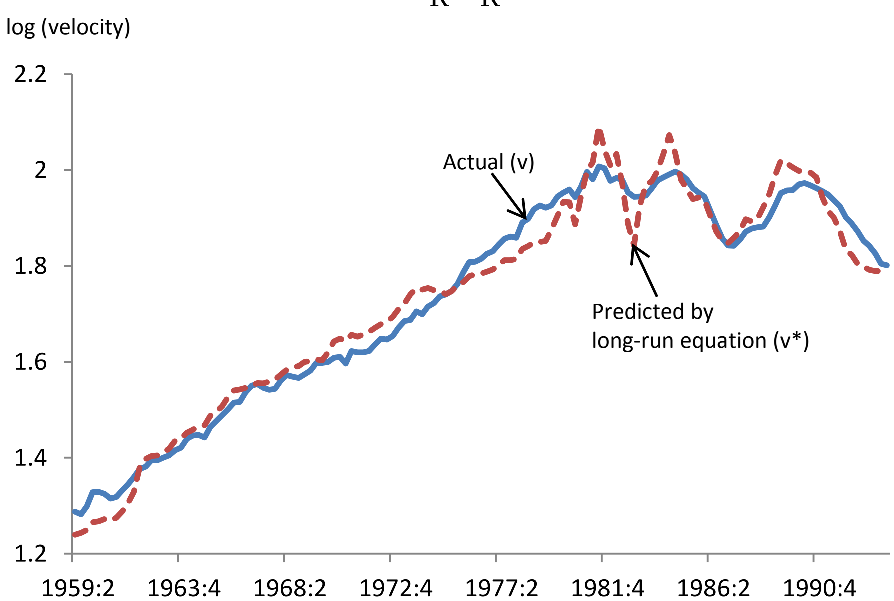


Figure 6

Nominal Money and Long-Run Demand
($R = R^{OP}$)

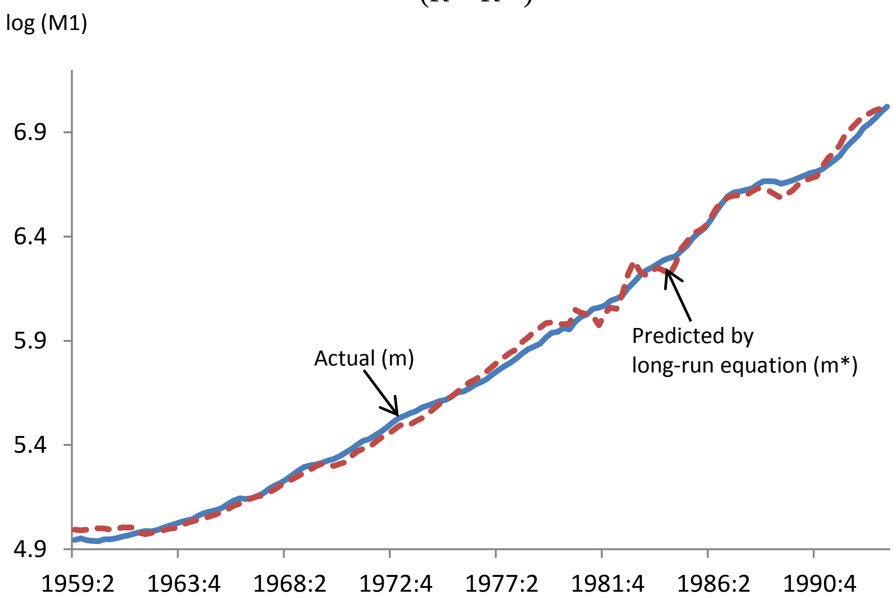


Figure 7

Velocity and the Partial Adjustment Model
($R = R^{OP}$)

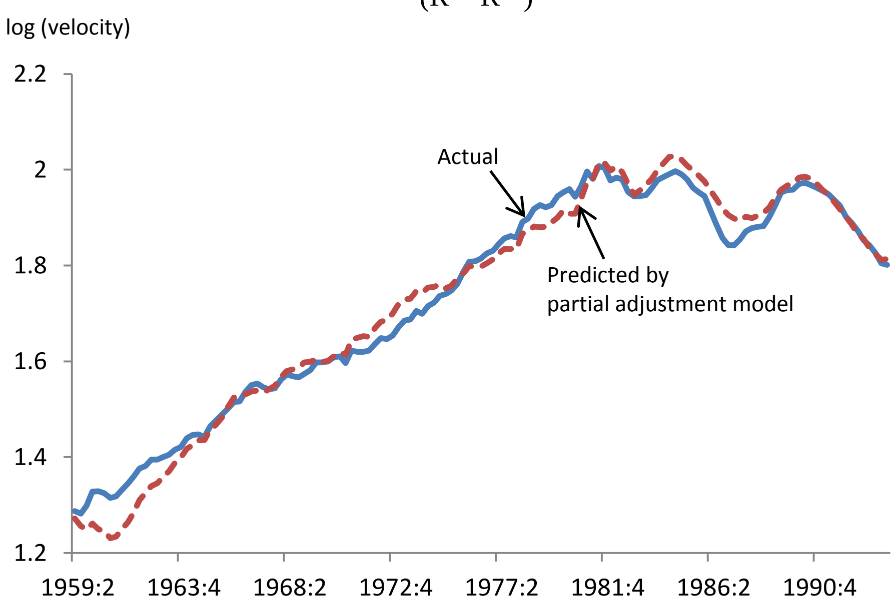


Table 1

Estimates of Long-Run Money Demand Parameters[a]
1960:3 – 1993:4

	$R = R^{TB}$	**$R = R^{OP}$**
θ_y	0.532	0.467
	(0.031)	(0.024)
θ_R	-0.040	-0.082
	(0.003)	(0.006)

Table 2

Estimates of the Short-Run Model, 1959:4 – 1993:4
($R = R^{OP}$)

	Two-Step	One-Step
k	0.012	(not identified)
	(0.002)	
μ	0.204	0.204
	(0.026)	(0.032)
ρ_1	0.538	0.509
	(0.092)	(0.096)
ρ_2	0.215	0.191
	(0.086)	(0.086)
θ_y	0.467[b]	0.514
	(0.024)	(0.032)
θ_R	-0.082[b]	-0.077
	(0.006)	(0.007)

[a] Estimation is by Dynamic OLS with four leads and lags. Standard errors in parentheses are calculated using Stock and Watson's (1993) DOLS2 procedure.
[b] DOLS estimates from Table 1.

Table 3

Estimates For Alternative Sample Periods
($R = R^{OP}$)

	One -Step Estimates			Two-Step Estimates		
	1959:4 - 1973:2	**1959:4 - 1976:2**	**1959:4 - 1979:3**	**1959:4 - 1973:2**	**1959:4 - 1976:2**	**1959:4 - 1979:3**
k				0.021	0.014	-0.004
				(0.002)	(0.003)	(0.011)
μ	0.644	0.000	0.004	0.753	0.174	0.382
	(0.130)	(0.052)	(0.026)	(0.101)	(0.079)	(0.135)
$\boldsymbol{\rho_1}$	0.825	0.463	0.449	0.909	0.753	0.977
	(0.146)	(0.136)	(0.116)	(0.124)	(0.149)	(0.175)
$\boldsymbol{\rho_2}$	-0.456	-0.172	-0.217	-0.495	-0.019	-0.048
	(0.125)	(0.130)	(0.118)	(0.117)	(0.132)	(0.160)
$\boldsymbol{\theta_y}$	0.404	56.080	6.418	0.390	0.526	0.240
	(0.021)	(6,844.000)	(39.820)	(0.015)	(0.112)	(0.152)
$\boldsymbol{\theta_R}$	-0.015	-1.814	-0.280	-0.015	-0.077	-0.036
	(0.006)	(218.500)	(1.925)	(0.006)	(0.032)	(0.043)